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LOST
CROPS
of
AFRICA

volume III
Fruits

Development, Security, and Cooperation
Policy and Global Affairs

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More than 1,000 people have participated in the National Research Council's overall study of the crops of Africa. Most contributed by nominating species of grains, fruits, nuts, vegetables, legumes, oilseeds, spices, sweeteners, and beverage plants they deemed worthy of inclusion. All those individuals played a part in developing this, the third product from the study. The following list, however, includes especially the ones who provided technical details that became incorporated into chapters of this particular book.

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PREFACE

This book is one of a series identifying innovations with promise for improving the quality of life in the earth's poorest regions. Like its predecessors—more than 30 reports extending over 30 years—it combines the knowledge of experienced individuals into a study crafted to provide insights, particularly for decision-makers at every level from the farm and village to the nation and beyond. This volume draws special attention to Africa's traditional fruits. Specifically, it emphasizes 24 cultivated and wild resources that seem useful for diversifying food supplies and improving nutrition across the hungriest continent.

Why such a seemingly obvious examination is needed results from a peculiar situation. Within the huge hungry zones below the Sahara are to be found several thousand native food plants, almost none of which have been given research or technical support. Plants that have fed people for millennia go largely or wholly without scientific or development attention today, even as millions in their midst suffer chronic malnutrition and related ills.

We call such neglected riches the “lost crops of Africa.” Among these forgotten foods a significant fraction are fruits. By highlighting a small selection we hope these pages demonstrate not only the potential latent in these few, but also inherent in the full array of Africa's indigenous edibles.

It is important to understand our use of the word “lost.” As in the case of “lost cities,” such as Zimbabwe, this is a word applying to an outsider's perspective. The foods described here are not truly lost; indeed, in many locations many are beloved companions, especially by rural populations. It is the mainstream of international science and people beyond the rural regions that remain unaware of the resources described here.

This book is the third in a study highlighting the promise inherent in the food plants indigenous to Africa. Each presents information useful to help a continent where millions confront severe and interlocking problems stemming from difficulties in food production and food distribution. The first volume, published in 1996, covered a dozen grains:

- African Rice (*Oryza glabberima*)
- Finger Millet (*Eleusine coracana*)
- Fonio (*Digitaria exilis* and *D. iburua*)
- Pearl Millet (*Pennisetum* species)
- Sorghum (*Sorghum bicolor*)
- Tef (*Eragrostis tef*)
- Other cultivated grains (*Brachiaria*, *Triticum*, *Paspalum*, etc.)
- Wild grains (*Echinochloa*, *Paspalum*, etc.).

Volume II, which published in 2006, covers 18 vegetables:

- Amaranth (*Amaranthus* species)
- Bambara Bean (*Vigna subterranea*)
- Baobab (*Adansonia digitata*)
- Celosia (*Celosia argentea*)
- Cowpea (*Vigna unguiculata*)
- Dika (*Irvingia* species)
- Eggplant (*Solanum aethiopicum*)
- Egusi (*Citrullus lanatus*)
- Enset (*Ensete ventricosum*)
- Lablab (*Lablab purpureus*)
- Locust Bean (*Parkia biglobosa*)
- Long Bean (*Vigna unguiculata*)
- Marama (*Tylosema esculentum*)
- Moringa (*Moringa oleifera*)
- Native Potatoes (*Solenostemon rotundifolius* and *Plectranthus esculentus*)
- Okra (*Abelmoschus esculentus*)
- Shea (*Vitellaria paradoxa*)
- Yambean (*Sphenostylis stenocarpa*)

Both those books and the current one stem from questionnaires in which Africans and Africa specialists nominated sub-Saharan food plants they considered underexploited. The resulting recommendations exceeded even the combined capacity of these three tomes. Indeed, the current trilogy outlines only a fraction of Africa's home-grown food heritage.

In fashioning the present volume, we chose to separate the resources based roughly on their uppermost level of management. Thus, the first section describes fruits that are cultivated at least to a small extent. These 10 chapters are, by contrast with the rest, longer and more detailed and the plants described are, scientifically speaking, better known. Part 2 describes 14 species that are still essentially untouched by the almost-magic hand of modern horticulture. Necessarily, these descriptions are more sparse and the conclusions more uncertain.

Every chapter began as a skimpy draft prepared from library sources as well as miscellaneous documents we had on hand. That first round included more than 40 different fruit types. Each description was mailed to the original nominators as well as to others located via the scientific literature and our own efforts. Their comments, corrections, and improvements were subsequently evaluated and integrated into a second set of drafts.

In turn, those upgraded descriptions were emailed to scores of specialists identified through the emerging Internet, yielding yet another round of insight. By this point more than a dozen fruits were clearly less worthy than

the rest and were summarily dropped. Next, the cultivated and wild fruits introductory sections were compiled from the accumulated information, much of it never publicly available.

Finally, the panel (page v) considered the end product of this extensive technical outreach. They evaluated the balance of the work and especially assessed introductory sections to ensure the overall thrust was in accord with their experiences with Africa's problems, needs, and potentials. A final draft was then reviewed in accordance with procedures approved by the National Academies' Report Review Committee.

This drawn-out process of writing and review led to the present work. As with the companion volumes, this is neither a textbook nor a survey of African botany or agriculture. It is a selective work that stands somewhere between a scholarly account and a popular review of 24 essentially independent fruit resources. The chapters are internally organized for easy access by administrators, entrepreneurs, plant lovers, and many more who could help release these overlooked resources from international obscurity.

This book is thus intended as a boost to African development, not a bequest to academe. Our goal is to leverage indigenous fruits into greater production, helping them achieve their innate capacities as well as raise nutritional levels, diversify agriculture, facilitate environmental stability, and open economic opportunities in a continent needing all those things.

Because our audience is broad, each chapter is organized with more than one set of readers in mind. The opening pages employ a general tone and are intended primarily for non-scientists and newcomers unexposed to the species in question. Subsequent text incorporates increasing levels of detail by which specialists and the cognoscenti can assess the relevance of these species for themselves, their region, or their research. This, the opposite of normal scientific writing style, has in the past worked well for our purposes of increasing awareness.

It should be noted that certain items of interest to readers beyond Africa's shores have been included. This is partly because in the past African crops have sometimes been belittled as merely "marginal foods"—as if lack of status in science equated to a lack of significance in (someone else's) society. Mainly though, it is because our pages highlight reasons why *everyone* should help resurrect Africa's forgotten foods.

Anyone interested in working with these fruits can easily find those of greatest interest by consulting the separate Introductions to Cultivated Fruits and Wild Fruits. There, the overall promise of each species is summarized in one paragraph, and then placed in the context of overcoming malnutrition, boosting food security, fostering rural development, and sustainable landcare. For convenience, the overall potential is also ranked in tables (see Tables 1 & 2), which also show where these fruits primarily occur in Africa. For further information, we recommend readers turn first to the Internet,

where it now seems each day there is new information on these old crops.¹

The first volume in this series—the one dealing with cereal grains—was written in the age before computers brought the world to our fingertips, and included appendices describing tangential technical breakthroughs and scores of selected readings. In the present volume we've curtailed similar addenda. Such changeable particulars are these days more surely uncovered and updated electronically and, unlike limited printings of books, can be accessed by millions just in Africa. We also once listed hundreds of research contacts complete with contact addresses and indicating sources of germplasm. However, because this report will also be digitally published, out of respect for electronic privacy we have eliminated listings of specific researchers and germplasm holdings; today these can easily be made known through the worldwide web. Moreover, with increasing bioconcerns over introduced organisms, as well as greater sensitivity to cultural heritage, the days in which individuals can freely exchange germplasm around the planet are past. Plant material today must always be transferred through appropriate channels according to phytosanitary, legal, and ethical norms. When dealt with safely and fairly, these crops will best approach their global potential.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this report:

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¹ Much can be found by starting with Internet search engines, using scientific and common names for these species. On-line, an especially notable, coordinated effort to collect information on this broad diversity of plants is "Plant Resources of Tropical Africa" (prota.org), a joint African/European nonprofit foundation, which is documenting 7000 indigenous and introduced species useful in Africa. The International Centre for Underutilised Crops (www.icuc-iwmi.org) focuses on underexploited crop plants in particular, with extended monographs on several species. Some sites dealing with these plants (such as ecoport.org) are now organized by users themselves, sharing their input. Collaborative, user-driven electronic "portals" would be a boon for each of these species.

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Calvin O. Qualset, University of California, Davis. Appointed by the National Academies, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authors and the institution.

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A NOTE ON TERMS

Throughout this book the word “Africa” always refers to Africa south of the Sahara. Similarly, “African plants” always refers to sub-Saharan species, omitting North African plants, which in reality belong to the Mediterranean-Near East complex.

Since the book is written more for citizens than for scientists, we refer to the fruits by common names. Mostly, we use English names, except where those might imply that a plant pertains to a single social group or locale (e.g., Natal plum). Such epithets can spark resentment among others who might also reasonably regard a crop with equal passion, patriotism, or their own proprietary feelings. In a few cases we have not hesitated to feature a minor but mellifluous name. Our focus is the future, and a grating or quixotic name can discourage furtherance of an otherwise great fruit. Lists of common names are also included in many chapters. These are representative rather than exhaustive. In some cases almost every valley or village uses its own word.

Nutritional values are presented on a dry-weight basis, unless noted otherwise, to eliminate moisture differences between samples. Many of these figures were derived by obsolete methods or are otherwise tentative. Modern techniques can be rapid, accurate, and inexpensive, and should be applied to all these plants. Although for sake of simplicity we sometimes refer to vitamin A, readers should understand that within the fruit it occurs disguised as provitamin A carotenoids. These nutrients are converted to vitamin A in the body, but precise modern measures for these fruits are rare and conversion factors vary.

The fruits considered are those that are eaten in the normal way. Botanically speaking, coffee is also an African fruit but—even were it still “lost”—its form of usage puts it beyond our scope. In the same light, the miracle fruit, a headline-happy African species that contains a fascinating non-caloric sweetener, is excluded. Finally, there is the unique case of akee, a fruit much-beloved in West Africa and Jamaica. We have omitted it on the basis that use requires an intimate understanding of the ripening cycle of its fresh arils, both unripe and over-ripe fruits being poisonous.

For certain non-African crops we have employed internationally recognizable names. Examples include peanut for groundnut, papaya for pawpaw, and cassava for manioc. This is because this book will likely be read by people of influence in regions far beyond Africa’s shores.

A WORD TO READERS

Everyone who works with plants assumes responsibilities. Some species described in this report—especially those which are less than domesticated—may be invasive or pestiferous outside their natural environs, and thus require due caution and on-going scientific assessment after introduction. Unless professionally inspected, they may also carry along unseen pests and diseases (particularly small insects and microbes such as virus or bacteria) whose populations might explode catastrophically in new locations. In addition, plant genes and germplasm are subject worldwide to both tangible- and intellectual-property laws; these legal rights hold especially true for food plants in which others—whether farmers or financiers—have already invested thought and labor or capital. For these reasons, most nations have official protocols based on intergovernmental conventions governing the safe and legitimate transfer of plant materials. These protect both people and the environment, and are rarely any obstacle to helpful activities. In the best interest of all parties, it is crucial that the requirements of such protocols be strictly followed.²

² Assurances may include at least a phytosanitary certificate and a written statement of consent (such as a material transfer agreement), and often a collection permit as well. Phytosanitary requirements for your country can be found by contacting your National Plant Protection Organization, listed on the website of the International Plant Protection Convention at www.ippc.int. Detailed information on proper access to genetic resources in conformity with the Convention on Biological Diversity can be found via www.biodiv.org.

FOREWORD

These pages highlight a collection of food plants that may seem to be just fruits. In reality, however, they are multipurpose assets for relieving problems across the vast and troubled landmass lying below the Sahara. The plights these fruits might lessen include hunger, malnutrition, rural poverty, devastation from unsustainable land practices, and their often-added burdens for women, mothers, and children. Even the suffering caused by fearsome disease might, to some extent, be relieved.

Such claims will perhaps seem overblown to the uninitiated. After all, the following pages portray mere plants. But consider this: the 24 resources highlighted here produce food of a particularly nutritious kind. Being fruits, they are among the priciest foodstuffs, many come from long-lived trees that protect land, and most are raised, harvested, and sold by women. Furthermore, in a continent beset by infectious diseases, the nutrients that come from fruits can boost general health, strengthen immunity, and help reduce the burden of disease.

For such reasons, all fruits should be larger contributors to Africa's diet. The advantage of the indigenous species we describe is that they are of African origin. These ancient foods evolved with humans as our ancestors ate their ancestors. The African landscape is already shaped by humanity preferentially selecting for these species.

Local origins are not, however, an unmitigated blessing. For one thing, it means that, with two glaring exceptions, these fruits are essentially unknown to those around the globe who most influence research priorities and funding decisions. For another, local pests and diseases have spent millennia perfecting their penetration of the plants' defenses.

These limitations, while substantial, are also manageable, and local fruits offer strong reinforcements for Africa's food security. When confronting the enormous challenge of helping sub-Saharan nations, outsiders—even those motivated by the best of intentions—hardly know where to start. The continent's problems seem impossibly complex—so intertwined and so overwhelming that there seems no place to even begin to build a solid base for solutions.

This book, however, identifies a wealth of entry points through which leverage can be exerted on several societal problems *at once*. Improving the plantings and productivity of baobab, to take a single example, would improve not just the rural landscape but also the social landscape, economic landscape, and even the topography of human health. Moreover, the improvement of baobab is a practical matter well within the capability of plant lovers, horticulturists, philanthropists, activists, educators, entrepreneurs and—most of all—innovative inhabitants of the lands where baobab trees thrive.

For such reasons African fruits deserve the scrutiny of science, but most of all they need the esteem and support of those who are not scientifically trained. Politicians and administrative authorities especially, in Africa and abroad, have yet to realize how much fruits can contribute to nutrition, to health, and to the general uplift in spirit that makes any nation, region, or continent great.

Africa's fruits can provide minerals and vitamins in locally available and attractive forms. They provide variety to the diet and taste buds, thereby enhancing the monotonous staples the impoverished masses endure day in and day out. They provide resources for small-scale horticultural enterprises and home gardens that represent a safety net for the rural regions and a prime means for raising income and relieving poverty in locales needing those most. Beyond all that, fruit trees hold fragile lands together, combating such encroaching calamities as deforestation, soil erosion, water pollution, desertification, urban blight, and perhaps even climate change. Not many people willfully cut down a fruit tree, and that fact of life could and should be capitalized upon for the common good.

Such possibilities undergird this book's perspective. It is hoped that in the years to come fruits will increasingly contribute to the personal welfare of African peoples. Already, consumers worldwide are demanding ever more fresh produce, further increasing the pressures on, and potentials for, the kinds of plants we describe.

The native fruits have a lot of catching up to do. But that is hardly Africa's own fault. In part or perhaps in main, the woeful neglect reflects international priorities of past decades. Those priorities were not unjustified: Near-miraculous rises in the quantities of wheat and rice in Asia probably staved off as big a famine as humanity ever faced. But a shortage of staples no longer limits most food supplies. The time for "quality foods" has come, and they especially strengthen "subsistence" economies. Being among the highest quality foods, fruits (and of course vegetables, too) seem likely to lead a rising tide of new and improved sustenance for a better-fed humanity.

Nowhere is that trend more important than in the nations whose underexploited resources we describe. And their indigenous fruits offer a wealth of opportunities for progress. Yet the next steps demand neither grandiose government enterprises nor massive international interventions. The advancement of local fruits can be jump-started by community initiatives as well as pioneers who undertake such tasks as:

- Locating superior varieties;
- Developing growth, harvest, and maintenance routines;
- Improving storage, handling, packing, and packaging to improve market acceptability and reduce devastating losses;
- Instituting standards and controls that improve quality, even to the level demanded by exports;
- Increasing individual and institutional awareness;

- Opening supplies to competition, fostering the vital price differentials that induce growers to excel; or
- Developing markets and the infrastructure (physical, legal, and mental) to compete locally and perhaps even internationally.

Of all these steps, the first—locating the best varieties—represents the key. Any undeveloped species tends to produce fruits varying in taste, size, appearance, texture, and proportions (including thick skins, large seeds, and thin flesh). Any undeveloped species also tends to produce fruits varying in horticultural qualities such as disease resistance or response to care and extreme conditions. One of the most vital and rewarding activities is to seek out the individual specimens with the largest number of desirable qualities. With those in hand, selection, clonal propagation, and other horticultural manipulations can quickly transform a plant's prospects for commerce and for national nutrition.³

It should not be thought that such advances must be restricted to prestigious researchers or plant-science specialists. Surprisingly few of the premier fruits of the Western world were developed by scholars; most are the products of farmers, horticulturalists, and amateurs.⁴ In Africa there is a vast constituency of motivated plant lovers and activists to pursue similar goals. These currently untapped thousands include farmers and growers themselves, amateur horticulturalists, village leaders, anthropologists, home economics specialists, doctors and public health professionals, nutritionists, entrepreneurs, missionaries, philanthropists, students, school children, school teachers, foresters, environmental activists, landowners, and fruit-loving citizens of all regions and responsibilities.

Such, then, is the wide audience this book hopes to reach. Furthering the understanding and greater use of native fruits provides opportunities for contributions by people of passion and persuasion, wherever they might be and whatever their place in life. It is especially hoped individuals positioned to help Africa get on its feet will find motivation.

There is, of course, a special place for advanced science in this humanitarian service, starting with Africa's trained agriculturists, for whom these fruits (and vegetables) provide an unparalleled opportunity to advance their regions and their careers. Research is particularly needed for

³ An example of this is the kiwifruit, which arose as a crop after a New Zealand grower noticed a single plant with double-sized fruits. Before that *Actinidia deliciosa* was a tiny wild berry of China with little future in formal cultivation.

⁴ For instance, the current "standard" avocado ('Hass') was discovered by the children of a mail carrier who, in the 1920s, was starting a small grove in the hills outside Los Angeles, USA. Unable to afford trees that were already grafted, he planted seedlings of unknown pedigree as rootstock, and then grafted the then-dominant 'Fuerte' variety onto them all. All the grafts took but on one seedling. He intended to chop it down but his children loved the flavor of its fruits so much he was persuaded to save it and, today, almost all of California's avocado comes from that single rogue seedling of Mr. Hass.

overcoming pests and diseases that suppress yields and destroy or disfigure the harvests. A key problem in Africa, as elsewhere, is that mammals, birds, insects, microbes, and other fruit-lovers seek to consume production before people can. The application of current biological knowledge could greatly boost the production and protection of traditional fruits, yet this is just one pressing and compelling arena: Virtually no aspect of these fruits has been touched by science. The separate chapters identify specific areas for incisive applied research, much of which can be undertaken now, with little cost, by small groups or individuals.

It seems especially noteworthy that the age-old foods described in the chapters ahead also offer practical new opportunities for developing regional cooperation among African states. These plants are a starter to catalyze collaboration in research as well as development, growth, and trade. As such, they should be regarded as a neglected resource for helping all the continent's inhabitants. Africa's "lost" fruits provide the possibility for advancing common interests continent-wide.

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LOST
CROPS
of
AFRICA

volume III part 1
Cultivated Fruits

INTRODUCTION

Like Asia and the Americas, the continent of Africa is blessed with a rich tropical flora. Many of the 50,000 or so plants that evolved within its forests and savannas ripen fruits to tempt the myriad wild creatures into spreading their seeds. Speaking generally, Africa has as many of these tasty morsels as tropical Asia or America.

This fact, however, is something one would never guess by looking in produce markets or college textbooks. Today, American and Asian species dominate tropical fruit production worldwide, including within Africa itself.

For this, there is good reason. Africa's fruits have not, by and large, been brought up to their potential in terms of quality, production, and availability. Geographically speaking, few have moved beyond Africa's shores; horticulturally speaking, most remain poorly known. Thus, the vast continental landmass lying between Mauritania and Mauritius contains a cornucopia of horticultural, nutritional, and rural-development jewels still waiting to be cut and polished.

Perhaps it is not strange the world bypassed these fruits. Until comparatively recently, most populations in Africa were disperse enough that fruits—seasonally abundant—could be picked wild without the demands of cultivation under domestication. Further, many African cultures—like many others—regarded fruits less as daily fare than a refreshing snack, child food, or some other kind of non-serious indulgence. Then when mango, banana, citrus, cashew, and papaya arrived from Asia, and then when guava, pineapple, avocado, and passionfruit arrived from America, incentive for advancing local fruit diversity increasingly vanished. In the face of these highly domesticated newcomers, local fruits entered a downward spiral in which lack of respect and neglect led in turn to a progressively greater lack of awareness and knowledge, until Africa's fruits receded into the background. Making matters worse was the reality of recent centuries, as traditional eating habits began to fade—including those incorporating or even depending on local fruits.

It should also be mentioned that the displacement of ancestral foods was not necessarily due to consumer preference. For one thing, compared to the already-improved foreign fruits, Africa's species could seem relatively difficult to select and reproduce, a hindrance to expressing their potential qualities and achieving their ultimate place in the food supply. That feature further turned growers toward the better-known tropical fruits, whose breeding and propagation problems had been already overcome and whose culture could be found in books and colonial expertise. In this light, the

powers who until the last century wielded the purse strings also focused their funds—both production and research—on bananas, pineapple, coffee, cacao, oil palm, and other fruits of proven higher value as export crops.

Thus, although the indigenous fruits described in the following section may be cultivated, most are unknown to the sort of large-scale organized operations that are routine with oranges, mango, banana, or papaya. Instead, they are grown mostly as small or solitary plantings in village settings and home gardens, and are produced more by tradition than horticultural technology. Almost all are raised from seed rather than the vegetative propagation that defines fruits elsewhere. As a result, yields are unreliable and often unrecorded, flavors are variable, and varieties unselected. Soil and fertility requirements remain uncertain, and even propagation techniques in some cases are unknown. In addition, nutritional information is lacking, incomplete, or so based on old or limited analyses it may be representative or may not be. Indeed, it has been said that the fruits of Africa largely persist in forms already recognized generations ago. It could also be said that the management of these plants largely persists in forms unchanged as well.

Regardless of all difficulties and doubts, however, now is the time to rediscover this heritage, to apply the art of horticultural science to African fruits, and to make them work harder. Both the need and the opportunity are nowadays great. The tragic and widespread occurrence of ill health among children is one glaring example why support for Africa's fruits is vital. Without doubt, neglect of nature's own endlessly renewable nutritional supplements contributes to this malnourishment, at least in rural districts. Native fruit resources, measured against communal nutritional needs, seem likely to be of the highest value. They hold promise to become levers for lifting the most nutritionally vulnerable in the most widely scattered areas of Africa. Indeed, fruits make the best of all food supplements. Not only are they appealing to the vulnerable young and old and ill, they provide what might be called "sustainable nutrition."

Moreover, fruits provide their wealth in the locale most needing sustainable nutrition. Every quality-of-life indicator shows the rural poor generally face the worst hardships. Approximately three out of every four desperately poor Africans reside *outside* the cities. And for at least the coming generation, rural inhabitants will outnumber their urban counterparts, even if mass migration to the cities persists.

If poverty's weight falls especially heavily on its rural population, then *rural* development is vital for achieving overall poverty reduction and improvement in African life. And developing Africa's own local fruits is one practical approach to nourishing these local lives.

SUMMARIES OF INDIVIDUAL SPECIES

Following are short summaries of ten notably promising cultivated fruits selected for treatment in this volume's opening section. The potential of these species to confront humanitarian challenges in Africa is addressed in the sections following these summaries, as well as in Table 1 on page 7. This information is drawn from the detailed chapters that follow their Introduction.

1. *Balanites* (desert date, lalob)

This small tree (*Balanites aegyptiaca*, Balanitaceae) tolerates heat and aridity so well it thrives into the heart of the Sahara. Deep-rooted and very spiny, it produces heavy yields of date-like fruits whose gummy, yellow-to-red pulp is more than a third sugar. Although these sweet treats are eaten raw, they are more commonly used as ingredients in cooked dishes. Some, however, are crushed and converted into drinks. The fruit also yields a kernel roughly matching sesame and soybean in composition, being about half oil and a third protein. To become edible it must be boiled for some time, but then it can be turned into many tasty items, including roasted snacks and a spread not unlike peanut butter.

Climate arid

2. Baobab

Few trees on earth engender respect like baobab (*Adansonia digitata*, Bombacaceae). Millions believe it receives divine power through the branches that look like arms stretching skyward (see the chapter on baobab as a vegetable in Volume II). Its fruits sometimes attain the size of melons, and their tough outer casings enclose angular packets of a strange, sticky pulp. A few hours in the sun dries this semisolid into a free-flowing, soluble powder. The resulting "baobabfruit flour" has a gingerbread flavor enlivened by a not unpleasant acid bite. It is nutritious enough to be stirred into warm water or milk to create a health drink. The fruit also contains nuts with an almond-like taste. Although difficult to get at (owing to a thick shell) the nuts are valued foodstuffs, eaten fresh, fermented, or roasted like peanuts. They are rich in both food energy and quality protein.

Climate tropical

3. Butterfruit (safou, bush mango)

Butterfruit (*Dacryodes edulis*, Burseraceae) may be unknown to the world, but in Central Africa and neighboring sections of West Africa this small tree is an almost universal component of traditional farming. Throughout this broad tropical belt it contributes importantly to nutrition and

farmer income. Like tomato or eggplant, the fruit is mainly used as a vegetable. It has a pleasant smell and attractive appearance and is extremely high in food energy. Indeed, up to two-thirds of the pulp comprises an oil of very desirable composition. In addition, the pulp is one of the best protein sources to be found in the world of fruits. About a quarter of the dry pulp is protein, and it is of superior nutritional quality. To top all that, butterfruit provides notable dietary minerals.

Climate tropical

4. Carissa

Carissa (*Carissa macrocarpa*, Apocynaceae), from South Africa and Mozambique, yields masses of shiny fruits that are often called Natal plums. Their thin red skin covers a pinkish-red, almost mealy, flesh that is flecked with a milky juice. Flavor varies from tart to more or less sweet, depending upon variety and maturity. Even though production is now haphazard and essentially unsupported by the muscle of modern knowledge, carissa promises to become a much greater crop. Even in its present form this fruit has an ample edible portion and, having no stone in the center, it can be eaten whole. These versatile foodstuffs make tasty jams, jellies, and drinks as well as attractive highlights in salads and desserts of all kinds. Some taste like raspberry; most, though, are as tart as cranberry.

Climate subtropical

5. Horned Melon

A spiky orange oddity crammed with green jelly and white seeds, the horned melon (*Cucumis metulifer*, Cucurbitaceae) has gone global in recent decades; New Zealand, Israel, and Kenya are among countries shipping it around the world. Back in its native habitat, southern Africa, the plant is little used, but in a few places—Malawi, for instance—people grow it for sale in the local food markets. Seemingly, its home territories could make much more of this strange comestible, not only as a dessert fruit but also as a vegetable like cucumber.

Climate temperate, subtropical, and semiarid

6. Kei Apple

The shrubby plant known botanically as *Dovyalis caffra* (Flacourtiaceae) produces fruits that resemble little golden apples. Indigenous to the southern zone—including Malawi, Zimbabwe, Mozambique, and South Africa—it becomes bespangled with fruits whose thin, tough skin shelters a yellow, melting, juicy pulp with a lively aroma.

Climate subtropical

7. Marula

Marula (*Sclerocarya birrea*, Anacardiaceae) is prized for its fruits as well as its seeds. Both are in high demand from Cape Verde to the Cape of Good Hope. In some societies the tree ranks as a major food supplier. The plum-sized fruits have a thick yellow peel and translucent white flesh. They can be eaten fresh but most are processed into things such as beverages, jams, and jellies. Although the succulent pulp has a unique flavor, writers struggling for a frame of reference have variously likened it to litchi, apple, guava, or pineapple. The kernels inside the seeds are commonly compared to macadamia nut.

Climate subtropical (the best-known species) or tropical (a separate and lesser known species)

8. Melon

The melon (cantaloupe, muskmelon; *Cucumis melo*, Cucurbitaceae) is one of the two African fruits that are known around the world. All the warmer regions produce it, of course, and millions enjoy a melon for breakfast, lunch, or dessert. Today's melons are based almost entirely on seeds carried out of Africa, probably on the backs of camels northward across the Sahara in the time of the Pharaohs. While today India, Japan, and many other countries have greatly improved, locally selected varieties, the full wealth of the species' diversity was not only left behind, it was forgotten, and remains to this day largely untapped. Who knows what kinds of 21st century melons can be developed by finally utilizing the "lost" half of this fruit's heritage?

Climate most climates

9. Tamarind

Throughout the tropics tamarind (*Tamarindus indica*, Leguminosae) provides an attractive backdrop to roadsides, fields, and markets from the East Indies to the West Indies. And everywhere it grows, people enjoy the shade cast by its feathery foliage, not to mention the curiously sweet-sour pulp found inside its brittle, gray-brown pods. What is not widely known is that tamarind is actually from western African. The original wild version, a common savanna tree, can be found over an area stretching from the Atlantic seaboard to the verge of Central Africa's rainforests and east. Senegal's capital is actually named for this tree, which in the local Wolof language is called "dakar." Despite its current spread, this species is far from fully exploited, and it could become an even greater tree in the tropics, notably including countries within the boundaries of its own home continent.

Climate dry savannas and monsoonal regions

10. Watermelon

Other than botanists, few people consider that watermelon (*Citrullus lanatus*, Cucurbitaceae) is indeed African. Yet this crop's wild ancestors are scattered abundantly across the dry wastes of the continent's semi-arid southern hinterland. The ancestral genes to be found in the wild and tended watermelons bespeckling millions of hectares in countries such as Botswana and Namibia seem likely to provide the genetic means for creating new varieties, new seed foods, new pickles, and new types of watermelon fruits with unusual colors, shapes, sizes, and flavors. It is entirely possible that genes from Africa's wild types could soon spark a watermelon rebirth worldwide.

Climate warm-temperate to tropical

TABLE 1: POTENTIAL ROLES FOR SELECTED CULTIVATED AFRICAN FRUITS

	Overall	Nutrition	Food Security	Rural Development	Sustainable Landcare	PRIMARY OCCURRENCE				
						West Africa	Central Africa	East Africa	Southern Africa	
*** = Outstanding; ** = Notable; * = Average										
Balanites	***	***	***	**	***	√				
Baobab	***	***	***	***	***	√	√	√		
Butterfruit	***	***	***	***	***	√	√			
Carissa	**	**	*	**	**					√
Horned Melon	*	*	*	*	*			√		√
Kei Apple	**	*	*	*	**					√
Marula	***	***	***	***	***	√	√	√	√	√
Melon	**	*	*	**	*			√		√
Tamarind	***	***	***	***	***	√	√	√	√	√
Watermelon	**	*	*	**	*	√		√	√	√

NB: The underlying justifications for these broad rankings are discussed in the following sections on Nutrition, Food Security, Rural Development, and Sustainable Landcare; greater detail is provided in the separate chapters on individual crops.

POTENTIAL ROLES FOR SELECTED CULTIVATED AFRICAN FRUITS

To give some idea of the potential of these fruits to help solve the great central issues of African economic, health, and environmental development, we now summarize the above-mentioned fruits' likely relevance to four of Africa's biggest needs for human survival and social serenity: 1) nutrition, 2) food security, 3) rural prosperity, and 4) general landcare.

OVERCOMING MALNUTRITION

Although pertinent nutritive information is often poorly available, it can be anticipated that all African fruits are useful sources of nutrients, particularly vitamin C. Indeed, a study of local fruits harvested and consumed in West Africa, particularly Senegal, suggests that they alone can meet year-round vitamin C needs. Of the 29 fruits analyzed, 11 had vitamin C contents higher than 20 mg per 100 g. Many may also be good sources of beta-carotene (provitamin A), usually revealed by a yellow coloration.

Fruits also provide necessary minerals. The often-substantial contents of calcium, phosphorus, potassium, and sometimes iron are of special value to children whose growing bodies desperately need these elements to build teeth, blood, muscle, bone, and brain. Many fruits also provide magnesium, an element critical for cellular metabolism, protein digestion, and proper functioning of the nervous system.

Furthermore, fruits rank high on the recommended-food charts because they provide dietary fiber. Numerous studies indicate that dietary intake of fiber reduces serum cholesterol and is perhaps associated with several other health benefits.

And in the continent's many dry zones fruits, are valued for providing water in a pure form. A melon, for example, makes a valued thirst quencher—not to mention natural survival kit—for people crossing deserts or working in hot fields.

Finally, it can be said that fruits are beneficial not only for what they provide but for what they don't. They contribute, for instance, no cholesterol and typically have only tiny amounts of fat.

Below is a summary of the merits of the fruits highlighted in this section, *specifically in terms of fighting malnutrition.*

Balanites (desert date, lalob)

Children like the sugary balanites fruits, and throughout the species' range these are widely consumed by the young. This makes it a key to malnutrition reduction in the vast, parched, and perilous arid zone where few other useful plant species exist. The pulp contains carbohydrate (notably

sugars), protein, a smidgen of fat, and undoubtedly notable levels of vitamins and minerals. In addition, the seed kernel is rich in both an oil of the desirable unsaturated type and a protein whose amino-acid quality almost matches that in peanut. The pulp and seeds, separately or together, are thus excellent dietary means for assisting the malnourished, both young and not so young.

Baobab

Nutritionally speaking, the strange chalky powder from a baobab fruit can be considered nature's gift to natural food fortification. The dry, soluble flour provides a simple way to add protein, carbohydrate, energy, fiber, provitamin A, vitamin C, several B vitamins, calcium, phosphorus, and iron to other foods even in remote areas where delivering those by other means is difficult. Moreover the protein has an excellent amino-acid profile, including good quantities of such essential vegetative rarities as lysine, methionine, cystine, and tryptophan. At least in principle, this seems like a readily available homegrown means for reducing malnutrition on a long-term and large-scale throughout much of Africa.

Butterfruit (safou, bush mango)

Packing a combination of protein and energy, butterfruit pulp is promising for reducing Africa's worst humanitarian problem, protein-calorie malnutrition in children. Although presently unreported in nutrition programs, it might prove a lifesaver for children, nursing mothers, and the desperately malnourished. Its protein contains levels of essential amino acids similar to those found in eggs, milk, and meat. Moreover, the oil making up roughly half the pulp is composed mainly of desirable unsaturated fatty acids. And beyond protein and edible oil, this fruit provides an array of minerals such as potassium, calcium, and magnesium. Clearly, this fruit possesses the nutrient power to counteract what is currently the most common form of malnutrition.

Carissa

Although generally eaten for pleasure rather than health, carissa nevertheless packs some nutritional wallop. Indeed, it contains somewhat more vitamin C than the average orange and enough calcium, phosphorus, and magnesium to designate it a fine source of minerals. The red pulp looks and tastes so good it is often added to sick-people's foods to entice them into downing pasty-colored porridges. The fruits are also dropped into water bottles and gourds to liven up the liquid contents. For these and other features carissa could be a good delivery system for the very nutrients everyone needs and not everyone gets.

Horned Melon

The nutritional value of the horned melon's flesh is low, and the seeds are poorly known. The fruit seems unlikely in its present form to make a major dietary contribution against malnutrition.

Kei Apple

Kei apples are highly acidic for the simple reason they have more vitamin C than oranges. Beyond that, little of their food value is known. This fruit's value in nutrition programs is certain to be good but not necessarily good enough to warrant special effort on those grounds alone.

Marula

Although an important source of several nutrients, marula fruit stands out for its vitamin C. In this regard, the flesh commonly surpasses orange, grapefruit, and lemon. Add to that macadamia-like nuts, possessing protein, an edible oil ranked with the elites, and minerals such as calcium, magnesium, and phosphorus, and you have a nutritional powerhouse borne by a widespread plant seemingly created for today's needs.

Melon

Dietarily speaking, most people consider melon a sugary nothing. But it provides potassium, vitamin C, and almost as much provitamin A as mango.

Tamarind

Tamarind pulp is a good source of the B vitamins thiamin, niacin, and riboflavin as well as phosphorus, potassium, and calcium (whose content is reportedly the highest found in any fruit). There are claims that tamarinds are also high in iron, which could make them useful anemia preventatives. The fact that kids love sucking on these not-so-pretty fruits means this long-lived and highly adaptable tree could be a significant nutrition-delivery tool. Plant tamarinds beside the tracks to school and you'll likely feed generations of children and, in addition, leave a legacy of shade for the society and soothing scenery for the ages.

Watermelon

Although no one eats watermelon for medicinal purposes, the contents of carotenoids—especially beta-carotene and lycopene—are substantial. Watermelon also is a significant source of vitamin C and fiber. As for minerals, the fruit supplies potassium and is at the same time very low in sodium. It also provides a safe liquid refreshment for washing down a meal.

BOOSTING FOOD SECURITY

The words “food security” signify the concept of access to sufficient food all the time. The principle is as important as ever because all-too-often a steady supply is thwarted, not just by poverty but by conflict or natural events. So it is for good reason that societies rely most heavily on staples, whose dry skins and starchy hearts make them easy to ship, sell, and store. This “always-ready” keeping quality supports everyone’s continuing need for food. However, when supplies of staples get shaky, people naturally turn to the wider variety of edibles around them. And many of these are fruits that grow on trees.

It may come as a surprise that Africa’s native fruits *can* help hungry stomachs fight back. Though we rightly think of fruits as having nutritional punch, many also pack proteins and carbohydrates. Such combinations have often staved off starvation until staple supplies could stabilize.

Below, we summarize the merits of the fruits highlighted in the book, *specifically in terms of food security*.

Balanites (desert date, lalob)

Balanites produces a wealth of resources where other plant life barely survives. A plunging taproot makes it drought resistant, thick bark helps it survive the ubiquitous grass fires. It also tolerates inundation, wind, sandstorms, shallow and compacted clays, salt spray, soil salinity, and termites. It would thus seem to make an ideal security shield for the food supply in an area where such hazards all too often decimate other food resources. And it is not just the fruits and seeds that save lives. In times of extreme famine, the flowers, leaves, and even bark become sustenance for people. Moreover, the seeds are so popular as animal feed they underpin livestock production in dry places and in droughty seasons when even goat and camel husbandry operates at their outermost limits.

Baobab

Perhaps this fruit’s most vital humanitarian use is in feeding those who cannot buy their way out of starvation during the hungry times. For this purpose, the pulp of baobab fruit is beaten into thin pancakes, which on exposure to the sun dry into hard, brown disks. Despite the disconcerting look of leather, these are immensely valuable in that they can be stacked up like dinner plates and stored away in a corner for months or even years. Poor people in a dozen countries rely on this reserve during droughts or other disasters when neither gardens nor markets yield adequate provender. And during famine times they also rely on baobab seed, a compact package of energy, protein, and micronutrients. This strange tree even supplies water to the thirsty. At the height of the rainy season villagers in parts of Africa prize

open a bunghole in the bark and fill the hollow interior with water. Thanks to natural preservatives, the water stays potable, and during the subsequent rainless months it saves lives.

Butterfruit (safou, bush mango)

This species seems likely to provide a superb means for ensuring food remains on hand during difficult times. Even now, the trees exist in countless villages and contribute to mass welfare in some of the hottest, most humid, and harshest of all agro-climates. By helping people survive the annual hungry season—the time when the old crop is gone and the new one is still growing—butterfruits provide the most basic kind of life insurance.

Carissa

Although in South Africa carissa hedges provide generations of kids the micronutrients they need, for the rest of Africa the fruit seems to have little food-security merit, at present.

Horned Melon

Of all the world's fruits, perhaps none has a better shelf life than horned melon, which can remain edible for 6 months even in the tropics. On the other hand, this peculiar fruit can be a challenge to store. Its spikes can stab neighboring fruits, opening them up to decay and ruin in days. They also contain little food energy. Overall, we see no particular Africa-wide food-security use for horned melon without further nutritional development.

Kei Apple

This robust, tolerant shrub can produce fruit during times of climatic stress. However, as of now it is neither widely known nor widely loved, and seems to possess little particular food-security significance for the continent at large.

Marula

Unquestionably, this great and treasured species has the potential to help build a line of defense against dietary insecurity. Marula provides food during the season when grain stocks have run low and other crops have yet to attain an edible state. Also, its nuts store so well they provide nutritious sustenance long after all else is gone. Throughout the plant's range, and especially where cereal crops are unreliable, villagers pile up marula seeds for food emergencies. Because of their fine taste, marula nuts are deemed a delicacy, but their fat, protein, and mineral contents make them a crucial food supplement during periodic drought or the annual hungry season.

Melon

In practical terms, there seems no particular food-security merit inherent in the ephemeral melon, which produces its flesh during the seasons of plenty; the seeds of certain types, however, have served as long-lasting provender in the past.

Tamarind

Although it may appear to be quite a minor food crop, tamarind has been called a tree of life because its fruits can be stored away without refrigeration and safely served weeks or months later. They become especially important during the dry season when fresh foods are scarce or nonexistent. Fulani nomads, for example, preserve tamarind pulp in the form of sun-dried cakes, which provide sustenance while they traverse the Saharan sands. This is a simple procedure that perhaps millions throughout Africa could exploit for food-security benefit.

Watermelon

In Africa's southern deserts the undomesticated and casually cultivated watermelons are an important source of both food and water. In times of drought African farmers have traditionally relied on them for emergency use. Sometimes wild fruits scattered across the desert become the sole source of moisture for their cattle—and even for themselves—for months on end. Moreover, people also pile the fruits up near their dwellings as a convenient cache of food and water. These ancestral watermelons remain edible and “potable” a surprisingly long time—up to a year has been recorded for some types.

FOSTERING RURAL DEVELOPMENT

For purposes of relieving rural poverty, fruits are powerful tools. They bring relatively high prices, can be produced efficiently on a small scale, and are among the poor's few natural treasures. For some rural Africans, there is perhaps no better way for achieving a modest income than through the production and marketing of fruits and fruit products. Many species are already grown at home and sold nearby; children also collect fruits to sell within their village. Nevertheless, supplies now reaching the cities mostly fall far below what could (or should) be marketed, and fruit consumption remains low throughout the continent, averaging less than half the amount eaten by Europeans and North Americans, for example—and far lesser amounts among the neediest.

For farmers, as for anyone with access to land, fruits provide an easy entry into the world of commerce as well as into at least the prospect of a reliable livelihood. The food and beverage industry searches constantly for new flavors, so Africa's fruits offer an opportunity that should be taken advantage of...perhaps comparable to cacao (chocolate), of which smallholders are often the major producers. Fruit-based foods and drinks can emerge from small processing factories—most likely situated close to the growing region (because of the costs of transportation and the likelihood of spoilage). Products might include juice, juice concentrate, puree, paste, dried fruit, canned products, and so forth. Successful fruit crops can also bring broad benefits by creating a ripple effect on the economy, raising the standard of living, keeping enterprising youth from fleeing the farm for the cities that beckon so insistently, and raising the tax revenues that result from general commerce.

Below we summarize the merits of each of the 10 cultivated fruits highlighted in this book's first section, *specifically as they relate to rural development*.

Balanites (desert date, lalob)

The middle of the Sahara is not the place to expect to reap profits on any grand scale. However, balanites could provide the basis for small industries that are otherwise inconceivable in the terrain where it grows. The seeds supply a quality vegetable oil that is a prized ingredient in foods as well as in local cosmetics. They also supply a raw material from which certain pharmaceuticals can be derived. In addition, the wood may be of small diameter, but it is highly prized for cooking because it burns almost without smoke. And, although outside the scope of this study, most parts of the plant are considered to possess various medicinal properties.

Baobab

Possibly, there is no better long-term answer more basic or more beneficial to meager rural lives than this ancient food resource. Baobab fruits even now help underpin rural commerce. Each day in West Africa, for example, they leave the countryside by the truckload, bound for the urban markets and for conversion into a popular drink sold in roadside stands as well as supermarkets in countries as far apart as Kenya and Mali. Such markets also proudly display sweets crafted from baobab pulp. Children commonly peddle these colorful candies to the public, and many an entrepreneur began her career selling baobab treats to friends and passersby for pocket money.

Butterfruit (safou, bush mango)

Butterfruit, too, is already a cash crop. Its fruits pour into cities and rural markets in considerable quantities. In the hot and humid zone stretching from Eastern Nigeria to Angola it is common to see women offering these fruits for sale. The tree is an excellent candidate for greater commerce. It has particular promise around the farm and the rural home because it provides so many useful byproducts—among which are forage for the animals, wood for cabinetmakers, and a scented resin that burns with a bright flame. There is also the promise of supplying industrial markets with oil. Both pulp and seeds contain large amounts of a vegetable oil whose qualities make it highly saleable for cooking and cosmetics. Although this oil is not now produced in any quantity, there are signs that larger scale production could be profitable.

Carissa

In South Africa carissa fruits are already commercial resources. Prized by one and all, they sell in considerable quantity in cities such as Durban. An added potential is probably to be found in processed products. Carissa jelly, made by straining or sieving the stewed, slightly under-ripe fruits and cooking them with sugar, is considered among the finest in Africa. It is now gaining aficionados in California and Florida as well. A boiled sauce, whose tang is reminiscent of the cranberry sauce beloved by Americans, is sometimes prepared. If cranberry can make it into the realm of commerce, carissa can too. Indeed, some carissa devotees wouldn't serve anything else.

Horned Melon

At first sight this would seem the least likely resource for rural development. The fruit seems uncommonly undesirable. Yet when New Zealand shipped the fruits to Japan in 1984 they sold readily and aroused intense curiosity. They were soon also exporting them to the United States,

and now horned melon is grown in many countries. Both Kenya and Israel export them to Europe and, nowadays, they are also transported by the container load across the Pacific. While such efforts demand considerable technology, making this seem a case where a lowly crop has a future *only* as a high-tech export, others believe horned melon may well serve as both a fruit and a vegetable that finds ready local markets as well.

Kei Apple

In the past, the sourness of even the ripest kei apple seemed a barrier to the crop's wider acceptance. But in today's markets, fruits need not be sweet to be successful. Cranberry, as we've said, is biting sour and is increasingly used for that very reason. Kei apple gives a bite (and color) to drinks, candies, jelly desserts, and many other food products.

Marula

This seems an excellent vehicle for rural development. Considerable demand already exists for both the fruits and the nuts. In Namibia, Botswana, Zimbabwe, and South Africa, a rising number of operations are being established to process marula fruit, some handling over 1,000 tons a season. The pulp is appearing in mainstream commerce in the form of juices, jams, jellies, puree, and liqueur. Oils are being extracted from the nuts and put into pricey products for the skin, a process pioneered in Namibia, which now exports marula oil for this purpose. Processing marula materials can offer help for some of society's most needy. Shelling the nuts, for instance, provides work for thousands of rural women who have hardly any other source of income.

Melon

Melons are reasonably priced and some have been bred with rinds robust enough to handle overseas travel. The scope and complexity of flavors, sizes, flesh colors, and textures makes melon one of the most interesting fruits. And it is more popular than most people think. In the United States, for example, melons are second only to bananas as the most-consumed fresh fruit per person. Moreover, melon could have a far greater future in commerce, especially given all the biodiversity still untapped in the vastness of Africa. There may also be markets for its seed as well. This is not a new idea: Sudan once exported tons of "senat" seeds annually, with only cotton, sorghum, and sesame earning more revenue some years.

Tamarind

This species has promise for boosting rural development in most parts of the tropics. The pulp is a versatile food that can be mixed into the myriad

different sauces and drinks favored in the equatorial lands. Its tang especially blends with the fire of chilies, a marriage lending many tropical dishes their distinctively tart, sweetly biting savor. Certain African countries have been advancing this as a commercial resource. In Mali and Burkina Faso, for example, tamarind-based drinks (both fresh and carbonated) rival world-famous soft drinks in popularity. And the locally produced tamarind-syrup concentrate is said to outsell the fancy fruit syrups France exports to Mali. The country is itself exporting tamarind syrups to Europe, where they are sold on the streets (not to mention the bars) of Paris and Rome.

Watermelon

Watermelon fruits are generally easy to grow and easy to sell. They would seem to offer prospects for rural development anywhere they can be cultivated. The seeds are also saleable. West Africa already exports them to France for snack food. Sudan does too. (These seeds, which commonly go by the name egusi, are dealt with in detail in Chapter 8 of the companion volume on Africa's vegetables.)

SUSTAINABLE LANDCARE

Trees and shrubs that yield edible products could be a key to establishing environmental stability from the Sahara to South Africa. They incorporate the very essence of sustainable agriculture. Seen in this light, fruit trees are among the most promising tools for securing agricultural systems that are both long lasting and gentle on the land. Benefits from growing fruit crops—especially perennial ones—include:

- Lessening soil erosion. The trees' roots and surface debris help reduce loss of topsoil and runoff, thereby maintaining soil fertility and slowing siltation of rivers, dams, irrigation systems, and other waterways.
- Lowering soil temperatures. Dense foliage absorbs about two-thirds of the sun's rays, while reflecting and transmitting the remainder, so that within the tree-shaded microclimate temperatures are lower, the light less damaging, and the site more stable and sustainable.
- Increasing organic matter in the soil. Leaf litter and decay add to the nutrients, tilth, stability, and productivity of the land.
- Breaking the wind. The physical presence of a cluster or even a scattering of trees reduces soil loss and improves the microclimate for other growing plants for the simple reason that wind is broken up so it is less likely to desiccate or disturb the soil.
- Supporting beekeeping. Fruit trees are, generally speaking, good sources of nectar and pollen. Their very presence therefore can produce income from honey, wax, and related beehive products. Honey also makes a good dietary-energy supplement, especially where foods are bland or the diets short on food energy.
- Reforesting the land. Tropical fruit trees are an element in reforestation that has been largely overlooked. The fact is that people everywhere like fruit trees, and will plant them and protect them because the trees generate blossoms, food, and funds. This is especially important for the future of Africa, where this interest could be the key to persuading the populace to plant trees.
- Earning carbon credits. For purposes of "global cooling," what could be better than trees that feed the hungry as well as provide all the benefits mentioned above? Fruit trees (together with the soil beneath them) are long-lived carbon sinks that local people respect and protect for generations.

Summarized below are some likely contributions of Africa's cultivated fruits to *sustainable landcare*.

Balanites (desert date, lalob)

Balanites offers ways to help address pressing environmental problems in perhaps the most drought-afflicted area on earth. Beyond the humanitarian benefits deriving from its fruits and seeds, balanites could help overcome

desertification, avoid soil erosion, and reduce the land destruction caused by cattle. The living trees themselves provide shade from the burning sun, shelter from the hot winds, and relief from the never-ending starkness of the desert all around. All in all, it helps stabilize both human life and the natural environment in these severely challenged regions.

Baobab

The tree may be tricky to plant, slow to mature, and susceptible to grazing, but once established it is nearly indestructible. The trunk soaks in water like a sponge, making it resistant to the grassfires afflicting the savannas each summer. Once past its juvenile susceptibilities, a baobab provides its multiple environmental benefits to successive generations.

Butterfruit (safou, bush mango)

In agroforestry and landcare, this versatile species also has promise. It is often seen scattered in riverbeds, across hillsides, and along the boulevards. Possibly it has potential in plantation forestry. The timber, although small in diameter and short in length, can substitute for mahogany. Its woodworking qualities and interesting appearance suit it to veneers and fine cabinetry.

Carissa

Various types of this bush are used for property boundaries, screens, ground covers, landscaping accents, barriers against intruders (two legged and four legged), or container plants. Carissa is also espaliered against a sunny wall or pruned into small trees to beautify a backyard. Few plants are more decorative, tough, or adaptable. The clean and shiny look of the stiff, bottle green leaves makes the shrubs handsome year-round, and the fragrant flowers and crimson fruits lend added beauty.

Horned Melon

In this species, we see no particular value for long-term protection of Africa's soil and environment, though we could be proved wrong. Interestingly, the vines wither at the end of the rains, but the fruits continue to ripen and persist long into the dry season, often serving as a water source.

Kei Apple

This tough shrub does well in almost any soil, including limestone. It is extremely drought resistant and tolerates salinity and even ocean spray. For this reason, for example, it is used as a windbreak or ornamental in coastal California. Its long sharp thorns deter both people and animals. It is commonly seen in hedges and it has been formed into rough rural corrals in southern and eastern Africa. In some climates the untrained plant takes on a

rather scraggly appearance, but it still makes an excellent hedge. Being evergreen, it provides a year-round screen.

Marula

A fully grown marula tree is large and spreading. People genuinely like it for its shade and beauty, not to mention having the fruits to eat. When farmers clear land, these trees are often all that is left standing. Marula thrives under exceptional heat. And it tolerates some of the most inhospitable terrain known to horticulture. Its value for environmental improvement could be outstanding.

Melon

Melon may offer no particular landcare virtues except as a seasonal groundcover, also containing minerals the deep roots pull to the surface.

Tamarind

The living tree is especially promising for restoring deforested and damaged lands to health and productivity. It is already used in anti-desertification programs because it grows in arid and other challenging sites, and it resists savanna groundfires. Rows are also planted among forest trees as firebreaks. Tamarinds probably have notable value for sequestering carbon because people hate cutting them down, and they are so tough they typically grow for centuries. Thanks to a deep and extensive root system, they are little affected by typhoons and cyclones. They withstand city smog and coastal salt air. A dense crown of drooping branches bearing feathery foliage makes this evergreen outstanding for beautifying parks, backyards, boulevards, markets, country roads, and the rest. For these reasons and more, it holds much promise in African reforestation, especially for plantings in places where people live, work, congregate, and revere good shade.

Watermelon

Like its cousin, the melon, it seems to offer no particular long-term landcare benefits or hazards, though its watery fruit in the wild can provide moisture to grazing wildlife long into the thirsty season, thus sustaining the animals that shape entire landscapes.

* * *

The above summaries have highlighted the benefits that may accrue from a broader appreciation for Africa's cultivated fruits. The abstracts were drawn from the detailed chapters that follow, where information is also offered on obstacles to fruition (few of which seem insurmountable).

DESCRIPTIONS AND ASSESSMENTS OF
INDIVIDUAL SPECIES



Balanites aegyptiaca Del.

1

BALANITES (Desert Date, Lalob)

It is hardly surprising that balanites (*Balanites aegyptiaca*) is exploited; what is truly surprising is that it isn't exploited more.¹ This small, deep-rooted tree tolerates such heat and drought that it thrives in the heart of the Sahara, and is common in places such as Tamanrasset, Algeria and Kordofan, Sudan. It is, moreover, exceptionally useful.² Indeed, it has so many useable parts and products that a proverb in the Sahara runs: "A *bito* (balanites) tree and a milk cow are just the same."³

Among other things, these very spiny trees bear heavy yields of fruits—as many as 10,000 annually on a mature tree in good condition. The gummy, yellow-to-red pulp of these date-sized morsels contains about 40 percent sugar. It is sometimes eaten raw, but is more commonly converted into drinks, cooked foods, and medicines.

The seed extracted from within that pulp yields a tasty kernel. Rich in protein and oil, this almond-shaped nut has perhaps more potential than the date-like flesh around it. In gross composition, it is something like sesame seed or soybean—about 50 percent oil and 30 percent protein. To become edible it must be boiled for some time, but then it can be processed into various tasty snacks, including roasted nuts and a spread that looks and tastes not unlike peanut butter.⁴

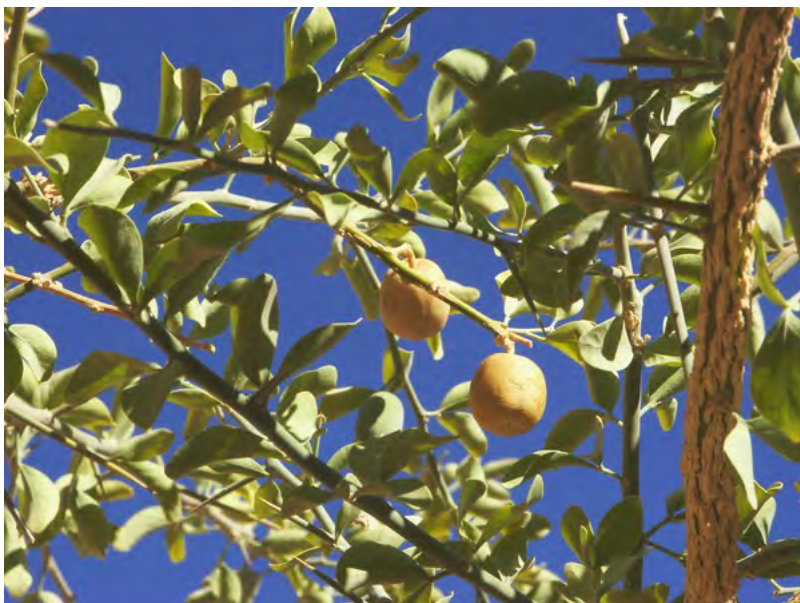
The tree provides other useful resources, too. In times of famine, the flowers, leaves, fruits, and even bark are relied on for food...indeed, for life itself. The seeds are always popular with animals, and they underpin

¹ We choose to call this fruit "balanites" (pronounced bal-an-EYE-tees or bal-an-IT-ees) only with reluctance. It is normally called "desert date" in English, but that name is confusing because the plant is not the common date, which certainly grows in deserts but comes from a palm. Lalob, the Arabic name, is used throughout the Middle East but is unknown in most of Africa.

² Strictly speaking, this is an undomesticated plant. We include it among cultivated fruits because in most Sahelian nations it is planted by farmers or stockbreeders. Moreover, it is planted for dune stabilization and other environmental purposes.

³ This was recorded in what was once called Bornu, a region now mainly found in northeastern Nigeria and Chad.

⁴ In a survey 3,000 people judged this "balanites butter" to be "tasteful, with good smell and high quality."



Balanites produces heavy yields of date-like, bittersweet fruits whose gummy, yellow-to-red pulp contains about 40 percent sugar. Although these sweet treats are eaten raw, they are more commonly used as ingredients in cooked dishes. Some are crushed and converted into drinks. The fruit also yields a nut roughly matching sesame and soybean in composition. (András Zboray)

livestock production in dry places and in drought seasons where animal husbandry reaches its outermost limits. The wood is highly prized for cooking because it burns almost without smoke. Oil from the seed is a prized ingredient in local cosmetics. Twigs plucked from the branches are used to clean the teeth. The living trees themselves provide shade, shelter, and blessed relief from the never-ending starkness of the desert all round. And the fact that the older plants have razor-sharp spines is put to good use in hedges around houses and kraals around animals. Finally, most parts of the plant are considered to possess various medicinal properties.

Considered in fullest perspective, balanites produces a wealth of resources where other plant life can barely survive. Its deep taproot makes it drought resistant. Its thick bark helps it resist grass fires. It also tolerates termites, seasonal inundation, winds, sandstorms, shallow and compacted clays, salt spray, and soil salinity.

If, as is generally believed, humanity began in Africa, then the bittersweet balanites fruit is likely among the oldest of all foods. Certainly, this resilient evergreen has been helping people out for thousands of years. Its fruits have been found in pharaohs' tombs dating back to at least the 12th

dynasty in ancient Egypt. Thus, even royalty has appreciated it 4,000 years.

For all its age-old history as a resource, this is still a “lost” crop. Balanites is seldom, if ever, included in textbooks or monographs of African food production. It is practically unknown to horticultural science. And a concerted effort to develop its true potential using modern capabilities has yet to be attempted.

That situation should be changed. This species produces the necessities of life in one of the world’s most difficult zones of existence. It helps stabilize life and environment in the most severely drought-challenged regions. Its native range extends through the hottest and driest parts of the continent: from the Atlantic coast at Mauritania and Senegal to the Red Sea at Somalia, Sudan, and Eritrea. It also extends onwards and eastwards beyond Africa, through the Arava Valley in Israel and Jordan to the Arabian Peninsula, Iran, Pakistan, and India (notably the Thar Desert).

This is not a rare plant. Throughout this vast, parched, and perilous region, scattered balanites can even now be found—and some occur in large concentrations. In Sudan, for example, the species makes up about one third of the total tree population in the country’s central provinces; Blue Nile Province alone is estimated to have a million *lalob* trees.

And people like balanites. Throughout its range the fruits are eaten (especially by children, not to mention camels, goats, and wildlife). Although each fruit may look and feel something like a date, it is usually stringy, bitter, and thin-fleshed. Certainly at this stage these fruits lack the date’s general appeal. Nevertheless, they should not be written off as some sort of fake date. Far from it. This is a fruit with potential to reduce malnutrition and to underpin food security in the ultimate torrid zones where there are few other useful plant species.

Balanites can also contribute to the reduction of rural poverty. Indeed, it might provide the basis for small industries otherwise inconceivable in the terrain where it grows. For one thing, the seeds could supply food-grade vegetable oil. The golden-yellow liquid is easily pressed out of the kernel and it is both stable and capable of meeting international food standards. For the world at large, a new oilseed may seem of no consequence, but in the seared savannas and desolate drifts where balanites thrives a locally produced high-energy food could be of outstanding importance.

Moreover, the kernels are a raw material from which pharmaceuticals can be derived. The seedmeal (the solid remaining after the oil is removed) contains diosgenin, a raw material for the production of steroids. The world’s craving for steroidal drugs—cortisone, birth-control pills, estrogen, anti-inflammatory agents, and many others—is strong and getting stronger. In this regard, alone, balanites might provide a new export for countries that, perhaps more than any on earth, need a source of foreign exchange. The trees are so common that Sudan alone could—at least in theory—produce 1,200 tons of diosgenin, which is enough to satisfy half the world’s demand.

All this untapped promise is what makes the fact that balanites is not better known and better developed so surprising. Of course, indigenous people appreciate it...their lives can depend on it. Scientists, though, have given it only scanty scrutiny, and national and international authorities have accorded it little organized support so far.⁵

As the world turns its gaze ever more intently on desert trees in a search for potential foods and sources of income, it will see in balanites ways to help address several of the most pressing humanitarian environmental problems for perhaps the most drought-afflicted area on earth. Balanites offers fruits, seeds, oil, and shade from the burning sun, but it also could help overcome desertification, avoid soil erosion, maybe thwart parasitic disease, and reduce the environmental destruction caused by livestock. Such possibilities are highlighted below.

PROSPECTS

A balanites tree is slow growing and its fruits are far from first class (when compared with the world's top fruits, that is), but its combination of benefits makes it one of the most promising friends to humanity in a vast region where no truly great fruit species can grow.

Within Africa

Although a very adaptable species, it is so little studied that the future is largely guesswork. The following, however, seem reasonable estimates.

Humid Areas Poor prospects. This thorny, irrepressible tree is a potential menace in well-watered regions, a zone that doesn't need it anyway.

Dry Areas Excellent prospects. Balanites has great untapped potential, even though it is already one of the most widely employed species in the vast droughty stretches of sand, stone, and savanna extending from Senegal to Somalia and from Sudan to southern Africa.

Upland Areas Unknown. Balanites is generally considered a lowland species. However, it occurs at altitudes up to 1,500 m in East Africa and 1,800 m in Konso, a region of Ethiopia where rainfall is under 650 mm and extremely erratic. In Algeria's Ahaggar—a region commonly described as “the navel of the Sahara”—it occurs at altitudes up to 1,800 m, with populations of around 30 trees per hectare.⁶

⁵ This is not to slight early pioneers who championed this species. These include French botanists such as A. Chevalier and A. Aubreville who worked in the Sahara during the 1930s. Also, a research team of the United Nations Industrial Development Organization (UNIDO) made special pleas for balanites development in Sudan in the 1980s.

⁶ Information from Brama Traoré.



Kanem, Burkina Faso. The small, deep-rooted, very spiny balanites tree tolerates heat, drought and blazing sunlight so well it thrives in the heart of the Sahel. The living trees provide shade from the burning sun, shelter from the hot winds, and blessed eye relief from the starkness of the desert. In times of famine, the flowers, leaves, and even bark provide sustenance. It would thus seem to make an ideal security shield for the food supply in an area where such hazards all too often decimate other food resources. Moreover, the seeds are so popular with animals that they underpin livestock production in dry places and in droughty seasons when animal husbandry operates on its outermost limits. (Laure Guerrini)

Beyond Africa

This plant is already widespread in the Arabian Peninsula, Iran, and much of South Asia. Here its prospects are as good as in the Sahara and Sahel. Beyond these Middle East and South Asian regions, however, this potentially invasive tree should not at present be introduced.

USES

As mentioned, balanites is a plant of many parts and many products. They include the following.

Fruits The ripe fruits are eaten raw or sun-dried and can be safely stored like dates. Some provenances are sweet, others bitter. People (and not only little ones) chew them as snacks. Commonly the sweet pulp is macerated in water to create a tonic, which is also fermented into forms that are more potent. The juice is also often mixed into porridges to liven up the flavor and add a touch of sweetness.

Seeds Today most of the seeds go unused, but in certain areas they are gathered in quantity. After soaking and sun drying, they can be safely stored for months. Subsequently, the kernels are extracted. Roasted, these balanites nuts have an enticing aroma and are typically added to soups and to the various cereal products that are enjoyed in Senegal, Nigeria, Chad, Uganda, and Sudan. The Shuwa in northeastern Nigeria, for example, commonly eat them this way. And to some Shari and Chad peoples these seeds are so important they are the foundation of everyday life.

Seed oil The seed's kernel can contain up to 60 percent of an almost tasteless oil. Sometimes called *zachon* or *betu* oil, it is highly prized especially in Sudan. The culinary properties are comparable to those of a quality vegetable oil. In a recent market survey, for instance, consumers rated it with cottonseed oil for flavor and cooking qualities.⁷

Resin When the bark is damaged, balls of resin form around the wound. The gummy exudate is soft, sweet, and pleasantly chewable—not unlike chewing gum. People deliberately slash the bark in a process reminiscent of inducing rubber from a rubber tree or gum Arabic from *Acacia senegal*. Collected from fresh wounds, the globs are full of fluid and pleasant to suck like sweets. Some are made into drinks; others used as glue.

Flowers This is one of the African plants whose flowers are widely eaten. In parts of West Africa boiled balanites flowers (called *dobagara*) are added to couscous, often at ceremonial meals. They are also eaten with *dawadawa*, a fermented cheeselike food prepared from locust beans (see companion volume on vegetables). The flowers provide important forage for honeybees. Children suck the nectar, too.

Leaves Young leaves are eaten, but only after thorough cooking (like spinach).⁸ Commonly, they are boiled and added to crushed peanut balls or to sauces or relishes. They are widely used in sauces in Burkina Faso, where the balanites is considered a dependable famine food.

Forage The leaves are also valued for feed, especially as they remain available deep into the dry season, when grasses and annuals have withered. All types of stock relish them, but cattle and sheep, repelled by balanites' spines, restrict themselves to the young shoots or suckers, which have tender spines, much protein, and relatively little fiber. The plant becomes especially important in times of drought, when animals have difficulty finding anything to eat. Indeed, seen in profile, the trees are usually jagged and lopsided from people hacking at them for feed. Locals are skilled at gathering the maximum foliage while stopping just short of killing the tree.⁹ Wildlife

⁷ A contributor from Sudan wrote to us, saying "I prefer it over cottonseed oil and consider it equal to [peanut] oil."

⁸ How widely this occurs is uncertain, but it has been reported at least from Niger, Burkina Faso, and Ethiopia.

⁹ Balanites leaves reportedly have high protein content. Goats and camels, unfazed by the thorns, browse young branches. Shepherds climb trees and pollard branches for their herds to feed upon, particularly during summer months. One contributor wrote: "In Konso (Ethiopia), balanites is one of the prominent fodder trees planted 'at random' in the fields for fodder, for soil erosion protection and for shade, as well as for the fruits." The combination of camels and this tasty, nutritious desert tree is particularly powerful.

devours the young leaves, fruits, and even the thorns. In particular, giraffes crop the top close.

Kernel Cake The seedcake left after the oil has been extracted from the kernels is nutritious enough to replace cottonseed cake in animal rations. This residue is promising as a locally produced “concentrate” for what are perhaps Africa’s driest and least accessible regions. It is high in protein (37 percent) and low in fiber (6 percent).¹⁰ It could prove economically important for much of Sahelian Africa.

Wood Even the unlopped tree is hardly shapely. It is short, and the often-crooked bole is seldom longer than 2.5 m. Despite this, heartwood is useful. It is attractive, easily worked, fine grained, durable, and resistant to insects, including termites.¹¹ It is made it into bowls, troughs, tool handles, walking sticks, gunstocks, cabinetry, plows, other farm implements, furniture, and mortars and pestles.¹² It is particularly sought for specific parts of camel and donkey saddles. And it is especially valued for fuel because it not only burns with little smoke but also yields charcoal of high energy content.

Shells Every ton of whole fruit yields half a ton of woody shells. These shells are hard, dense, and highly combustible. They make good fuel as well as good charcoal and particleboard.

Spines In West and East Africa people often pile the branches together to form thorny brushwood barriers. They also grow living fences by planting balanites root cuttings in a row. After a few years—if initially protected from camels, goats, and fire—this process forms a hedge strong enough and spiny enough to keep out most two-legged intruders, all cattle, and most goats (except the famous “climbing goats,” which are too clever by far). It is especially suitable for cattle kraals.

Extracts Extracts of fruit and bark, while harmless to mammals, kill the snails that schistosomes require as intermediary hosts. They also kill this much-feared parasite’s free-swimming life forms as well as the water flea that harbors guinea worm (dracunculiasis), a serious disease in West Africa.

¹⁰ O.A. El Khidir, A.Y. Gumaa, O.A.I. Fangali, and N.A. Badir. 1983. The use of *Balanites* kernel cake in a ration for fattening sheep. *Animal Feed Science & Technology* 9:301-306.

¹¹ Careful selection is important here because the sapwood is difficult to distinguish from the heartwood; many logs are mainly sapwood, which is very susceptible to damage by wood boring insects and fungi.

¹² In much of Africa mortars and pestles are still used for grinding seeds, dried flowers, and leaves—both for daily foods and for medicines.

Other Young branches, stripped of their spines, are used as toothpicks. The hard round seeds are used for rosary beads, necklaces, and playing-pieces for board games (such as *darra* and *warri*). Whole seed is sometimes burnt in a special partial-combustion container to produce a gooey black tar (*ghotran*), employed in treating mange, a skin disease notably affecting camels. In Ahaggar, Algeria, Touareg women have used the oily kernels to lighten their face and suppress black spots on their skin. Balanites is also a common hedgeplant, widely grown, for example, in the town of Tamanrasset, where many inhabitants plant it around their food plots.

NUTRITION

The fruit is bitter when green, but palatable when ripe. It perhaps should not be eaten in excess, as the saponins it contains in various proportions are laxative. Nonetheless, schoolchildren in parts of West Africa reportedly suck 15-20 balanites fruits a day seemingly without ill effect. Given such experiences down through centuries, the presence of toxicity seems unlikely, but uncertainty nevertheless remains.

Nutritional details are variable, but the pulp seems quite nourishing. Its carbohydrate (notably sugars) content ranges from 40 percent (fresh-picked) to 70 percent (fully dry). The dried pulp also contains about 5 percent protein and 0.1 percent fat. Vitamin and mineral contents have yet to be detailed but—as in most dense fruit pulps—are likely to be substantial.

As has been noted, the seed kernels are rich in oil. Amounts from 30 to 60 percent are recorded. This lipid consists largely of linoleic and oleic acids (about 30 percent and 25 percent respectively), and would be classified as unsaturated, the type most desirable in foods. Kernels and seedmeal are also rich in protein (above 25 percent). Apparently, it is only slightly inferior in amino-acid quality to peanut. The seed kernels of most plants generally provide good mineral content, and their oils often contain fat-soluble vitamins. In particular, the golden kernels of balanites probably contain notable levels of carotenoids; groups such as the Dinka who consume them regularly are reported to have low incidents of vitamin-A deficiency.¹³

Although the above analyses indicate a high nutritive value, just how good a food the kernels are remains in doubt. Sometimes they are steeped 3 to 4 days before being eaten, and whether this is necessary, precautionary, or reflective of just certain types is currently unknown. Seedmeal tested on rats showed no gross toxicity.

HORTICULTURE

Whereas the species is basically uncultivated, individual trees have been planted for centuries and in recent times tiny plantations have been

¹³ Information from C. Gullick.



Southern Sudan. During all of the years humans have been in Africa, they have been eating balanites' date-sized fruits. Kernels are for supplementary food, famine food, or even the staple food. They are also useful for producing industrial products. (Caroline Gullick)

established in Niger, Chad, and northern Nigeria. From this it is known that balanites is easily established by direct seeding. Seeds are readily available, although they are prone to insect borers which greatly reduce the viability. Those seeds that have passed through goats or camels germinate and sprout readily, and are easily found in places where animals are kept overnight. In a perhaps better way to ensure germination fresh seeds can be placed in water, boiled a few minutes, cooled, and left to soak overnight. An alternative is manual scarification followed by 24 hours of soaking.¹⁴ In addition, wild seedlings can be dug up and transplanted into a plantation setting.

Vegetative propagation is straightforward. As mentioned, root cuttings are used to form hedges. The roots readily form suckers, which are cut off, rooted, and planted. They strike readily. Vegetative reproduction can also be performed using stem cuttings. This ease of cloning makes the species ideal for propagating elite specimens.

The tree grows slowly at first, leaving it vulnerable to grass fires, grazing animals, and weed competition (in fertile soils) for at least 3 years. Once past the establishment phase, however, plants need no protection. They show

¹⁴ A contributor reports successful direct seeding without supplementary irrigation in a severe region of the northern Sahel, where total rainfall was 172 mm. Seeds were removed from their shells, soaked for 12 hours in 30°C water, and sown at 3 cm depth (twice the diameter) after the rains had properly started. There were 500 to 2,500 seeds per kilogram. Information from Eden Foundation.

excellent persistence and appear immune to almost all natural injuries. Some hedges in the Sahara are believed to have survived at least a century.

Management is not an imperative, but in dry areas pruning helps the trees survive drought. The trees coppice readily, and bounce back without lasting damage even after heavy pruning.

Seedlings mature relatively slowly. The first fruit yields can be expected in 5-8 years, depending on plant and on location. Once fruiting begins, however, the tree can go on producing annually for at least 75 of its 100-year lifespan. And for all those decades it can be extremely productive (an average yield is said to be 125 kg of ripe fruit per tree).

HARVESTING AND HANDLING

The fruits are usually harvested from the ground. Like true dates, they store well in dried form, and are often put aside for use during the hungry season. However, they do not keep as well as dates and those destined for longtime storage must be gathered before they ripen.

Compared to the fruits, the seeds store much better—up to a year if they are clean, dry, and protected from insects. The kernels are subsequently extracted by cracking the seeds open by hand or by boiling them in water until the shell bursts apart. Next, a bitter principle in the kernel must be eliminated. This is usually done by cooking the kernels twice and then either steeping them 3-4 days or leaching them with hot water (60°C) for 2 days. As noted earlier, the debittered kernels are tasty and can be roasted like peanuts, used in sweets, or ground into the paste like peanut butter.

LIMITATIONS

Uncertainties and qualifying factors are to be expected with what is basically an undomesticated species. As to the plant itself, there are problems of slow and erratic growth, irregular fruiting, sharp thorns, frost sensitivity, susceptibility to browsing, and damage by certain insects. As to the seed and fruit, there can be difficulties with insects and rodents unless care is taken. In farm fields the trees may compete with nearby crops for moisture in the root-zone. However, this depends on the local conditions, and on pastureland balanites reportedly makes a good companion crop.

A principal obstacle to the fruit's commercial exploitation has been the difficulty of obtaining adequate and regular supplies.

There are technical difficulties too. One is removing the sticky skin on a large commercial scale. Another is the woody shell that limits industrial utilization of the seed. Although machines for separating this hard covering from the kernel have been described, they all tend to crush the seed. As of yet, no one has invented a machine to extract the kernels whole and undamaged via mechanical means—a major constraint to developing food products from this nut in quantity.

Balanites is not recommended for planting outside its native habitat. After reaching Curaçao in 1885, for example, it infested that dry Caribbean island. Goats favor the fruits and are the major disperser of its seeds.

NEXT STEPS

With a plant of such diversity, dispersion, and usefulness the task of presenting a comprehensive picture of its developmental needs is daunting. Below are a few possibilities.

Making Use of the Existing Resource A 1979 survey found trees in the Sudan yield more than 400,000 tons of fruits per year. The one million trees in Blue Nile Province produce at least an estimated 100,000 tons. Of those, only about 2 percent reached any marketplace in that barren and sparsely populated area where transport and communications are difficult. The rest go to wildlife or rot. In such places more needs to be done to help local people, most of whom live in poverty, take better advantage of the potential in their midst. This is true in countries from Mauritania to India.

Food-Security Activities This reliable, resilient, and beneficial species could be a powerful weapon in projects to make life more secure in locations that too often need food relief due to drought. Tests, trials, and support for balanites plantings and development in places such as the starvation-plagued Ogaden and Konso regions are encouraged. When drought arrives, these may save much hunger, if not many lives.

Stopping Desert Creep Contrary to popular impressions of a few years back, the Sahara is not marching relentlessly on its way to the ocean, but the movement of sand dunes and degradation of land are nonetheless serious problems. Indeed, desertification threatens to demolish roads, tracks, railways, waterways, towns, farms, villages, and dams—all of which are being denuded of vegetation, due to drought and overuse, and are being left vulnerable to the irrepressible Sahara sands.

To combat the advance of the sand, officials and laypersons alike have initiated many measures—mechanical, chemical, and biological. Tree planting, however, remains the most popular and practical. Over the entire Sahelian region small farmers are planting trees to keep their land from turning to desert. Eucalyptus and neem are perhaps most popular, but of all the trees tried so far, balanites is among the most effective. It is one of the very few that can survive on dunes in locations where annual rainfall is as low as 100 mm. Moreover, the locals particularly favor it for its wood, fruit, fuel, forage, and its medicinal value.

This tree thus could have a civil benefit of great importance even if its products never become widely exploited. It could end up protecting the vital infrastructures of a dozen countries.

International Cooperation As this crop is as at home in Arabia and India as it is in Africa, there are possibilities for joint and parallel research activities in developing balanites. The value to the Empty Quarter of Yemen and Saudi Arabia and the Thar Desert of India are perhaps as great as to the Sahara sands. Indeed, in India (where the species has long been called *Balanites roxburghii*) the fruits are often much larger than in Africa. Through grafting or cross-pollination the Indian plants offer a possible key to rapidly improving the production of balanites fruits in Africa and the Middle East. Cooperative research, testing, DNA analyses, and much more are well worth fostering.

New Plantings Although existing natural stands are extensive and may be useful for industrial purposes, the greatest commercial hope lies in organized plantings of select, superior material. Indeed, balanites shows such promise as a resource that immediate plantation trials are highly recommended. In areas where it is already known, efforts need not be delayed by extensive quests for the ideal plant to clone. It should be noted that in the wild the species grows as scattered trees and perhaps may not be amenable to plantation-style production, especially in extremely arid locations. However, there is every expectation that it will adapt well.

Horticultural Development There are no detailed studies regarding optimum cultivation methods, hence there is much scope for improving yields. For example, studies into seed viability, optimum planting times, spacing distances, soil fertility and watering could all lead to improvements. There is also little understanding of pollination and fruit set, or knowledge of pests and diseases and their effects on yield. Thus it would be prudent to investigate issues such as vegetative propagation, pruning regimes for maximum fruit set, spacing, water use, and micro-site enrichment. In these and other research activities, local insights could well prove invaluable.

Genetic Selection A species as variable as this holds much scope for improvement by selection. The tree is so widely distributed across Africa and Asia it seems likely that many different ecotypes, if not subspecies, already exist. It is likely that some with large and sweet fruits, fast growth, high yields, small thorns, or perhaps no thorns are just waiting to be discovered by the observant traveler.

Toxicological Testing Despite the fact that it has been eaten for years, more toxicological testing is necessary before balanites can be wholeheartedly recommended as a major food source. It seems likely that the traditional methods for preparing it rely on leaching out the soapy ingredients. While unpleasant to eat, these saponins are not toxic.



Thou Market, southern Sudan. Across the Sahel, women generate income from balanites seeds, which are about half oil and a third protein. After processing at home, they can be turned into many tasty items, including roasted snacks and a spread not unlike peanut butter. They also supply a vegetable oil that is a prized ingredient in foods as well as in local cosmetics. (Caroline Gullick)

Industrial Development The plant's several products with industrial potential need and deserve further development. These include diosgenin, oil, and various fermentation products. The same can be said for its byproducts (such as protein-rich feeds), which may end up becoming vital resources for many of the world's most needy nations.

Cracking the Nuts As noted, the principle obstacle to extensive commercial exploitation has been the lack of suitable machines for removing the sticky pericarp and for decorticating the nuts. A research breakthrough could transform the potential of this species.

Non-food Uses Just how good the various balanites products are as medicinals, pest-control agents, skin treatments, animal feeds, and chewsticks for teeth cleaning have yet to be solidly determined. Tests should be run. These would make interesting research projects because the tree grows where few or no other sources for such products exist.

Public Health In areas beset by schistosomiasis or guinea worm, planting balanites along the edges of irrigation canals, around water holes, and along the banks of rivers could be tested. Fruits are lethal to the infective stages of these serious disease organisms. However, there is uncertainty over the practicality of such uses because a strong emulsion of the fruits can be toxic to fish. Even if this proves unworkable in natural waterways, it may work in wells and troughs and other constructed water supplies. The fruit's ingredients are not toxic to humans or domestic animals.

SPECIES INFORMATION

Botanical Name *Balanites aegyptiaca* (L.) Del.

Family Zygophyllaceae (Balanitaceae)

Synonyms *Balanites roxburghii* Planch., *Agialida barteri*, *Agialida larteri* van Tiegh., *Agialida senegalensis* van Tiegh., *Agialida tombuctensis* van Tiegh., *Balanites ziziphoides* Mildbr. et Schlechter, *Ximenia aegyptiaca* L.

Common Names

Arabic: heglig laloab, lalob (fruit)

Bambara: seguene, zegene, ségé né,

English: desert date (ripe), Egyptian myrobalan (unripe), torchwood, Jericho balsam

Ethiopia: ghossa, dyemo, shifaraoul (Amharic), bedena (G), hangalta (K), maghe, mogha (T)

French: dattier du désert, myrobalan d'Égypte, savonnier

Gourmanché: bangbaalu

Nigeria: aduwa (Hausa)

India: ingudi-vraksha (Sanskrit), hingol (Hindi, Bengali)

Kenya: mnyra, njienja, mjunju (Swahili), eroronyit (Turkana), olongosw/u, ol-ngoswa (Maasai), mulului (Ka), otho, sadhto (Luo), baddan (Bor), segene (Bama), tunywo (Pok)

Moré: kielege, kielega

Nepal: cheure (Nepalese)

Senegal: sump (Wolof)

Somalia: ader, goot, kiti, kulan, kullen (Somali)

South Africa: umHulu, umgobandlovu (Zulu)

Sri Lanka: ingudi

Sudan: heglig, heglieg (Arabic), laloub (lalobe), korak, tira, kuri (Nuba)

Uganda: ekorete, ecomai (Ts), too, to (Ach), lugba (Bar), thoo (A),
logba, lugba (Md), lubwoti (Rl)

Zambia: kasalusalu, mfwankomo, mklete, mkumudwe, msalu, pulupulu
(Ny)

Zimbabwe: nyachoko, muvambangoma (C), muongo (To), nulu (H)

Algeria: teboraq, teboragh, tborag (Tamahâq)

Senoufo: sancere logolo

Mauritania: taïchot (Arabic), murtoki (Poular)

Description

Balanites is a shrub or, more usually, a small tree 3 to 6 m, rarely 10 m tall, with a furrowed stem up to 45 cm in diameter. It is long-lived, and may exceed 100 years. Bark is scaly, deeply fissured, and gray or dark brown. The fissures, which run vertically, reveal the yellowish younger bark beneath. Its stems are intricately branched and the canopy more or less spherical. The slender drooping branchlets bear long green spines and gray-green leaves made up of two leaflets. The trees are either evergreen or wholly or partially deciduous. There is also a narrowly branched taproot, which may penetrate several meters to reach the watertable. On inland dunes in Senegal, lateral roots were dug up and found to extend out nearly 30 m.

The flowers are hermaphroditic and self-compatible, though pollination is usually by other flowers on the tree or out-crossing with other plants. Pollinators are primarily bees, ants, and flies, as well as beetles and the wind. The fruit is a plum-like drupe. Green at first, it turns yellow-red as it ripens. The skin is thin, loose, sometimes wrinkled and leathery, becoming parched when ripe. It is easily removed. The inside parts are composed of a soft, edible pulp surrounding a woody stone. The stone constitutes about half the weight of the whole fruit—the skin and sugary pulp together make up a third, and the seed at the center 15 percent.

Distribution

The species is indigenous to woodlands along the Sahara's southern border from the Atlantic to the Red Sea. It is often commonplace on the savannas across that area. Individual trees have been planted extensively in villages far to the south of its natural range. In eastern Africa, it is found as far south as Natal.

It is also found in Southwest and South Asia. As noted, it was introduced to the Caribbean more than a century ago, and on Curaçao has overrun part of the dry eastern end of the island. It is also growing in Puerto Rico and probably other Caribbean islands.

Horticultural Varieties

None reported.

Environmental Requirements

Balanites is typically found in ecosystems from deciduous bushlands to savanna woodland thickets to open desert, where it occurs mostly in and alongside wadis. The trees themselves occur scattered or as pure stands, the latter possibly being due to human intervention. Owing to their value, balanites are often left to live when all else is felled.

Rainfall The species' precipitation range is 100 to 1,400 mm, but the most trees occur where rainfall is between 250 and 800 mm. In the driest areas, they occur only where the roots can reach groundwater.

Altitude The tree is found from 380 m below sea level (in the Jordan Valley) to 1,800 m above sea level in Ethiopia and Algeria.

Low Temperature It is frost sensitive.

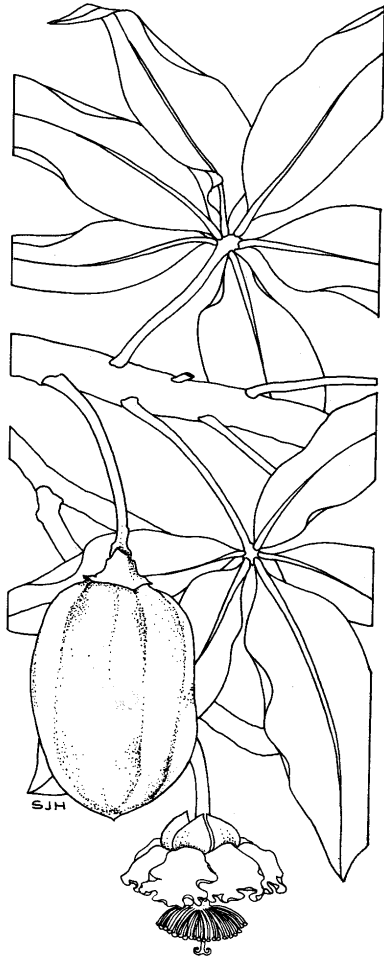
High Temperature Easily withstands temperatures that soar into the upper 40s day after day.

Soil Balanites trees can be found on a great variety of soils: sands, clay, cracking clay, alluvial soils, and gravel, for instance. However, it clearly prefers clay, and when it is found on pure sand there is usually an underlying layer of clay. Although the plant readily survives periodic inundation, it does not tolerate prolonged waterlogging.

Related Species

Africa contains several other *Balanites* species. Although none seems to offer promise as a fruit crop each is an interesting plant in its own right and is worth some horticultural attention. They typically provide fodder for goats, cattle and sheep, and occasionally camels. But along with the balanites, they could perhaps prove useful in food-security interventions.





2

BAOBAB

Across much of Africa the baobab (*Adansonia digitata*) is a common sight. Wherever it grows people rely on it for food. Some count this tree's leaves among their most valued vegetables. Others consider its fruits the finer food. And all rely on baobab seed for sustenance during famine times.

This strange tree also provides drink. At the height of the rainy season, villagers commonly prize open a hole in the bark and fill the hollow interior with water (usually from a ditch dug at its base). During the subsequent dry months that tank-in-a-trunk becomes so valuable it is sometimes guarded day and night against parched passersby.¹

Food and drink are just two of the baobab's blessings. Others include shade, medicines, rope, and various raw materials that make everyday living possible. All in all, it can be said, and with a large measure of truth, that baobab is Africa's Tree of Life.

Probably the most distinctive plant of them all, baobab is unforgettable. The trunk often appears so grotesquely swollen as to suggest a giant brandy bottle. The crooked branches, affixed to the "cork," look like squirming roots shooting skywards. That image is so immediately apparent that baobab is often called the "upside-down tree."

Few plants engender so much respect. Millions believe each tree receives divine power through those "roots" reaching toward heaven. Out of both regard and gratitude people maintain baobab near their houses. Indeed, baobab often seems like some vegetative pet that moves in wherever it finds a friendly family (which in a way it does—sprouting from seeds thrown out in household food wastes). Most baobab trees are individually owned or at least individually claimed for a season² and many are passed down the generations like some valuable piece of property. A baobab commonly becomes part of the family, and its death proves as painful as that of a beloved friend.

¹ On the other hand, in Mali and Burkina Faso it is common to see large clay jugs (*canaries*) carefully placed in the hollow of a baobab tree and kept full of water for the use of thirsty travelers.

² Many are claimed by "squatters" who—partly to increase productivity, but mainly to secure their claim to the tree for the coming season—are the first to prune back branches.



Few trees on earth engender respect like baobab. Millions believe it receives divine power through the branches that look like arms stretching toward heaven. The baobab is entrenched in the folklore of much of Africa. This is partly because of its singular appearance but also because of the cures and the foods it provides. (Jerry Wright)

This chapter deals specifically with the tree's fruits, which are as unique as the tree itself.³ Sometimes reaching the size of melons, they have a furry coating and a tough, gourdlike shell. Cut one across and you expose an arrangement something like an orange, with angular packets of soft pulp surrounding a cluster of seeds.⁴ There, however, the similarity stops. Baobab fruit is the very antithesis of an orange: its pulp is dry when fully ripe. Often white, but also yellowish or pinkish in color, this so-called monkey bread is a mealy solid resembling something from a cereal. Indeed, a few hours in the sun easily converts it into a free-flowing flour.

Nutritionally speaking, this strange chalky fruit-powder is like nature's own fortified food. The label on a commercially packaged version now sold across Europe,⁵ records that 100 g of it provides protein (5 g), carbohydrate (30 g), energy (130 calories), and fiber. In terms of daily nutritional needs,

³ The leaves, which are perhaps the main baobab food Africawide, are dealt with in the companion volume on vegetables.

⁴ From this, at least according to one explanation, derives the Arabic name *bu hibab* (fruit with a lot of seeds) and from that in turn comes the English name *baobab*.

⁵ Baobab Fruit Company (www.baobabfruitco.com).

that same 100 g of dried baobab fruit pulp also supplies 25 percent of provitamin A, 500 percent vitamin C, 34 percent thiamine (B1), 17 percent riboflavin (B2), and 106 percent vitamin B6. As to mineral requirements, it provides 33 percent of the calcium, 26 percent of the phosphorus, and 50 percent of the iron needed each day.

Considering that this is an unaltered, natural product from the heart of malnourished Africa, those are certainly thought-provoking figures. Moreover its protein has a spectacular amino-acid profile, including surprising quantities of such essential nutritional rarities as lysine (15g per 100g of the protein), methionine (5g), cystine (11g), and tryptophan (1.5g). Is it any wonder, then, that Europeans searching for good health are buying baobab fruit flour?

With a gingerbread flavor enlivened by a high but not unpleasant level of acidity,⁶ monkey bread is not for every sweet tooth. However, it is notably refreshing, a feature especially appreciated in the desiccating climates where the tree occurs. Most commonly this soluble powder is stirred into warm water or milk to create a beverage. Each day in West Africa—Senegal, Gambia, and Burkina Faso, for instance—fruits are hauled into cities by the truckload for sale in the central markets and for eventual conversion into this refreshing thirst-quencher. Despite being a sort of poor-person's soda, the drink is important in upscale commerce. One sees it on display, for instance, in supermarkets in countries as far apart as Kenya and Mali.⁷

Proudly displayed there too are baobab sweets. The fruit's pulp is often boiled in sugar and brightened with food coloring to form candies. Children commonly peddle these among themselves; many a budding entrepreneur began her career in commerce selling baobab treats for pocket money.

And sweets and drinks are just two of the fruit's uses. The tart-tasting pulp helps to season the taste of bland foods. West African pastoralists—the Fulanis, for example—use it to acidify a yogurt-like material that is a major food. Known as *nono*, this yogurt/baobab combination is said to relax the nerves after a hard day tending the flock or the field. Millions consider this pick-me-up a necessary part of getting through the afternoons.

Perhaps the fruit's most vital use, however, is to provide food security to those who cannot buy their way out of hunger. For this purpose, the pulp is beaten into thin pancakes, which on exposure to the sun turn into dry disks. Despite a disconcerting appearance, these leathery circlets have an immense importance because they can be stacked up like dinner plates and stored away for months or even years. Poor people in a dozen countries rely on this shelf-stable reserve for sustenance during droughts or other disasters when neither gardens nor markets yield enough. Then, the brown baobab fruit-

⁶ This is due to the vitamin C level, which is widely touted as being at least 10-times that of orange.

⁷ More commonly, however, the pulp powder is sold rather than the drink itself.

leather is normally boiled up to create a tasty fruity food whose nutritional balance serves to keep the scales of life and death from tipping beyond hope.

And this fruit holds yet more eatables. Embedded in the pulp packets are the clusters of seeds, whose kernels taste like almonds and are rich in both protein and food energy. Although difficult to get at, owing to the seed's thick shell, the kernels are valued foods—consumed fresh, fermented,⁸ or roasted like peanuts. In each case the resulting products are typically boiled into a thin gruel with sorghum or pearl millet and drunk like chicken broth or barley water. With their protein, calories, and micronutrients, they add notable nourishment to the daily diet.

Considering that it is perhaps Africa's best-loved tree, baobab is surprisingly neglected by development programs. Until recently, the species was excluded from almost anything dealing with reforestation, agriculture, nutrition, or rural-poverty. Such neglect was not without reason. For one thing, the sight of the bulging trunk and spongy wood makes old-line foresters shudder. For another, the tree is reputedly difficult to grow; the seedlings being both slow to establish and vulnerable to herbivores. And for a third, local people sometimes resist planting baobabs, which they perceive as being "backward" or, worse, possibly attracting bad spirits.⁹

Nonetheless, in many villages young baobab trees are these days often transplanted to a convenient location and then carefully protected from roaming animals. And today the species is finally being included in at least some rural-development programs. Several Sahelian nations are formally producing the seedlings in nurseries and planting them in villages.¹⁰ Although these enterprises are tiny in the context of the overall food needs, most people, including even timber-minded foresters, are at last coming to recognize this tree's potential.

This is clearly a beneficial change in outlook. Nevertheless, the species has far greater promise than is presently recognized. Possibly, there is no better long-term answer more basic or more beneficial to meager rural lives than this ancient food resource. The tree may be tricky to plant, slow to mature, and susceptible to grazing, but once established it becomes nearly

⁸ This is done especially in parts of West Africa, where baobab seeds are often handled like those from locust trees, whose seeds are turned into the famous cheesy fermented solid known as *dawadawa* (see companion volume on vegetables).

⁹ Owing to ancient traditions, there are some localized taboos against planting the tree.

¹⁰ Niger in particular seems to have taken up the cause. Several contributors from there have pointed this out. "We have raised, planted and distributed baobab since 1965," wrote one. "In several of our village forestry efforts, people asked for baobab along with the other trees," wrote another. "In Gaya, we have planted baobabs since the early 1970s," wrote a third. Clearly the interest in planting baobab is spreading: "In recent trips through Mali and Burkina Faso, I saw a surprising number of young baobab in small kitchen gardens adjoining family homesteads," wrote yet a fourth.

indestructible.¹¹ The trunk holds water like a sponge, and it resists drought as well as the dry-season grassfires afflicting the savannas each summer. And a low center of gravity combined with widely spreading roots help mature trees withstand the wrath of storms. Once past its juvenile susceptibilities, a baobab can provide its multifarious benefits for generations to come. The Chinese say that, “it is a wise man whose grandfather planted trees,” but to plant a baobab is to touch not just the grandchildren but history itself.

PROSPECTS

Baobab can contribute uniquely to Africans—and especially to the rural poor. Through selecting, propagating, planting, and creating more production as well as through better organizing the mass-markets and processing the fruit on an industrial scale, there is potential for reducing hunger and rural poverty in some of the earth’s most difficult-to-feed locations. There is also great promise for establishing “life-insurance plantings” that provide essentially permanent food security for a village, a valley, or a vast region. There is even the possibility of generating worldwide exports in baobab fruit pulp, thereby introducing this ancient food to all mankind. Given concerted action now, the prospects of all these occurring within the next 20 years seem high.¹²

Within Africa

Humid Areas Uncertain prospects. As a rainforest resource, this dryland tree seems hardly promising. However, one report notes that specimens receiving up to 1,250 mm annual rainfall grew almost twice as fast as those planted at the same time in nearby dry areas. Also, notable are the baobabs growing with vigor in humid forests along the Kenyan coast, where rainfall ranges from 1,500 to 2,000 mm.¹³ In Mozambique the tree thrives in swamp forests, although there it turns tall and slender, making it appear embarrassingly svelte.

¹¹ This longevity is not guaranteed in the presence of elephants, which dote on the fruits and bark and sometimes shred the trunks to access the water inside. This is a problem only in southern and eastern Africa. Elsewhere, there are no elephants.

¹² A monograph on the tree, and its potential, is available online via www.icuc-iwmi.org: Sidibe, M. and J.T. Williams. 2002. *Baobab* (*Adansonia digitata L.*). Fruits for the Future 4. International Centre for Underutilised Crops, Southampton, UK.

¹³ These trees produce pinkish colored fruits twice the size of those produced in the hinterland. The leaves are larger, too.



Baobab fruits sometimes attain the size of melons, with their tough shells enclosing angular packets of a strange pulp that is nearly solid. Indeed, a few hours in the sun dries the sticky semisolid into a free-flowing, soluble powder that has a gingerbread flavor as well as a pleasant acid bite. It is nutritious enough to be stirred into warm water or milk to create a health drink. The fruit also contains nuts that taste like almonds. Although difficult to get at (owing to the thick shell) the nuts are valued foodstuffs, eaten fresh, fermented, or roasted like peanuts. They are rich in both food energy and quality protein. (Kazuo Yamasaki)

Dry Areas Excellent prospects. The baobab occurs mainly in savannas. It is not only the biggest tree in the Sahel but arguably the most beloved. Some people have even dubbed it “Mother of the Sahel.”

Upland Areas Unknown prospects. The baobab normally occurs below 600 m elevation, but it seems likely that—within the species’ outermost temperature- and rainfall tolerances—altitude may be no limit.

Beyond Africa

Although it grows satisfactorily in lands beyond Africa (most famously northern Australia), baobab seems unlikely to become a significant resource in locations where it is now unemployed.

USES

A species like this is certainly hard to categorize in a few sentences. Its more than 30 different products and uses include the following.

Fruits The chalky solid from the gourdlike fruits is consumed in many different ways, however by far the greatest amount is eaten with porridge and/or milk. When employed as part of a hot dish the powdery pulp is often stirred in after the final stage of cooking, thereby preserving the vitamins. In some places, people merely break off a piece of the fruit's outer shell, add water, stir the contents, pour out the resulting solution, and boil it into a tasty and nutritious beverage. The pulp is so acidic it can substitute for baking powder or cream of tartar—in curdling milk, for example. It is also used to make glue for paper.

Seeds The kernels are eaten raw and, as noted earlier, are also fermented and roasted. In each case they are typically boiled with cereal grains to form a thick porridge, thin gruel, or watery drink. During food emergencies these kernels (like the surrounding pulp) become a life-saving staple, both because they store well and because they are exceptionally rich in protein, food energy, and micronutrients.

Flowers Although pollinated by fruit bats, the flowers are also a favorite nectar source for bees.

Leaves Fresh baobab leaves provide an edible vegetable similar to spinach. Today, this is the tree's most important food use. In the companion volume on African vegetables we have devoted a whole chapter to this use.

Trunks By nature, baobab is a trunk-succulent, meaning that its wood typically remains damp. As already noted, people in the drier parts of Africa employ their baobabs as water reservoirs. The trunk may be naturally hollow, but more often the inner tissues are deliberately scooped out. The space within can be huge: As much as 10,000 liters of water has been stored in a single stem. Baobab trunks are also occasionally used for dwellings, storage sheds, bus stops, bars, dairies, toilets, watchtowers, grain stores, shelters, stables, or even tombs.

Roots A red dye can be extracted from the roots.

Environmental Relief Baobabs are sometimes planted for shade, shelter, boundary-markers, or landscaping purposes. In the desiccated center of Mali, where the scenery is unrelieved by any notable permanent feature, they also serve as formal reference points (individual trees are marked, for instance, on the Institut Geographique's National 1:200,000 maps). In the

season when the rains are expected the trees are eagerly watched, because Africa's farmers understand that the greening of the baobab means planting time is at hand.

Fiber In the full-grown tree, the bark is 10-15 cm thick, and the inner portion is composed of tough longitudinal fibers that are so flexible, strong, and durable that even in the era of nylon and steel they are used to make rope, clothing, fishing nets, rugs, mats, baskets, thread, and musical-instrument strings—not to mention paper tough enough for banknotes. The fibers can be woven into coarse fabrics, some of which are waterproof. Senegalese weavers, for example, produce rain hats and even drinking vessels out of them. In addition, the fibers are notable for making supple and extremely strong bags. Many a harvest moves from field to village and then on to market in a baobab bag. Although other tree species die when their bark is stripped off, baobabs not only survive, but quickly regenerate it.

Wood As a timber, the soft and spongy wood quickly succumbs to rot. It is, in fact, spread over fields as mulch. Nonetheless, in Madagascar it is used to thatch roofs.

Fuel The hard bark, the fibrous fruit husks, and the dense shells of the seeds all burn well. Even the corky trunk matter makes an excellent fuel when dried. It is used, for example, for baking large clay pots.

Medicinals Regarding baobab's therapeutic values there are many claims. The bark is widely used for treating chest complaints. Root extracts are applied against skin sores. The leaves are prescribed for stomach and lower-back pain, for kidney and bladder disease, for asthma, insect bites, and more. And the fruit pulp is said to be especially useful for treating diarrhea, something that—given its mineral content and food energy—seems likely to be perfectly valid.

Other Senegalese horticulturists recently learned to bonsai the tree. The miniature, fat-bellied, squirmy-branched baobabs thus created might well prove popular as eye-catching novelties, even worldwide.

NUTRITION

As noted, this fruit is no succulent tropical delight. The raw pulp is about 90 percent dry matter, the exact reverse of expectations in a fruit. That dry matter is nutritionally not unlike that of a cereal or a rootcrop such as potato, comprising: about 80% carbohydrate, 10% fiber, 5% crude protein, and 0.2% fats. In samples from separate trees and locations the food-energy

levels have ranged from 200 to 350 calories per 100 g of dry weight.¹⁴ Given the near absence of fat, this energy must come mostly from carbohydrate, which is said to be rich in pectin and to also include glucose, other sugars, and mucilaginous matter.

As already highlighted, the protein itself has a remarkable nutritional quality. Further, that protein occurs in a surprising amount for a fruit—as much as 5 percent has been measured—and it seems to have a high digestibility in the bargain.

It is the levels of vitamins that distinguish this fruit flour from, say, wheat flour. The fruit pulp, as we have said, is remarkably high in vitamin C content. Individual trees with vitamin C content up to 500 mg per 100g have been found. The “norm,” however, is around 200 mg per 100g of pulp (or twice the amount in concentrated orange juice).¹⁵

The pulp is also rich in several of the B vitamins. Moreover, it apparently contains both free tartaric acid and its potassium salt. Indeed, several minerals have been measured in high levels, including (per 100g) phosphorus (100-200 mg), calcium (300 mg) and iron (7 mg).¹⁶ These are all exceptional figures also.

The seed kernels represent a second, separate source of nutrients. Proximate analyses (dry-weight basis) indicate they can be up to a third crude protein and a third fat, with nearly 10 percent crude fiber.¹⁷ The “baobab nut” thus contains more protein than peanuts and its protein appears rich in lysine, methionine, cysteine, and tryptophan. Moreover, some kernels can contain more oil than soybeans, and that oil provides a fairly good measure of unsaturation; nearly 90 percent of the oil is oleic, palmitic, and linoleic acid in almost equal parts.¹⁸

HORTICULTURE

Unless pretreated, seeds can take a year to germinate. Commonly, they are dunked in boiling water, usually for less than a minute but sometimes longer. Some, however, are scarified or carefully pierced (to let water in) and then soaked overnight. Sulfuric acid treatments may be most effective.

¹⁴ Respectively, Baobab Fruit Company (baobabfruitco.com), and Saka, J.D.K. and J.D. Msonthi. 1994. Nutritional value of edible fruits of indigenous wild trees in Malawi. *Forest Ecology and Management* 64:245-248.

¹⁵ Information from J. Scheuring.

¹⁶ Saka and Msonthi, 1994, op. cit., and Eromosele, I.C., C.O. Eromosele, and M. Kuzhkuzha. 1991. Evaluation of mineral elements and ascorbic acid contents in fruits of some wild plants. *Plant Foods for Human Nutrition* 41:151-154.

¹⁷ Arnold, T.H., M.J. Well, and A.S. Wehmeyer. 1985. Koisan food plants: taxa with potential for economic exploitation. Pp. 69-86 in Wickens, G.E., J.R. Goodin, and D.V. Field, eds., *Plants for Arid Lands*. Allen and Unwin, London.

¹⁸ Booth F.E.M. and G.E. Wickens. 1988. Non-timber uses of selected arid zone trees and shrubs in Africa. *FAO Conservation Guide 19*. FAO, Rome.

Once treated, most seeds germinate within three weeks.

Horticultural handling methods are essentially unreported, but bare-root seedlings have been transplanted from nurseries with reasonable results. In addition, saplings more than a meter tall have been root-balled and transplanted to the field. The species is hardly known for speedy growth, but on favorable sites its seedlings have reached 2 m in height in 2 years and 12 m in 15 years. This is far above the norm, however, given that few baobabs are planted in favorable sites.

No serious pests or major diseases are known. Young trees are susceptible to both wildfires and browsing by roaming herbivores (wild *and* domestic), but once their middle-age spread begins showing only elephants, lightning, or exceptional cyclones affect them.

Severe pruning is sometimes used to maintain canopy size. Within reason, this does no particular harm, and in fact it probably stimulates greater leaf growth. However, annual pruning naturally does reduce the tree's potential for fruit formation.

HARVESTING AND HANDLING

Villagers often punch foot-holes into the smooth trunk for easy access to the fruits above. Most, though, knock the fruits off from the ground using long poles. The fruits themselves are unusual in that they remain dangling during the dry season long after the tree sheds its leaves. They are also unusual in remaining edible far past the point where other fruits would have decayed into putrefaction. Stored under normal ambient conditions, they keep for up to 3 months, a feature especially important for hungry regions because they are still edible at times when other sustenance is hard to secure. The impervious rind and the dryness of the pulp are probably the major features behind this life-saving resistance to rot.

Typically, however, the pulp is extracted and ground into powder within three months of the harvest. The sifted powder is often marketed in 100g quantities and sold in wrapped plastic bags. The dried pulp powder can be stored for long periods with little loss of vitamin C.¹⁹

LIMITATIONS

The living baobab is not always a farmer's friend. For one thing, it occupies a lot of room and throws a lot of shade. For another, its spreading shallow roots compete with nearby crops for nutrients and water.²⁰ And it is an alternative (but relatively insignificant) host of insects that attack cotton.

Although under ideal conditions the plant may be no laggard, slow

¹⁹ Information from J. Scheuring.

²⁰ Perhaps for this reason, the areas around a baobab are often patchy or bare of vegetation. However, the bareness may also be due to shade as well as to the inevitable trampling by people and animals enjoying the shade.

growth is the rule rather than the exception. It matures late, too: Trees raised from seedlings take 8-10 years before commencing to fruit and about 30 years before achieving full abundance.

Sadly, many baobabs are now killed by acts of mindless inadvertence. Saplings have slim stems and their own leaf form, so that few people recognize them for what they are. And, going unrecognized, they fall to the common fate of “open access resources”: indifference. Groundfires, goats, gazelles, and galoots stripping off too many leaves destroy the majority of baby baobabs. The absence of protection is a major constraint to the species’ further development.

In some areas cultural values get in the way. Baobabs are subject to many taboos. In the Gambia, for instance, they are considered evil and villagers resist planting them. In addition, many people refuse (purely on principle) to plant any tree that regenerates itself spontaneously.

NEXT STEPS

This single species gets to the heart of so many vital African needs that the time has come to move ahead with vigor. Such a widespread people’s resource is worthy of pan-African cooperation in programs dealing with food, nutrition, agriculture, forestry, agroforestry, horticulture, rural development, home economics, and more.

Baobab is already so useful that background research is not essential to progress. More pressing is the need to employ the knowledge and germplasm already on hand to mount planting, protection, and development programs that combine traditional knowledge with modern scientific understandings. These can be big or little, concentrated or dispersed, rural or suburban. The mass-markets, including those processing the fruit on an industrial scale, also need organizing. Progress may not be quick or easy—given the lack of precedent and the tree’s slow growth—but around baobab plantings whole rural-uplift programs can be built. In that regard, baobab is relevant to operations dealing with:

Rural Poverty In the purely commercial sense, the tree is a prime candidate for developing farm and plantation products for marketing locally, regionally, and around the world.

Hunger Monkey bread, with its balance of protein, energy, vitamins, and minerals, seems capable of improving the food supply (not to mention health) of many societies with little cost or change in daily habits.

Malnutrition Programs focused on nutritional interventions should embrace or at least test baobab as a tool for achieving their goals. The various parts of this plant are not so different in nutritional power from the relief foods shipped in from factories far away. Yet they are locally

acceptable and locally produced. Kwashiorkor, marasmus, avitaminosis, rickets, scurvy, diarrhea, and maybe anemia are among the scourges likely to be relieved by this powdery fruit product.

Food Security This species offers promise for establishing “life-insurance plantings” that provide essentially permanent food security.

Deforestation Tree-planting programs throughout the vast semiarid and subhumid regions of Africa should at least consider planting baobab. The species is a prime candidate for self-motivated forestry and successful plantings will, as we have said, leave a resource for millennia. The tree is not for everyone or every site, but for all that its importance is universal.

Balance of Payments Deficits For a continent short of foreign exchange, it is notable that baobab’s export potential could eventually be large. Already, some African nations trade its food products among themselves, something that could be both increased and extended outwards to other parts of the globe. Indeed, an export industry based on the all-natural, soluble powder with potent nutritional punch might be the best economic engine for leveraging the crop to new commercial heights. Employing an African product to improve nutrition in other parts of the world may seem like an irony, but among other things it will induce the production discipline, safety inspections, and quality controls to make baobab better for all Africa too.

Economic Development Beyond fruit products, there are opportunities for successful commerce. To mention a few, there are the tree’s use for shade, shelter, water storage, boundary markers, beautification (both in landscapes and cosmetics), and even tourism.²¹ In this regard, the bark should not be overlooked. Its fiber may seem esoteric but within Africa it is a *very* important product.²² And it is a renewable one: Although often completely stripped, baobabs regenerate their bark with remarkable agility.²³ Waterproof baobab hats, bags, and baskets might also well attract worldwide interest and international sales.

²¹ In Madagascar at least certain towns attract visitors from around the world to admire their baobabs. Majunga, for instance, touts its famous baobab, “a more than 700 years old tree [that] makes the city proud.” And twenty kilometers north of Morondava there is “the most popular place for baobab spotters, Baobab Alley.”

²² One of our contributors wrote, “this [fiber] is a major use in Mozambique. It is difficult, at least close to villages, to find unscarred trees.”

²³ In this regard, it is not unlike Portugal’s cork oaks, which produce billions of corks for the world’s wine bottles. But their growth and fruit production is also severely stunted.

Wild Resources Although new plantings probably hold the key to eventual success, the existing trees offer opportunities for greater commercial ends. Kenya, to mention just one country, is estimated to utilize less than a tenth of the potential inherent in its existing baobabs. In this vein, the thoughtlessness that now sees millions of saplings mindlessly destroyed needs to be counteracted by educating everyone to protect young baobabs. In a like spirit, the taboos need to be overcome: Baobabs are certainly not evil, and any tree that regenerates itself spontaneously still can use the help of horticulture (especially where fruits are heavily exploited and no seeds ever make it to the ground).

Nutrition Earlier, we presented figures on the protein, mineral and vitamin contents of the fruits and seeds—ones that should be of consuming interest to anyone working to overcome Africa's chronic malnutrition. Such figures, however, have yet to be subjected to adequate independent verification for underpinning continent-wide endeavors. Thus, food chemists should now carefully check the fruit's composition across the plant's range, determining various geographical differences and putting the overall nutritional profile onto a sound footing.

Beyond that, virtually everything relating to nutrition awaits attention: digestibility studies on each ingredient—protein, fiber, calcium, other minerals, vitamins. Studies on how storage and various food-processing methods affect nutrient content also would be helpful.

Clearly, monkey bread could become a key tool for overcoming deficiencies in vitamins, protein, and food energy. Anyone involved with efforts to overcome general malnutrition and its related maladies should consider testing this common fruit food. An important approach to chronic malnutrition might be all around Africa...just unrecognized by the majority.

Food Technology In light of the almost complete lack of basic knowledge of this foodstuff, much remains to be done regarding the science of harvesting, handling, cooking, storing, and processing the fruits and seeds. Food technologists of the world could find much of interest and humanitarian relevance here. Research into variability in flavor and local acceptability might be useful too. In addition, means for detecting fraudulent baobab powder mixtures, which now occur in some markets, are needed.

Although baobab products are widely eaten, it would be prudent to check the fruit-pulp and the seeds for toxic or noxious components that might be detrimental if used more intensively or if fed to malnourished babies. In addition, it would help to have some measure of any hazards due to such things as adulteration, poor sanitation, and bad handling. In this regard, studies on spoilage could be conducted. Despite the fruit's renowned longevity, there is likely to be a place for preservatives as well.

MALI SHOWS THE WAY

In Malian Dogon country, baobabs are often planted in courtyards, carefully grown for 5-6 years, and then carefully transplanted to family owned fields, where the trees are protected from roaming animals.

There are already many examples of baobab “orchards” planted in the periphery of Sahelian towns and cities (Bamako, Mopti, etc). Those orchards are all harvested for leaves rather than fruit—leaves are more abundant and harvesting can commence in a much shorter time than for the case of fruits. In Mali, local agroforestry researches have perfected grafting techniques with close to 100 percent success rate. Already more than 5,000 trees in over 100 farmer orchards have been grafted with stock from trees with extremely high vitamin C content.

In Sahelian Mali and Burkina the fruits are also a major food. Besides domestic consumption, there is an enormous trade of baobab fruit northwards and eastwards in Mali where it is prized alike by Moor, Tareg, and Fula.

Water Why is it that the water inside the trunk of a baobab remains potable for months?²⁴ At present, there seem no answers that question, and this mysterious process of water preservation needs investigation. Apparently, the living wood leaches natural preservatives that keep water from fouling. Whatever that leachate contains, it must be remarkably good at killing microbes considering that the trees stand firm with sopping trunks for thousands of years.

Edible Oils Despite the fact that the kernels contain only 10-15 percent oil, the tree might make a useful oilseed in spite of its many other uncertainties.. Currently the oil is only rarely used in cooking, but that seems only through a lack of supply. In parts of Senegal (and doubtless elsewhere) people employ it in preparing traditional dishes for certain festivals. It is an attractive golden liquid with a mild taste and good nutritional balance. Exploration by oil chemists is needed.

Horticultural Development Although overall priority should be given to getting more of today’s baobabs planted, parallel programs on breeding and improving the species need to be pursued. Collections of seeds should be made from the different types throughout its distribution range and made available to researchers, non-governmental organizations, and others anxious to advance this species. Here is another opportunity for powerful pan-

²⁴ That is, as long as the hole in the trunk is covered to block outside contamination.

African cooperation. The differing ways in which separate seedlots perform in different locations across the continent will uncover much about the plant that is currently unimagined, and that information will be of value to all.

Some idea of the yields—of leaves, fruits, pulp, and seeds—and comparisons between top-producing trees is required. This might be a good opportunity for local, national, or regional contests to see who can come up with Africa's "best and fairest" baobabs. Beyond that, comparisons on sweetness, nutritional quality, taste, and other food values could be included. Selecting for seed qualities—including large size, ease of shelling, and high oil and protein contents—could also prove highly successful.²⁵

Taken all round, these are important preliminaries for selecting (and perhaps even breeding) baobabs that yield more and better food. The availability of various highly productive forms would transform everyone's view of this crop and facilitate the species' progress toward ultimately becoming a much greater resource.

If there is one breakthrough that would transform the tree's place in world resources it is vegetative propagation. Techniques need to be worked out. Multiplying elite specimens via cuttings or grafts or other method could, all by itself, foster vast new plantings, not to mention new profits and new perceptions. For one thing, seedlings of such clones are likely to produce their first harvest in under half the current time—i.e., at age 4-5 years, like apples and other fruits. For another, it will raise yields, reliability, and overall product quality.

Field management is also an important area for development. Artificial and natural regeneration techniques for managing baobab in the field require documentation and assessment. Age-old experience in the baobab's various locales could be invaluable guides here.

The species' ecological tolerances and preferences are poorly understood. Baobab tolerates many different types of sites, but at least one researcher has noticed "a tremendous response to choice of planting site, even to microsite." This too needs clarifying.

Pharmaceuticals All parts of the tree are used in traditional medicines, but so far there is little proof of efficacy.²⁶ Pharmacological investigations should be undertaken. Proving or disproving claims will not necessarily be easy: traditional preparation methods are often complex and secret.

²⁵ On this point, our contributor John Scheuring reports: "In our work in Mali, we found that people from several kilometers around recognized certain trees for their particular fruit or leaf qualities. In fact the tree with the highest vitamin C content we ever found was already well known locally for its fruit quality."

²⁶ Much of the early familiarity of Europeans with the baobab came from its fruits, which were commonly sold in the herb and spice markets of Egypt during the 16th century, probably for their medicinal value in reducing or removing fever. The first recorded reference was by the 14th-century Arab traveler Ibn Batuta, who highlighted the trunk's capacity to store water.

The *Pharmacopée Traditionnelle Sénégalaise* recommends the naturally dried pulp of the fruit for use against dysentery, fever, and rickets. Those uses seem likely to be scientifically sound, and rather modest investigations can probably give them pan-African acceptance.

SPECIES INFORMATION

Botanical Name *Adansonia digitata* Linnaeus.

Family Bombacaceae

Common Names

Afrikaans: kremertartboom

Arabic: bu hibab, hahar, tebeldis; fruit: gangoleis

Bambara: sira

Burkina Faso: twege (Moré)

English: baobab, monkey-bread tree, Ethiopian sour gourd, cream of tartar tree, vegetable elephant, abode of the gods

French: tree: baobab; fruit: pain de singe, calabassier, arbre aux calabasses

Fulani: bokki, bokchi, boko

Ghana: odadie (Twi), tua (Nankani)

Hausa: kuka

Jola: buback

Kenya: mbuyu (Swahili); mwamba (Kamba); olmisera (Maasai); muru (Bajun);

Mandinko: sito

Malagasy: Bozo (Sakalava dialect)

Manyika: mubuyu

Ndebele: umkomo

Portuguese: imbondeiro

Shona: mayuy, muuyu, tsongoro (seeds)

Sudan: tebeldi, humeira

Swahili: mbuyu

Tsonga: shimuwu

Tswana: mowana

Venda: muvuhuyu

Wolof: bui

Yoruba: luru

Zulu: isimuhu, umshimulu

Description

There is no such thing as a typical baobab—individual specimens vary in size, shape, height, trunk shape, and girth. Nonetheless, no one ever mistakes one. Typically, the tree reaches 20 m with a trunk that is cylindrical, tapering, bottle-shaped or irregular. Although normally 3 to 5 m in diameter, massive trunks can be 10 m across.²⁷ The lower parts are bare. The top, divides into stiff upward-pointing branches, giving the impression of a bottle full of twigs. The thick, fibrous bark has a smooth, silvery, metallic-gray or purplish surface and a remarkable ability to heal itself when damaged. Surface roots spread far from the base of the tree, although the deep taproot disappears with time.

The biology of the baobab is poorly known. The trees are deciduous, leafing out during the period of maximum heat just before the first rains arrive. Juvenile trees have leaves of simple form, but a mature tree's leaves have segments that radiate outward, somewhat like the fingers of a hand. Trees remain in leaf through the rainy season, during which time they also develop huge pink or white flowers (though flowering can occur at almost any time). These blossoms are solitary and showy, being up to 20 cm in diameter and hanging on long stalks. Their petals are waxy, snow-white, and pendulous. Though they attract abundant bees (and even bush babies), in the main they seem mostly to be pollinated by bats.

The fruits form up to six months after flowering, during the late dry season or early wet season. In shape, they vary from spherical to oblong and slender to ovoid, measuring 12-40 cm in length and 7-17 cm in diameter. Their woody gourdlike shells are up to 1 cm thick and are coated with a velvety coating of yellowish brown hairs. Inside, they contain the powdery pulp, divided longitudinally by fibrous septa into about 10 chambers. Each chamber contains many kidney-shaped, brownish black or purple seeds that are approximately the size of fat beans and have a hard shell. Just how long the seeds remain viable is unknown, but it exceeds five years.

Distribution

The species occurs throughout semiarid continental Africa, from the Senegal coast to northern South Africa. Its northern limit across West Africa is about 16°N; its southern limit is about 15°S in Angola, 22°S in Botswana, and 24°S in Mozambique (at Chokwe). It is particularly plentiful in the Sudano-Sahelian zone and is renowned in Madagascar, where it was introduced probably by Arab traders.

²⁷ The earliest Western description of the baobab was by Alvisé Cadamosto, who saw some at the mouth of the Senegal River in 1454. He estimated the trunks to be about 11 m in diameter. A naturalist since has reportedly seen trunks 9.75 m in diameter on trees only 21-24 m high. Those were roughly half as wide as they were tall!

Beyond Africa's shores, baobab has been planted in many tropical locations. Some can be found scattered across tropical America and tropical Asia. Many are found in India, Sri Lanka, and elsewhere around the Indian Ocean owing to Arab traders who carried it there from Africa in the 14th and 15th centuries or earlier. It is also known (together with a local counterpart, known as *boab*) in Australia's "Top End."

Horticultural Varieties

Some varieties have been distinguished, based mainly on fruit shape. But there are doubts as to their genetic validity. In Mali, varieties are indigenously differentiated by their trunk color; white, black, or red.

Environmental Requirements

Baobab occurs almost exclusively in tropical latitudes. It is well adapted to dry and hostile environments and mostly occurs in the semiarid and subhumid zones. A light demander, it does not thrive in dense forest.

Rainfall This species is most common where mean annual rainfall is 200-1,200 mm. However, it is also found in locations with as little as 90 mm or as much as 2,000 mm.

Altitude The tree can be found from sea level to 1,500 m, but most occur below 600 m.

Low Temperature Mean annual temperature: 20-30°C. Frost sensitive.

High Temperature No limits within Africa. In areas where baobabs grow temperatures get well into the high 40°C .

Soil Grows on many different soils but develops best on deep, well drained, generally moist, calcareous sites. Despite being intolerant of waterlogging, it thrives along the banks of rivers such as the Niger. Reportedly tolerates laterite as well as relatively alkaline (e.g., limestone) soils. Apparently does poorly in the sandy "millet" soils of the Sahel.

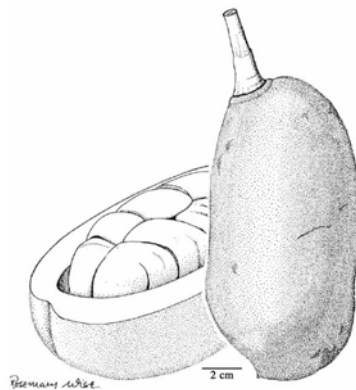
Related Species

The region of origin of *Adansonia digitata* is not clear, but Madagascar is the center of diversity for the genus overall. Of the eight *Adansonia* species, six are found only in Madagascar, one other occurs in Australia, and the last, the baobab of this chapter, appears to have originated somewhere on continental Africa. The six Madagascar species are interesting in their own right. They are widespread on the island's western slopes and are particularly numerous in the southwest. Three are particularly noteworthy for their appearance and utility:

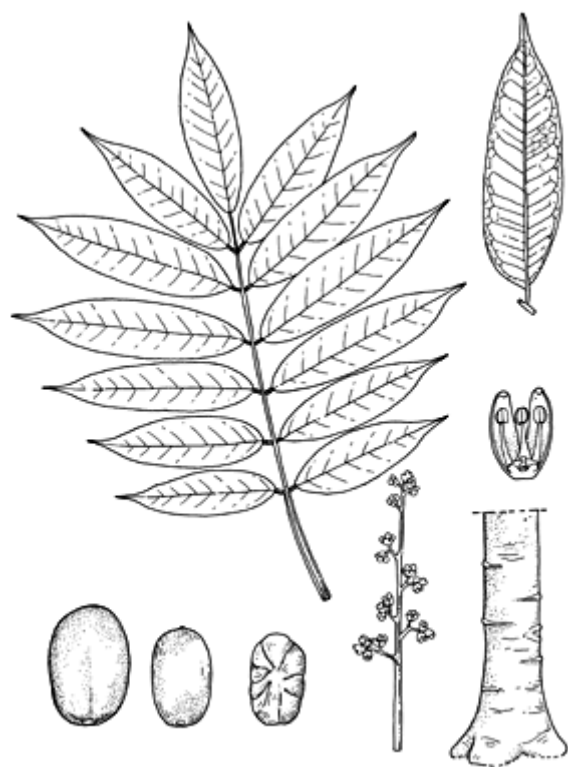
Za (*Adansonia za*) Occurring in the south, west, and northwest, this species—Madagascar’s most widespread baobab—forms whole forests, with thousands of ungainly bottle-shaped trees making perhaps the eeriest habitat to be seen anywhere. The seeds are eaten and the trunk is sometimes hollowed out as a cistern. This very big tree reaches 30m in height, with a trunk that is cylindrical, slightly tapering, or swollen. The primary branches, often tapering, ascend properly toward the heavens.

Renala (*Adansonia grandidieri*) The most statuesque baobab of all, this flat-topped species has been called “a pure gem.” It has an otherworldly look and is often represented on the cover of books on Madagascar. The fruits are eaten and the seed kernels are so lipid rich they were once exported to France for processing into cooking oil. Nowadays both fruits and seeds are used only locally and on a small scale. Known locally as renala or reniala (Mother of the Forest), it is widely honored as the dwelling place of spirits. Offerings are placed at its base to ensure fertility, fine harvests, and good fortune. Famous groves occur in the western part of Madagascar, near Morombe and Morondava.

Bozy²⁸ (*Adansonia suarezensis*). This species is restricted to a tiny area near Antsiranana (Diego Suarez) on Madagascar’s northern tip. Indeed, its distribution is limited enough to threaten extinction. Given current trends, according to some observers, it is likely to survive only another decade or two. Yet this is a tree with tasty fruits and large edible seeds, which apparently have the highest oil content (46 percent) of any baobab seed. Modest efforts might rescue this species from extinction and also turn it to great benefit. The tree itself is large, up to 25m tall and 2m across. The trunk typically tapers gently from bottom to top and the crown is flat, with branches radiating horizontally.



²⁸ The name is used for all northern Malagasy baobabs, but primarily this species.



3

BUTTERFRUIT (Safou, Bush Mango)

The colorful prunelike morsels of the butterfruit¹ (*Dacryodes edulis*) are well known in Central and West Africa. They are roasted or boiled with maize as a main course, they are enjoyed (fresh or cooked) as snacks, and they feature in traditional ceremonies and special functions. These are commercial fruits that pour into cities and rural markets in considerable quantities. They are especially important in the hot and humid zone stretching from Eastern Nigeria to Angola. There, women peddling the fruits at locations along the highways are a common sight.

The trees are much appreciated in their own right. They are deliberately planted in and around countless farm plots as well thousands of villages. Indeed, they occur in most or possibly all West and Central African villages. And from the appearance of both the fruits and the trees it is clear that generations of Africans have exercised selection for quality and desirable growth forms. Many of these trees receive at least rudimentary horticultural care. Indeed, good specimens are zealously protected. And when forests are felled and burned to open up farmland, butterfruits are left standing.

As a result of all this interest, the species is a major component of the traditional farming systems in parts of West Africa, especially Nigeria (Eastern, Delta and Edo states), as well as in the four Central African neighbors, Cameroon, Congo-Brazzaville, Congo-Kinshasa, and Gabon. Throughout this region, it is an important source of nutrition and income for many farmers and is among the most widely used fruit trees.

Yet for all its geographical spread, ancient heritage, and current value, butterfruit is barely known to science. This is both strange and sad. People tend to like this fruit once they get to know it. Given a push, it could definitely be a bigger contributor, perhaps eventually reaching millions who today have never heard of it. That would contribute to enhancing the welfare

¹ In popular literature this fruit is often called “African pear” or “bush mango,” awkward terms that are botanically and culinarily misleading. A common English name in Central Africa is just “plum,” “bush plum,” or “African plum,” due to its shape and color. It is called safou in Angola, Gabon, Cameroon, and the Congos. It is also known in French as “prunier” and the fruits called “prunes.” Because they resemble avocado in composition and texture we suggest “africado” for international marketing purposes.



Butterfruit has not been cultivated to any extent but small organized plantings have already been established in Cameroon. It is, of course, a major component of traditional agroforestry systems, where it is neither scattered nor sporadic. (© Erick C.M. Fernandes, ecf3@cornell.edu)

of farmers in some of the most difficult climates for growing food and cash crops. And it could also enhance survival. In southeastern Nigeria, for example, it is traditionally used to get through the hungry season.²

On nutritional grounds alone, the more extensive use of butterfruits could

² Information from J.C. Okafor.

be a very good thing. The pulp packs a combination of high protein and high energy that makes it a promising weapon for fighting the world's worst humanitarian problem, protein-calorie malnutrition. Although presently unemployed or even untested in nutrition programs, it could in principle prove a lifesaver for children, nursing mothers, and the desperately sick.

In this regard, the essential amino acid concentrations are noteworthy. The levels of lysine, leucine, and threonine are similar to those found in top-quality animal proteins—eggs, milk, and meat, for example—and much higher than those in most plant staple foods such as wheat, barley, rye, rice, maize, sorghum, or melon seed.

The oil making up one-third to two-thirds of the pulp is also noteworthy. It is a good source of essential fat for human nutrition, being composed mainly of unsaturated fatty acids. Also, it has good potential for such things as salad dressings and cooking oil.

And beyond protein and oil, this fruit provides a good array of minerals, including phosphorus, potassium, calcium, and magnesium. Sodium, on the other hand, is remarkably low (1.5-5.2 mg per 100 g in recent analyses).

Despite its nutritional qualities, the fresh fruit does not appeal to everyone. A dessert delight this is not. Although Central and West Africans may consider it delicious, this fruit turns off sugarcoated taste buds. Indeed, many visitors cannot stand its sourness and slipperiness. One needs to develop a taste for even the sweetest types.³ This is not as big a limitation as it may seem. This fruit is used mainly as a vegetable, like tomato, and is generally consumed along with maize, cassava, or plantain.

Despite any culinary limitation initial impressions might present, the fruits have enough advantages to warrant much greater development. For one thing, they have a pleasant smell. For another, they are extremely attractive in appearance. Unripe butterfruits are orange, red, pink, or even purple; ripe ones are deep blue, green, violet, or black. On the inside they are just as colorful: the pulp comes in pink, white, green, or pale yellow. The green form is the sweetest; the pink is the prettiest, although most people consider it barely edible.

Although we have chosen to place this plant in the volume on fruits, it could equally well be considered an oilseed. Both pulp and seeds contain outstanding amounts of a vegetable oil useful for such things as cooking and cosmetics. Although this oil is not now produced in any quantity, that could change. The plant comes from the same region as the African oilpalm, which a century ago arose from Central-African obscurity to become one of the world's major crops. According to one estimate, even the nondescript

³ One of our contributors wrote: "It has a resinous taste, which one has got to get used to. But then you become an addict!"



These butterfruit are not just transplanted wild types—they differ greatly from wild fruit in the vicinity, which indicates a high degree of selection by farmers. (© Erick C.M. Fernandes, ecf3@cornell.edu)

butterfruit specimens taken straight from the wild can produce more than twice as much oil as their counterparts in the wild oilpalm.⁴

Whereas the tree is grown in myriad farm fields and village compounds, it is not now cultivated in organized plantations. A few pioneering researchers, however, have established experimental plantings in both Nigeria and Congo, and have achieved results that point the way toward larger scale production.⁵ Also, oil extraction has advanced to the commercial stage in Gabon and is being tested in Nigeria and Cameroon. And in Congo-Brazzaville, oil processing is being carried out on a pilot scale (100 kg per hour, using an electric oil press).⁶

Beyond commercial production in orchard-like plantings, the tree is an excellent candidate for household plantings. It has particular promise around

⁴ Giacomo, R. 1982. Biologie florale du safoutier (*Dacryodes edulis*) au Gabon. Rapport du projet FAO/CIAM, Libreville, Gabon. Some scientists contend that the butterfruit should have been chosen from the start. It can yield 7-8 tons per hectare, compared with 3 tons per hectare for the wild oilpalm. What it can do in plantations, given some research, is unknown but could be outstanding.

⁵ Information from J.C. Okafor. The Congo plants are at the University of Kinshasa.

⁶ Riedaker A. and T. Silou. 1998. Safou. Pp. 227-229 in N. El Bassam, ed., *Energy Plant Species*. James & James Publishers, London.

the farm and home because it provides so many useful products—including fruits, browse, wood, and a scented resin that burns with a bright flame. Indeed, it is seen as a reliable friend for both times of need and times of plenty. People like having it nearby.

This versatile species also has promise for agroforestry and utility use. Even now, it is often seen growing scattered in riverbeds, across hillsides, and along the verges of boulevards. It even has potential in plantation forestry. The timber, although small in diameter and short in length, can substitute for mahogany. Its woodworking qualities and interesting appearance suit it to veneers and fine cabinetwork.

Although it has received little formal scientific support, some enthusiasts have rallied to this species. These “crop champions”—who include researchers, extension workers, growers, and traders—joined hands to form a formal bilingual network, the African Safou Network, in the late 1990s.⁷ Other groups have also shown interest, and butterfruit is slowly finding a more prominent place in research and development in West and Central Africa.

Three international organizations have also championed the crop. In southeast and southwest Nigeria, the IFAD-ICRAF-IITA Agroforestry project is selecting varieties which better meet the demands of the growing local market. It is also developing propagation and horticultural techniques. Already, the results have caught the attention of farmers, who have long been frustrated by the trees’ slow maturity. Butterfruit’s potential for greater production and more income appeals to many farmers.⁸

PROSPECTS

Butterfruit could possibly become an African counterpart of the avocado, a protein- and oil-rich fruit that has gone global only within the past 50 years. Avocado is from the American tropics, but is now a substantial resource in a score of countries, including some within Africa itself. Butterfruits are quite unlike avocado in size, shape, or color, but they are very like avocado in their soft, buttery pulp, and in their rich protein and high oil content.

Within Africa

Considering the place this fruit occupies in its native region, there seems every reason to expect that its improved cultivation will be profitable and rewarding there. It also has promise in many parts of Africa that are now unaware of it.

⁷ Information from J. Kengue.

⁸ A forward-looking monograph on butterfruit’s potential is available in French from the International Centre for Underutilised Crops: Kengue, J. 2002. *Safou* (*Dacryodes edulis*). Fruits for the Future 3. ICUC, Southampton, UK; see www.icuc-iwmi.org.

Humid Areas Prospects here are high. In much of West and Central Africa's humid-tropical zones, the butterfruit is already well known and the trees are both deliberately planted and protected from destruction when clearing forest. But its true potential as a major commercial crop is not yet tapped. The species is poised for a breakout, but needs the push of better knowledge to get it to the take-off point.

Dry Areas Moderate prospects. The tree withstands extensive dry spells but seems unsuited to truly arid locations.

Upland Areas Uncertain prospects. Although no one knows how butterfruit will perform at elevation, the prospects could be substantial, except of course in those locations where frosts are fierce or frequent.

Beyond Africa

Although so far untried outside Africa, butterfruit is probably not limited to its native continent. Indeed, it seems extremely adaptable and tolerates many combinations of temperature, rainfall, and soils. Taken all round, the species' prospects for both reforestation and nutrition programs seem to be excellent throughout much of the tropics.

USES

This is another of the versatile crops producing multiple products of importance to rural peoples, including the following:

Fresh Fruits The fruits can be eaten raw, but the pulp softens and comes off the seed easiest after a brief heating. For this reason, most fruits are blanched in hot (sometimes salted) water for a few seconds. At times they are softened by a few minutes roasting in the embers of a fire. Some are fried. A newly developed technique is to pack the fruit in a sealed plastic container and stash it in the sun for an hour. This not only softens the pulp and separates the seed, it saves the fuel. Peel and pulp are normally eaten together, scraped from the seed with the teeth as if eating a mango.

Cooked Fruits In some places butterfruits are mostly eaten between meals. More often, the pulp is used to supplement starchy diets based on staples such as maize, cassava, cocoyam, plantain, or sweet potato. In eastern Nigeria the fruits ripen at the same time as maize, and the two are commonly eaten together, usually in the form of snacks.⁹ In this case the fruits, as well as the maize, are roasted over the embers of a dying fire. In the

⁹ "This is a very delicious combination," wrote one of our contributors in Nigeria. "It sells fast and is expensive."

home this is a minor limitation because it must be cooked after the main part of the meal. For street vendors the problem is more acute because they must keep the fire going, which adds expense.

Animal Feed The species has utility as an animal feed. The leaves are fed to livestock to good effect. The kernel found inside the stone at the center of the fruit contains over 3 percent protein (wet weight basis), and is commonly fed to sheep and goats.

Ornamental Plantings The tree is widely employed for shade. In parts of eastern Nigeria, it is planted in avenues along village roads. Mostly, however, it is planted around gardens and homes.

Wood The heavy heartwood's elastic quality makes it useful for axe-handles, mortars, pestles, and pillars for houses and buildings. It is also suitable for carpentry and fine woodworking. As noted, it is not unlike mahogany, and its woodworking qualities and interesting appearance make it suitable for veneers and for fine cabinetwork.

Other Uses The bark of the living tree yields a resin used to caulk the inner surface of calabashes and to mend earthenware vessels. The waxy gum is also used as a lamp oil and a salve to treat skin parasites. In southeastern Nigeria, the tree is used as an indicator of the planting season: When butterfruit leaves emerge, it is time to plant the crops. The kernel is said to be useful in dissolving stones in the kidneys.

NUTRITION

The fruit's lipid content is extremely high, which is why the tree was initially called "butter tree." Oil constitutes 33 to 65 percent of the pulp, depending on the tree, its maturity, and the care it received. Dietetically speaking, the oil is a desirable one, being made up of 58 percent unsaturated fatty acids (oleic, 34 percent; linoleic, 24 percent) and 43 percent saturated fatty acids (stearic, 6 percent; palmitic, 37 percent).¹⁰ At room temperature (22°C) it separates into a liquid upper layer and semi-solid lower layer, which likely means that the saturated and unsaturated fats are simple to separate. The raw oil has an olive green color, but can be partially bleached to straw yellow. An energy content of 445 calories has been reported.¹¹

¹⁰ Ucciani, E. and F. Busson. 1963. Contribution a l'étude des corps gras de *Pachylobus edulis* Don (Burseraose). *Oleagineux* 18:253-255. For further nutritional information, see also Kengue, op. cit., and Mbofung, C.M.F., T. Silou, and I. Mouragadja. 2002. Chemical Characterisation of Safou (*Dacryodes edulis*) and Evaluation of its Potential as an Ingredient in Nutritious Biscuits. *Forests, Trees and Livelihoods* 12:105-117.

¹¹ Information from T. Silou.

The fruit is also a rich source of protein. Indeed, crude protein constitutes 20 to 30 percent (dry-weight basis). Its amino-acid composition makes it an excellent supplement to cereals and starchy roots. Lysine and tryptophan—essential amino acids deficient in cereals such as maize—are both present in good quantity in butterfruit. The pulp also contains leucine, valine, isoleucine, tyrosine, arginine, cystine, and threonine, all of which are indispensable to human health and often inadequate in malnourished diets.

Butterfruit has about half the vitamin C of oranges but other vitamin levels seem unreported. Important dietary minerals are present in useful quantities. The contents of potassium (850-1257), calcium (136-210), and magnesium (129-150) are especially notable. In addition, there is iron (2.3-20), copper (1.1-1.7), zinc (1.1-1.5), and manganese (0.56-1.26). Of note, is the near absence of sodium (1.5 to 52mg/100g).¹²

HORTICULTURE

At present, these fruits are mostly gathered from trees cultivated on farms or in village compounds. In other words, there are few intensive plantings. Although production in orchards and harvests from hedges also occur, most of the trees grow singly in gardens.

The plant is traditionally propagated from seeds, which are usually spaced at least 12 to 15 meters apart because of the tree's spreading habit. The stone is placed flat in a shallow hole and covered with a centimeter or two of earth. In Cameroon, the seed is often planted directly at the foot of a banana tree. Although fresh seeds germinate readily, they quickly lose viability. (Clean ones reportedly remain viable 21 days; those with the pulp attached only 7 days.) The seedlings are transplanted when about a year old, at the beginning of the rainy season.

Vegetative propagation has long been considered very difficult. ICRAF researchers at Onne, Nigeria, however, have developed methods for air layering the plant.¹³ Budgrafting with juvenile budwood is also possible.¹⁴

On a farm or in a village, young trees are commonly trimmed to a manageable size for easy harvesting. The species' ability to take heavy pruning is also desirable in agroforestry because farmers can cut it back to reduce the shade cast on crops growing nearby.

¹² All figures are mg per 100g. Silou T., D. Mampouya, L.W.D. Loka. and M. Saadou. 1999. Composition globale et caractéristiques nutritionnelles des huiles extraites de 5 espèces des cucurbitacées du Niger. *Rivista Italiana della Sostanze Grasse* 76:141-144.

¹³ In 2002, ICRAF, with headquarters in Nairobi, changed its name from the International Centre for Research in Agroforestry to the World Agroforestry Centre.

¹⁴ Information from J.C. Okafor.

A difficulty is that these trees come in two “genders”: female trees that regularly produce heavy fruit crops and male-hermaphrodite trees that either never produce or produce a small crop irregularly. Unfortunately, only a quarter of the natural population is normally female and three-quarters of the population are therefore useless for food production. Vegetative propagation provides the opportunity to multiply the female trees, especially ones with desirable traits.

HARVESTING AND HANDLING

The fruits are ripe when they have darkened from pink to blue/black. Hand picking typically occurs in the morning, with men or boys climbing into the trees and using hooked poles to draw the fruits within reach. Mature ones are packed into bags (holding up to 10 kg) that are usually hung on a branch. When filled, the bags are lowered on a rope to the ground.

Once picked, the fruits become quite perishable. In the oppressive heat and humidity of tropical lowlands, they do not keep much more than a week. Storage in a cool and airy spot, preferably a basket, helps. Deterioration occurs through moisture loss and the fruit consequently shrivels. Dampness is especially to be avoided; it causes the fruit to soften faster and turn moldy. For this reason, butterfruit is not harvested on rainy days. Similarly, it cannot be packed densely or stored in airtight containers such as plastic bags.

LIMITATIONS

The cropping system, which is mostly traditional and unsupported by scientific verification, seems to have two major constraints: Most stands have too many male trees and the females themselves are too variable—oftentimes every tree bears fruits of different size, character, and quality, making them hard to handle and market.

Farmers report that many trees do not bear regularly. So far, no clear-cut pattern has been detected. The problem may be due to a genetic predilection toward alternate bearing. It may be due to high temperatures (anything above 23°C is thought to reduce fruit set and yield). Or it may be due to pollination failure (perhaps caused by heavy rainfall at flowering time). In addition, it is reported that some trees drop most of their fruits at an early stage of development, which could be due to a nutrient deficiency in the soil.

Currently, the species is strongly seasonal, fruiting during the wet season when other fruits are abundant. Also, the fruiting season is short.

Post-harvest losses can be enormous. In addition to shrinkage and rot, the fruits invisibly lose nutritional value.¹⁵ Part of the problem is caused by bad harvesting technique: resulting in rapid deterioration.

¹⁵ In one microbiological investigation, such losses were caused by *Botrydiploia theobromae*, *Rhizopus stolonifer*, *Aspergillus niger*, and *Erwinia* spp. The first two species accounted for most of the damage. Information from J.C. Obiefuna.

NEXT STEPS

This crop seems capable of tackling problems of the poor, of the malnourished, and of the land. It can become a basis for rural development. Obviously, a productive, high-energy, high-protein food like this is worth developing. Now that better growing techniques are known, governments, individuals, and organizations throughout its range should get involved. Steps to achieve better use of the species' potential include the following.

Increased Trade Already butterfruits enter commerce within and between Central and West African countries. But that commerce can be enlarged and made more efficient. Nothing would help this crop's further advancement more. Any increase in "demand pull" will see farmers and traders leaping in to produce and sell more butterfruit.

Malnutrition Trials As noted, the more extensive use of butterfruit in Central and West Africa could be a good thing solely on nutritional grounds. Its combination of high protein, high energy, and good mineral profile makes it a promising weapon for fighting malnutrition. Now is the right moment to test its potential as a lifesaver for children, nursing mothers, and the desperately sick. In particular, the extracted pulp cake might make a useful nutritional supplement. Protein content is lower than common oilseed cakes such as peanut, safflower, and soybeans (ranging from 30-50 percent), but richer than maize, rice, sorghum, and wheat (all 15 percent or less).

Food Security Assessment As noted, people in southeastern Nigeria rely on butterfruit to survive the hungry season. This phenomenon and its replicability elsewhere deserve investigation.

Increased Planting This species is a promising candidate for organized production on an organized scale. Programs to mass produce selected plants and distribute the planting materials to farmers could be especially helpful. In this way, the health and welfare of the people—especially children, the elderly, and the poor—will be improved.

Horticultural Development This highly variable plant is about where the avocado was a century ago: it suffers from a lack of target types upon which to build horticultural production. The discovery of the equivalent of the 'Fuerte' avocado¹⁶ will quickly change the situation. The lack of organized selection or improvement seems largely due to neglect. With more detailed studies, many bottlenecks and difficulties will undoubtedly disappear.

¹⁶ Selected from a California backyard in 1905.

Among horticultural practices needing development are those for:

- Reducing premature fruit drop (abortion);
- Changing the “gender ratio.” Whereas a dioecious species like this typically needs only a handful of male plants for every 100 females, plantings in Nigeria have proved to have up to 80 males.
 - Improving pollination. The floral biology and the mechanism of fertilization need investigation. This likely will help not only improve fruit-set but the breeding and improvement of the species. Males supposedly produce their pollen poorly and irregularly, but reliable males that shed their pollen at the right time for the local female trees must surely be around;
 - Fruiting out of season. Butterfruit would rise in significance if the crop fruited a few months earlier or later. This is not a far-fetched notion. In southeastern Nigeria, for instance, forms that ripen several months after the normal season have been observed;¹⁷
 - Reducing pests and diseases;
 - Improving field management. Better practices, alone, will result in better yields and more extensive cultivation.
 - Rejuvenating old, but good-quality trees;
 - Dwarfing. As with apples, creating smaller plants would make the butterfruit more manageable. Already, it is known that pruning seedling trees to a height of 1-1.5 m produces dwarfing.¹⁸

Gathering the Diversity This species offers a huge range of genetic diversity. Selection for such things as fruit size, pulp thickness, fruit quality, taste, seed-oil content, tree height, and fruiting season all offer promising possibilities for horticultural progress.

Germplasm collections—both wild and in cultivation—are needed to preserve the range of variation. Special attention should be paid to collecting germplasm in the species’ West/Central African region of genetic diversity.

Propagating Select Forms Making selections from the species’ diversity is crucial to the crop’s future. Vegetative multiplication will lead to plantations of highly productive clones, which would transform this crop almost overnight. The plant has so far resisted many classical vegetative propagation techniques, but much more effort along these lines is warranted.

Fatty Acid Composition Among the many things to select for is polyunsaturation in the oil. The fatty acid composition varies significantly between plants and maybe between countries. Samples gathered in Cameroon, Congo-Brazzaville, Congo-Kinshasa, and Gabon, for example,

¹⁷ Normal types ripen June-August; late types November-January.

¹⁸ Information from J.C. Okafor.

have shown the following ranges: palmitic acid, 41-47 percent; stearic acid 2-3 percent; oleic acid 20-34 percent; and linoleic acid, 19-29 percent.¹⁹

Diversifying Uses That a food so rich in protein and lipid has not been seriously investigated is surprising. Their functional properties deserve assessment to determine the breadth of possible uses in a wide variety of different industries.

While not showy, the flowers are strongly perfumed and attract masses of pollinators. According to one account,²⁰ more than 80 percent are honeybees. Thus, butterfruit may well be a valuable honey tree.

Nutritional Research As mentioned, butterfruit seems likely to be very effective for feeding malnourished people. The traditional practice of eating the fruit together with maize, cassava, or plantain should be encouraged. The fruit's low carbohydrate content makes it a good supplement to those carbohydrate rich foods. Because it helps make up deficiencies in minerals and essential amino acids, the fruit neatly balances the starchy staples in the daily diet. It also contributes considerable food energy.

Needed are more measurements on the nutrient content of the many different varieties. Also needing documentation are the ways the fruit is used in traditional diets. Given that information, means for improving and modifying local diets can be determined more precisely.

Food Technology Tropical conditions give a fruit as perishable as this one a short shelf life. Post-harvest storage is one key to its greater commercial use. Refrigeration is an obvious possibility; few technical details have yet been reported, but trials indicate that lower temperature does increase the fruits' storage life. Means for reducing post-harvest losses—including pest- and disease control—would be useful. Pickling and other preservation methods should be tried as well. These could help make the fruit available out-of-season, and especially in the “hungry season” when nutrients such as this fruit provides are hard to find. Nutrient losses using various storage, processing, and preservation techniques also need detailing.

Reforestation Trials The tree has potential for use in environmental-improvement programs confronting such issues as soil erosion, the stabilization of reclaimed gullies, urban beautification, and the provision of shade for parks, paths, roadsides, schoolyards, and bus stops (especially those where children gather). Given the tree's many uses, it can contribute both environmental benefits and food for the needy.

¹⁹ Information from T. Silou.

²⁰ Giacomo, R. 1982. Biologie florale du safoutier (*Dacryodes edulis*) au Gabon. Rapport du projet FAO/CIAM, Libreville, Gabon.

SPECIES INFORMATION

Botanical Name *Dacryodes edulis* (G. Don) H.J. Lam

Family Burseraceae

Synonyms *Pachylobus edulis*, *Pachylobus edulis* var. *mubafo*, *Pachylobus saphu*, *Caharium edule*, *Canarium mubafo*, *Canarium saphu*, *Sorindela deliciosa*

Common Names

Bantu: bekwa (Banyangi, a subgroup of Bantu origin)

Benin: orumu

Cameroon: plum (pidgin), sibakwbri (Bakweri), sa (Beti), sa (Ewondo), tsem (Bamiliké), assa, tchou, letse, sau, say (Oroko)

Central African Republic: sene (Tonga), bukoe (Kitembo)

English: African pear, African plum, bush butterfruit, eben tree, native pear, bush mango

French: safoutio, le safoutier (the tree); safout, prunier (the fruit)

Nigeria: iben, ube, oibo (Ibo), elemi (Yoruba), orumu (Edo), eben (Efik), boshu (Boki), orumu, (Urhobo), oromi (Afemai)

Congo: safou, nsafou (Kikongo and Lingala), osaw

Description

The butterfruit tree is commonly 8-12 m high when grown under cultivation in the open, but up to 45 m in the forest and in old plantations. The trunk is generally cylindrical and straight. Although it can reach 1.5 m in diameter, it is normally much smaller. The plant has compound leaves with 4-12 pairs of leaflets (odd-pinnate; with a single terminal leaflet). It is deciduous, losing its leaves in the dry season.

Although the species has male and female flowers on separate plants, there are hermaphrodite (male/female) trees as well. Male flowers are larger (8-25 cm long) than female (5-15 cm long). At least in some vigorous inflorescences, the terminal bud forms the flowering shoot for the following year. Only female flowers produce fruit of course. Although the amounts vary, female inflorescences tend to be very productive. Hermaphrodites are less productive.

The fruit is ellipsoid, globular, or conical; 4-15 cm long, 3-6 cm in diameter. It is rose pink to white when young, deepening to blue, purple or even black at maturity. The pericarp, which represents half the weight of the whole fruits, consists of a thin, waxy, and colored epicarp and a pulpy mesocarp that is light pink, rose, light yellow, light green, or whitish in color. This pulp varies in flavor depending on the tree.

Distribution

Gabon appears to be the center of origin for the genus *Dacryodes*; among the 19 species that occur in Africa, 11 are found there.²¹ *Dacryodes edulis* seems to originate in the humid intertropical regions of southern Nigeria, Congo, and Cameroon. As noted, it is cultivated throughout West and Central Africa: the Gulf of Guinea, the interior basin of Congo, Cameroon, Congo, Gabon, Nigeria, Uganda, and central Angola.

Horticultural Varieties

There are no named cultivars but, botanically speaking, the species involves at least two distinct varieties:²²

- *Dacryodes edulis* var. *edulis* has large fruit, usually more than 5 cm long by 2.5 cm wide;
- *Dacryodes edulis* var. *parvicarpa* has small, more or less conical fruit, usually less the 5 cm long by 2.5 cm wide.

Environmental Requirements

Most of the world's oil-bearing plants are confined to narrow ecological areas. (Oilpalm and coconut, for instance, are restricted to hot and humid areas.) Butterfruit, however, tolerates several. It thrives, for example, in all the ecological zones of Nigeria and Cameroon except the very dry northern provinces. Although it fits well into savanna zones, its fruit production is greatest in the humid forest zones. In general, performance is best in the shade and in good soil.

Rainfall The plant tolerates rainfall from 600 mm to 3,000 mm and more. By some accounts, low humidity at flowering time may frustrate fruiting.

Altitude Low-medium elevation, from sea level to 1,500 m.

Low Temperature Unknown. One contributor reports the minimum at his location as 9°C (in January). Possibly the plant requires "low" night temperature for uniform flowering (22°C or 14°C have been suggested).

High Temperature Thrives where temperatures top 40°C.

²¹ Aubreville A. 1962. *Flore du Gabon, No. 3: Irvingiaceae, Simaroubaceae, Burseraceae*. Museum. National d'Histoire Naturelle, Paris.

²² J.C. Okafor described two varieties, both of which are cultivated (though var. *edulis* is preferred on account of large size). Okafor, J.C. 1983. Horticulturally promising indigenous wild plant species of the Nigerian forest zone. *Acta Hort.* 123:165-176

Soil Seems not to present a limitation. The species has been reported growing on oxisols, ultisols, loamy clay, sandy clay, humic ferralitic soils, deep loam rich in organic matter, andosols, and ferruginous (chalybeate).

Related Species

Currently, 19 *Dacryodes* species are recognized. None of the others has received even the pitiful amount of research accorded the butterfruit. Yet some species produce edible fruits. They, at least, deserve at least preliminary investigation. Examples are:

- *Dacryodes buettneri* (Gabon). Large and important timber tree;
- *Dacryodes igaganga*. Another large and important timber tree;
- *Dacryodes klaineana* (Sierra Leone; common name “damson”). Fruit juicy with a taste said to be “deliciously sweet/sour”; and
- *Dacryodes macrophylla*. Fruit also juicy and “deliciously sweet/sour.”





4

CARISSA

Carissa (*Carissa macrocarpa*) produces masses of beautifully shiny fruits that look something like plums. Their thin red skin covers a pinkish-red, almost mealy, flesh flecked with a milky juice. Flavor varies from tart to almost sweet, depending upon variety and maturity. In South Africa these are already significant commercial resources. Every January and February in southern Natal, for instance, large quantities are sold, notably along the roadsides.¹ Prized by one and all, they are bought in considerable quantity in cities such as Durban.

Even though production is now haphazard and essentially unsupported by modern horticulture, carissa has good potential as a greater crop. This fruit has an ample edible portion and no stone in the center. It can be eaten whole. Some have a sweet flavor suggestive of raspberry, but most are more like cranberry.

These are versatile foodstuffs. Fresh, they can be eaten out of hand. Halved, they make attractive and tasty additions to salads and desserts. The red pulp looks and tastes so good it is often added to sick-people's foods to entice them into eating bland pasty-colored porridges. The fruits are also dropped into water bottles and gourds to liven up the liquid contents (not necessarily plain water).

Despite widespread use as fresh fruits, carissas are more satisfactory when cooked. They are commonly tossed into soups and stews and squeezed over fish and meat, to which they impart both sweetness and flavor. Many are boiled into brightly colored preserves or fruity-flavored syrups. Some are canned or stewed or baked into pies and tarts.

The boiled juice and pulp have a milky-red appearance but both turn bright red on the addition of a little sugar. Carissa jelly, made by straining or sieving the stewed slightly under-ripe fruits and cooking them with sugar, is considered among the finest in South Africa. It is now gaining aficionados in

¹ In reality, two closely related species occur in South Africa. This chapter focuses on the larger-fruited one, *Carissa macrocarpa*, which is locally called big num-num (grootnoem-noem in Afrikaans). It is indigenous not only to Kwa-Zulu/Natal but also to the Eastern Cape. Outside South Africa, the fruits are commonly called Natal plum, carissa, or carissa plum.



Strictly speaking, the carissa is not an orchard crop—at least not yet. However, it is one of the better-known indigenous horticultural species of South Africa—grown mainly for its hedges, but renowned for its fruits. Not only is a carissa hedge striking to look at and impenetrable, its flowers exude a fragrance as delightful as jasmine, and its shiny red fruits are always in demand. (Forest & Kim Starr, USGS)

California and Florida as well. It has an exquisite color and a delicate flavor. A boiled sauce, whose bite and zing are reminiscent of the cranberry sauce Americans slather over turkey at Thanksgiving, is sometimes prepared; some carissa devotees prefer it.

In spite of their culinary attractions and widespread use, the fruits themselves are not currently produced in intensive culture. Instead, they are obtained from scattered ornamentals and hedgerows, both of which are common across southern Africa. This is because various types of the bush are used for property boundaries, screens, ground covers, landscaping accents, barriers against intruders (two legged and four legged), or container plants. Carissa is also espaliered against a sunny wall or pruned into small trees to beautify a backyard.

Few plants are more decorative, tough, or versatile. The clean and shiny look of the stiff, bottle green leaves makes the shrubs handsome year-round, and the bursts of fragrant flowers and crimson fruits lend added beauty. The star-like flowers, brilliant white against the deep-green foliage, provide special interest during the long flowering season. For this reason, the carissa has become a valued ornamental in California. Hedges of it are to be seen, for example, at the Los Angeles International Airport and at the University of California Santa Barbara.

PROSPECTS

We are far from being the first to suggest that carissa be cultivated on larger and wider scale. So far, however, little along those lines has occurred in practice. Nevertheless, recent decades have seen some progress. In that time, types with large fruit and high yields have been selected, and techniques for their vegetative propagation worked out. Some of these elite plants yield fruits as big as oranges.² A few have been selected specifically because they hold their fruits high above the thorny foliage, making them easier to harvest. And in California, some creeping cultivars have been selected for groundcover.

With these (and future) horticultural developments the carissa could become an important fruit of the warmer parts of the world. The species seems poised for greater success, and a handful of horticulturists could set it on its way to culinary usefulness in at least a dozen nations within Africa and without. The benefits of this breakout would go far beyond good nutrition and beautification. The potential for profit may be judged from recent commercial experiences with the cranberry, which in the past few decades has become a billion-dollar resource grown on a mere 10,000 hectares. On its merits, the carissa seems to have a similar potential for producing a terrific return from a tiny area.

This is not to say that the task will be easy. Difficulties include problems with picking the fruits (because of the plant's spines), handling the fruits (sticky milky juice), and preserving the fruits (chilling and handling and dealing with the milky latex juice have yet to be perfected). Nonetheless, relatively modest research seems likely to counteract each of these problems and thereby provide the world a new and especially brilliant crop.

Within Africa

The carissa plant is quite adaptable. It grows especially well in subtropical coastal areas—such as in Natal, southern Florida and Southern California—where it has a competitive advantage over plants that are bothered by sand and sea and ocean spray. But it appears to be adapted to other types of locations, although just how well it will perform as an economic crop is presently far from certain.

² Carissas with diameters of 6 cm have been produced in California. Information from C.A. Schroeder.

Humid Areas The promise in Africa's humid lowlands is uncertain and could be slight. The climatic ranges of Africa's various *Carissa* species are currently undetermined, but the plants tend to occur in subtropical and warm-temperate zones.

Dry Areas The species highlighted in this chapter (*Carissa macrocarpa*) enjoys its greatest production (at least given current experience) not in dry regions but in well-watered subtropical and warm-temperate zones. It has, however, quite reasonable, although not exceptional, drought tolerance.³ On the other hand, a related species, *Carissa haematocarpa*, withstands desiccated sites well, and holds high promise as a dryland crop.

Upland Areas Only trials will tell whether the carissa will prove a useful crop for Africa's highlands. For that particular region, *Carissa bispinosa* would likely be a better choice. Indeed, this relative might become strikingly useful throughout many tropical highlands. In its utilitarian promise it is almost as good as *Carissa macrocarpa*.

Beyond Africa

On the face of it, this is a plant with appeal beyond Africa. It is already cultivated (mainly as a hedged ornamental) in many subtropical areas around the world, as well as in a few tropical locations. But it is possible carissa will become a "cranberry for the warmer regions." Whether (or how soon) this happens will depend more on personal initiative than scientific support or government grant. Although the plant is already sufficiently developed for use as a crop, dedicated individual attention is needed to make it a satisfying commercial success.

USES

Like many species highlighted here, carissa offers many uses, including:

Fresh Fruits In South Africa, most carissas are eaten out of hand. For this, they must be fully ripe, dark red, and slightly soft to the touch. Like a strawberry, they can then be eaten whole, without peeling or seeding (this fruit's most outstanding feature) and have only slight acidity. Halved or quartered, ripe carissas make particularly good toppings for cakes, puddings, and ice cream. They are also much praised in fruit salads, to which they add both sprightly tang and vivid color.

³ Information from Harry van den Burg.

CARISSA HEDGES

The carissa is particularly valued as a hedge plant. It is used extensively in the southern half of the United States as an ornamental shrub and hedge planting. It withstands shearing admirably and its growth is compact and low.

“To make a hedge,” wrote David Fairchild, the dean of US plant explorers, “is a very simple matter. The seeds are sown in a seedbed, and when the young plants are 15 cm high they are transplanted to the place chosen for the hedge and set a foot apart, alternately in parallel rows, distant from one another a foot or more. As the plants grow they are trimmed into the desired hedge form, and the oftener they are trimmed the thicker they interweave their tough, thorny branches, making an impenetrable barrier for stock of all kinds. When in flower the white jasmine-like blossoms show off strikingly against the dark background of foliage; and the red fruit which follows is quite as pretty.”

Processed Products This is the carissa’s most immediate market. It may be processed into canned or frozen fruit, jelly or preserves, salads, sherbets, and sauces as well as juice. When less than fully ripe, they are very acid. Indeed, they can be considered a sort of “Africanberry,” yielding tangy sauces and jellies resembling those North Americans enjoy with turkey. As noted, unripe carissas are also good for jelly and jam, pies, and tarts.⁴ They are preserved whole by pricking, cooking briefly in a syrup, and sterilizing in jars. Peeled or unpeeled, they are also made into syrup or sweet pickles. Manufacturers of jams, jellies, and other foodstuffs can add a small proportion of ripe carissas to enhance the red color. Fruity vinegars are produced from overripe carissas. Even carissa wine is a possibility.⁵

Hedges Because of the strong spines, this plant makes great barriers. As has been mentioned, it is particularly valued for this in South Africa. It is especially useful for landscaping and privacy screens near the ocean because it tolerates both salt spray and wind damage. It also makes a sturdy, protective, stock-proof hedge for farms and homes. Even when closely trimmed, it continues yielding fruit in abundance, and home hedges are a major source of the fruits now sold. Prostrate cultivars that hug the soil are widely employed in California as groundcover.

⁴At this point in the draft one of our contributors enthusiastically scrawled: “Good jelly with venison!”

⁵One contributor attests to that fact. “I’ve tasted some very nice amateur wine from it,” he wrote on an early draft.



The pulp is sweet and milky red. It provides an excellent quantity of vitamin C. (Cori Ham)

NUTRITION

The carissa has relatively large quantities of sugar as well as sufficient acid and pectin to make good jelly. It is an excellent source of vitamin C, containing somewhat more than in the average orange.⁶ However, it is only a fair source of the other vitamins investigated. The fruit also contains calcium, phosphorus, and magnesium.

HORTICULTURE

This plant is easy to grow. Seeds germinate in 2 to 4 weeks but the seedlings grow very slowly at first. Plants grown from seed may begin producing fruit within 2 years,⁷ but they are highly variable and some prove unreliable and sparse bearers.

Vegetative propagation is preferred. Air-layering, ground-layering, or shield-budding are all possible. Cuttings planted directly after removal from

⁶ One analysis found 53 mg per 100 g of whole fruit. Wehmeyer, A. S. 1986. *Edible wild plants of southern Africa: data on nutrient contents of over 300 species*. Council for Scientific and Industrial Research, Pretoria.

⁷ Contributor Cori Ham notes, "I have a record of a carissa seedling bearing fruit just 18 months after germination."

the parent bush do not readily form roots unless grown over bottom heat. However, a method has been devised whereby nearly cutting grows.⁸ This consists in notching young branchlets by cutting them about halfway through. These are then bent downward and allowed to hang limply. After two months, when a callus has formed over the notch, the cutting is removed from the parent and placed in sand under a lath shade. Within a month it strikes roots. Such cuttings typically begin producing fruit within 2 years.⁹

Maintaining the plants is simple. A standard, balanced fertilizer for fruit production seems to suffice.

Pollination can be a problem. In its homeland, small beetles, hawk moths, and other night-flying insects visit the flowers. Elsewhere, various degrees of unfruitfulness have been attributed to inadequate pollination. Hand pollination is possible. In future, however, all hazards of poor pollination might be avoided by using plants whose floral structure favors a high degree of self-fertilization. Some of those have already been selected.

Even when grown solely as a fruit crop, carissa is often pruned into the form of a narrow hedge. This increases accessibility of the fruit, apparently without diminishing yield.

As a fruiting bush, the plant requires little pruning beyond cutting it back to restrain exuberant growth. If left uncontrolled the bush becomes too “spready” for easy access to the upper section where the fruits form. As long as not grossly overdone, trimming the plants is beneficial in that it induces more fruiting tips to develop. The plant may also be trained as a vine along a trellis, although this creates a straggling form of growth and seems to produce fewer fruits.

HARVESTING AND HANDLING

The main fruit production occurs in summer. The productivity is high, and 3 tons per hectare is considered a minimal yield under commercial production in South Africa. When growing conditions are favorable, the plants produce many off-season fruits as well.

The ripe fruits must be handled with care. They are thin-skinned, easily bruised, and highly perishable. Like peaches, they ripen at slightly different times, so each must be harvested as it ripens.

LIMITATIONS

All parts of the plant exude a milky sap when cut or broken. This is not poisonous but it often can mar the fruit’s appearance. As in figs, however, it

⁸ Information from Edward Simmonds.

⁹ Cori Ham also noted: “At the University of Stellenbosch, we’ve found that carissa propagates easily from cuttings if we use a commercially available growth hormone called Seradix B number 2. We’ve also found that the cuttings bear fruits after just 6 months in the nursery. They are grown under irrigation and set fruit continuously.

disappears with cooking. Stewing or boiling causes the sap to adhere to the pot (which must not be aluminum) and it can be easily rubbed off with a dry paper towel or a cloth soaked in salad oil.¹⁰

The fruits have a short shelf life because the “milk” in the red flesh congeals. This is a concern in discerning markets and where the fruit is unknown. For the same reason, the cooked pulp and juice can turn an ugly, milky red. Adding sugar, however, transforms them into a brilliant and beautiful shiny red treat.

The shrub is viciously thorny; to pick the fruit without jabbing yourself is difficult. Moreover, the fruits themselves are often pricked and punctured, which induces decay and blemishes.

Carissas are eaten fresh only when fully ripe. They are best if eaten the day they are picked. Under-ripe fruits lack the tangy, raspberry-like flavor and their latex tends to coat the mouth.

NEXT STEPS

Many things can be done to move the carissa forward into greater use. These include the following:

Varietal improvement There is much variation in carissa. In quality the fruits range from soft and many-seeded to firm and almost seedless. Many advances seem possible through selection and breeding. These include:

- Creating plants with fewer or shorter spines (to facilitate harvesting);
- Developing fruits with longer shelf life;
- Improving the fruits’ flavor, appearance, and juiciness; and
- Raising the productiveness of the plants; some fruit very prolifically while others fail to set more than a few fruits (despite blooming freely).

Plantation trials During the testing phase little genetic development is needed: the selections available are already of adequate (although not ultimate) quality. Tests and trial plots using better clones should be established to study the yield-per-hectare, the management methods, harvest requirements, and other features that have to be done on a practical scale.

Horticultural advancement In addition to genetic improvement, yield must also be raised and the regularity of fruiting smoothed out by such things as irrigation, fertilization, pruning, and the inducement of dormancy. In United States, various degrees of unfruitfulness have been attributed to inadequate pollination and the unproductive plants, apparently self-infertile, have been cross-pollination by hand, after which they bear fruits normally.

¹⁰ At this point on the manuscript, contributor Cori Ham noted: “The milky latex gave problems in manufacturing nectar. The latex settled out in the bottles into an unattractive white layer and it also stuck to the equipment causing a major cleaning operation.”

As carissa (i.e., *C. macrocarpa*) grows so well on its own roots, there seems little point in seeking compatible rootstocks. However, Firminger, an English horticulturist who worked in India in the mid-19th century, stated grafting carissa onto seedlings of karanda (a related Asian species, *Carissa carandas*) rootstock considerably increased fruitfulness and reduced the tree's size, making it easier to handle and harvest. This needs reconfirming.

SPECIES INFORMATION

Botanical Name *Carissa macrocarpa* (Eckl.) A. DC

Family Apocynaceae

Synonyms *Carissa grandiflora* (E. Meyer) A. DC; *Arduina macrocarpa* Eckl.; *A. grandiflora* E. Mey.; *Jasminonierium grandiflorum* (E. Mey.) Kuntze.

Common Names

English: carissa, carissa plum, Natal plum,

Ethiopia: agam

French: carissa

South Africa: amatungulu (Zulu)¹¹, big num-num, grootnoem or grootnoemnoem (Afrikaans), um-tungulu (Xhosa)

Uganda: epwakai/oba, acuga, enyonza, omyonza, omweronde

Description

The carissa is a large shrub or small evergreen tree as much as 6 m tall when left to grow free. It is twiggy, densely branched, and its stems bear long, strong, stiff, bifurcated spines. All parts contain milky latex. The species includes much genetic diversity and types varying greatly in growth habit, cold tolerance, spine shape and form, self-compatibility, and fruit characters have been observed.

Plants from seed usually grow into branchy shrubs, though a few become (after many years) attractive small trees with substantial trunks. Those grown from cuttings vary from prostrate ground covers to tall hedge plants. Cuttings tend to sucker badly unless all belowground buds are first removed.

Fragrant, white flowers—up to about 5 cm in diameter—appear intermittently all year (especially in warm areas near the coast), but most abundantly in spring and summer. They are big, attractive, and reminiscent of star jasmine. Some gardeners compare their sweet fragrance to jasmine; others to orange blossoms.

¹¹ Amatungulu is a plural; for one fruit the Zulu name is umntungulu.

Some carissa plants bear flowers that are functionally male. These male blossoms are larger than normal, their anthers are larger, and the stamens are much longer than the style. Functionally female flowers have stamens and styles of equal length as well as small anthers that produce no pollen.

The fruits appear in summer through fall, but at least a few can usually be found ripening every month of the year. They are paired berries, ovate to spherical, and 2.5 to 5 cm long. A fully ripe fruit has a waxy skin that is bright crimson streaked with darker red; it is thin and bruises easily. The flesh inside is deep red or crimson with white mottling. In the center are about twelve small brown flat seeds. Some are nearly round while others are elongated and pointed at both ends.

Distribution

The carissa is a common coastal species in South Africa. It is found on sand dunes and on the edges of coastal forest in Eastern Cape Province northwards through Natal to Mozambique. Now widespread tropically, it has become fairly common in southern Florida and is established in cultivation in southern California.

Horticultural Varieties

Horticulturists in South Africa, California, and Florida have selected and named carissa types that tend to bear more reliably than normal.¹² These are now being propagated vegetatively to reproduce them true to form. They tend to have large oval fruits of good texture and few seeds; they mature evenly and have good qualities for making jellies and for pies. They are also very productive.

In California, cultivars selected for fruit quality and productivity include Fancy (an erect form bearing many large fruits with few seeds), Torrey Pines (produces good crops of fruit and abundant pollen), Frank (low yielding, but a good supplier of pollen), Chelsey, and Serena. In Florida one of the best fruit bearers is said to be Gifford.

Efforts have been directed to the development of dwarf, compact, less spiny types for landscape use. Popular among these are: Bonsai, Boxwood Beauty, Dainty Princess, Grandiflora, Green Carpet, Horizontalis, Minima, Ruby Point, Prostrata, and Tuttle.

Environmental Requirements

The plant's climatic limits are basically unknown. However, based on present-day knowledge, it requires a warm, moist subtropical location. It

¹² A list is given by Julia Morton in, Morton, J.F. 1987. *Fruits of Warm Climates*. Julia F. Morton, Miami, Florida.

accepts a variety of exposures including full sun and fairly heavy shade. In shade it tends toward taller growth.

Rainfall Although native to coastal areas with annual rainfall of about 1,000 mm, the plant is drought-resistant and requires no watering in summer rainfall areas. As noted earlier, it has reasonable drought tolerance.

Altitude Unreported, but in Swaziland, it reaches about 1,000 m. A likely upper limit for good growth is 1,500 m.

Low Temperature The carissa grows where temperature rarely falls below freezing. Well-established plants can, however, survive -5°C relatively unscathed. Young plants need protection when the temperature drops to about zero.

High Temperature The upper limit is unknown but during summer in Pretoria it survives temperatures up to 32°C (in the shade). Best growth is obtained in full sun.

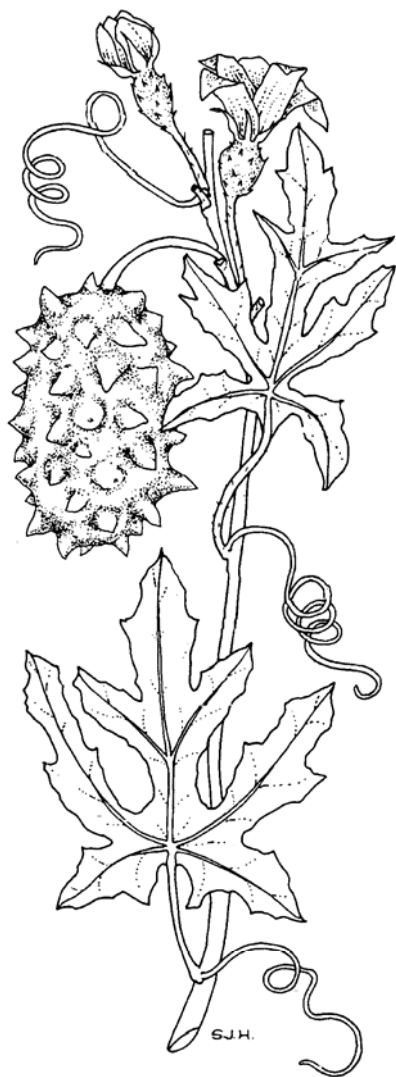
Soil The plants are not exacting in soil requirements. Almost any substrate, limestone heavy clay to sand, is fine as long as it drains well.

Salinity Carissa is quite salt tolerant. For irrigation purposes, water of 8 mmho conductivity (about 5,000 ppm) is acceptable. As mentioned, it withstands salty spray, making it a good choice for coastal gardens.

Related Species

Generally speaking, *Carissa* species in Africa occur in two vast belts from Senegal to Sudan, and from Ethiopia to South Africa. These, too, produce edible fruits. At this stage, they remain undeveloped and the fruits seem less tasty than the species from Natal. As noted, however, *C. haematocarpa* may have special potential in drier areas, and *C. bispinosa* at altitude. A few *Carissa* species are also found in Europe, Asia, and Australia. Though *C. macrocarpa* currently seems most promising as a potential cultivated crop, the others deserve exploratory research and testing.





5

HORNED MELON

Horned melon (*Cucumis metulifer*) is one African fruit that has broken into international commerce, albeit recently, and largely on its looks alone. Until you see one, it really is difficult to appreciate its appearance. One author described it as “an extraordinarily attractive object, simultaneously ugly and beautiful.” Others use words from “cute” to “horrifying.”

The unique appearance of today’s horned melon¹ is what sells the fruit in increasing numbers worldwide. It has moved beyond curiosity to become fairly common in many upscale markets, often because people like to eat it but more often for its outstanding (and long-lasting) visual qualities. In fact, from a global perspective, horned melon is as much an ornament as a food.²

This surprising success became possible when, in 1982, an adventurous New Zealand couple began cultivating this formerly obscure and essentially wild African fruit. Among its genetic diversity, John and Sharyn Morris found a horned-melon specimen whose fruits were breathtakingly brilliant. They learned how to produce it on a commercial basis. They designed special shipping boxes. And within two years they were exporting their Kiwano® to Japan, where it aroused intense curiosity and sold readily.

Soon fruits were being flown to the United States, and then they began arriving by container loads on ships. In all U.S. history, few fruits have been heralded with more hyperbole. One fruiterer who markets over a hundred specialty crops reported that, “Horned melons created more furor and generated more curiosity than any produce item we have helped introduce to the American scene.” Moreover, American farmers started to grow their own. Israel too began commercial production, and now sells fruit to Europe under the name Melano®. It is now also grown along the Mediterranean, and Kenya too is exporting these strange-looking fruits. Most are still shipped by air and, despite the high costs passed on to consumers, they sell.

¹ Other common names include jelly melon, métulon (France), and the trademarked names Kiwano® (New Zealand) and Melano® (Israel).

² Such uses should not be dismissed just because they don’t feed the buyer; the desire for ornamental plants around the house can put good money into a growers’ pocket. After all, the biggest use for the nearly \$200 million pumpkin crop in the United States is the hollow Halloween jack-o-lantern; the flower industry is of course worth billions.

To eat a horned melon, you slurp down the vivid green jelly inside. The embedded seeds are soft and normally swallowed at the same time. The taste? Some liken it to lime, others to cucumber, and yet others to a ripe-banana/green-banana cross, or even pomegranate or papaya. Yet others say that it is just like itself and little else; whatever the taste, it grows on a person. Many cultivars have no hint of cucurbit bitterness, and there are good opportunities for improving the overall flavor. The sugar content in some selections has already been doubled. But the primary allure for buyers is still its appearance, both as a whole-fruit decoration or as a beautiful garnish when sliced or diced.

Of all the world's fruits, perhaps none has a better shelf life. The horned melon is a buyer's dream, sometimes remaining in good condition for 6 months at room temperature even in the tropics. It ships without refrigeration, and in the home, uncut, it can remain a delight for months. Indeed, this is one fruit that must be kept far away from cold. Chilling softens it and makes it susceptible to molds. Cool *decreases* shelf life.³

The horned melon can also be a seller's nightmare. Anyone who harvests and packs it must wear gloves because the leaves have needly hairs and the piercing horns on the fruit make it hard to handle. Shippers use nylon brushes to quickly and easily grind down the sharp spikes to rounded nubs, so people can then handle the fruits without stabbing themselves. Even so it is necessary to protect each fruit, for the ground-down projections can still easily spear adjacent fruits unless there is space or a barrier between them.

Despite the fact that this money-maker seems like a modern creation from New Zealand, the crop is actually an old one out of Africa. It grows, usually wild and not abundantly, in the warmer climes of southern Africa, and sporadically as far north as Nigeria and Ethiopia and even eastward across the Red Sea. It is a resilient plant, found especially clambering along roadsides and gully fringes as well as on fallowed and abandoned lands. It seems to prefer life among the weeds, and it is commonly overlooked by passersby. Of course, the average wild specimens are not nearly as colorful or distinctive as today's cultivars, but they are nonetheless unmistakable.

In a few parts of Africa, people cultivate this plant in backyard plots, adding its fruits to their salads and other dishes. A few even garden it commercially. It is well represented, for instance, in Malawi's food markets. Flesh and seeds are eaten raw, and in places the immature fruits are relished like cucumber. Wild fruits are also baked whole like pumpkin, especially across the Kalahari, and are also sun-dried for future use. Nonetheless, in most parts of its native habitat, hardly anyone knows this fruit well.

The horned melon has already revealed to the world one rewarding facet of its character. Although this chapter naturally focuses on its surprising

³ Ironically, this has proved to be one of the biggest problems with marketing horned melons in the United States. Supermarket managers are so used to cooling and watering their produce that they cannot break the habit.



A spiky orange oddity crammed with white seeds and vivid green jelly, the horned melon has gone international in recent decades, with several nations shipping it around the world. Back in its African home, the plant is still little used. Seemingly, much more could be made of this strange comestible, one of the few fruits with green flesh when ripe. (© 2005 Monica Palacios-Boyce, Ph.D.)

commercial success, readers should not ignore other merits—such as long storage life or resistance to grazing—as they work to bring this plant to its full potential. Currently, essentially only one genetic aspect of horned melon is exploited: its stunning visual appeal.

Expanding research on this profitable quality will continue to have pay-offs, but visionaries should not let this blind them to other possibilities that are perhaps contained in the untapped biodiversity of this widespread species. Any plant from the same genetic pool as melon and cucumber, yet which has such high tolerance to disease and drought, deserves much greater attention from plant champions. For example, expanding its now-thin flesh could be a goal, perhaps developing a much-needed substitute for disease-bedeveled cucumbers and pickling gherkins. Maybe targeting baking qualities could yield a new, staple-like source of carbohydrates. Even fiercer spines might be emphasized, creating prickly “desert water bottles” that ward off four-legged thieves while holding their moisture for humans. Other innovators might focus on the abundant seed. As with other “lost” fruits, combining imagination, hard work, and a little luck might transform horned melon into an indispensable part of Africa’s own fruit repertoire.

PROSPECTS

What future this brilliantly delightful member of the cucumber clan will have is anyone's guess. In its present form, it may prove a fad that collapses. Many people are disappointed who bite into the fruit anticipating a taste to match the exciting appearance. On the other hand, so many people pay good money for its looks that this alone might motivate clever horticulturists to overcome any perceived culinary constraints. In Africa, Zimbabwe, Botswana, and South Africa already grow sweeter selections. A great tasting horned melon might become a major crop to join its cousins, the melon and watermelon (see chapters in this section). Other routes may also open. In particular, its potential as another "cucumber" seems promising.⁴

Within Africa

Humid areas Uncertain. The plant can thrive under humid conditions, but tropical heat and humidity tend to foster vine growth over fruit set.

Dry areas Good prospects, especially when irrigation is available. This is its native habitat and, in Botswana for instance, the plant survives where the rainfall is around 450 mm rainfall. However, it generally needs to be irrigated like melon to get reliable commercial production and to extend the harvest beyond the rainy season.

Upland areas Fair prospects. The plant is found naturally occurring to elevations of about 1,000 m. However, the level of success as a fruit crop depends on temperature; uplands whose growing season is cut short by cold may be problematic.

Beyond Africa

Some types should produce almost anywhere melons thrive (see Chapter 8). In Israel the crop is mainly grown (under irrigation) in the Dead Sea Rift, where heat and other conditions are extreme.

USES

This fruit is generally eaten raw or transformed into juice. Not everyone likes eating horned melon out-of-hand, but those that do usually cut it lengthwise and serve it "on the half shell." Another method used by

⁴ Additional prospects, as well as greater technical detail than possible here, are outlined for horned melon and an increasing number of other African species by Plant Resources of Tropical Africa at www.prota.org; see Preface.

harvesters and packers in New Zealand is to cut off one end, loosen the jelly inside with a knife or clippers, put to mouth, and squeeze.

The fruit can also be used in prepared form. There are claims it is, “the best thing ever to happen to a salad”; others believe that it is at its most delicious when simply mixed with plain yoghurt. In France, chefs make sorbets from the pulp. Various “green” drinks have been concocted as well, while pouring the pulp over vanilla ice cream is said to create a special treat, the sweetener in the ice cream bringing out the flavor latent in the fruit.

In Botswana, whole ripe fruit are baked in the coals of fires. They are also peeled, split open, sun-dried on both sides, and stored as ready-made preserves. This cucumber relative can also be used as if it were one. Immature fruits are often peeled and eaten raw, tasting like cucumber. Both these and the small, hard, wild forms are also often pickled like gherkins.

The leaves—like those of other members of the family—are picked when young, boiled, and eaten like spinach. The leaves have a high concentration of useful minerals, but the presence of antinutritional or toxic components is unknown.⁵ One contributor notes that they’re “not too tasty,” a frequent criticism of highly nutritious leafy vegetables.

NUTRITION

The fruits are more nutritious than cucumbers, having notably higher values for most nutrient components. One analysis shows the fruit to be about 90 percent moisture, and containing (on a dry-weight basis) about 10 percent protein, 6 percent fat, and 45 percent carbohydrate, with only about a third to a half the vitamin C of fresh oranges.⁶

By analogy with its relatives, it seems possible the soft flat seeds—which have a nutty flavor—are rich in both protein and oil. If indeed good for you (see Limitations), these might make them an important foodstuff, especially in malnourished regions.

AGRONOMY

Although this fruit is produced commercially in New Zealand, France, Israel, Kenya, California, and elsewhere, few details on how to grow it properly are published. The seeds are reportedly hard to germinate, but one of our contributors wrote, “Seeds germinate readily if they are prepared as

⁵ It was recently reported that mineral concentrations in the leaves exceed 1 percent of plant dry weight, “a much higher value than typical in conventional edible leafy vegetables.” Odhava, B., S. Beekrumb, U. Akulaa, and H. Baijnathc. 2007. Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. *Journal of Food Composition and Analysis* 20(5):430-435.

⁶ Arnold, T.H., M.J. Wells, and A.S. Wehmeyer. 1984. Khoisan food plants: taxa with potential for future economic exploitation. Pp. 69-86 in Wickens, G.E., J.R. Goodin, and D.V. Field, eds., *Plants for Arid Lands*. George Allen and Unwin, London.

follows: “The seed plus jelly is diluted by water and one should let it stand until it begins to smell and is contaminated with fungi (about 5-7 days at room temperature). Then they must be well washed from all jelly, which contains some inhibitory factor for germination. Next step is to dry the seed in air on nets and keep them dry til use.” Some growers report greater production if plants are established in nurseries and then transplanted.

At first sight, the growing plant would seem to have no particularly special requirements. Practices used in cultivating squash, melons, or cucumber are likely to bring success. But we are told that Israeli researchers have found that irrigation regimes, fertilizer applications, sowing dates, and stand densities all affect yield and fruit quality considerably. In particular, it was found that fruits growing on the ground suffer blemishes and off-colors. Premium fruits are therefore grown on high trellises.

This climber grows well under trees or in thick bush and is said to “leap” onto a fence post or a fence wire in full sun. Israeli farmers grow it using open fields, shade houses (open to the air), and greenhouses (closed), a combination that allows them to supply the fruits year round.

The plant is notably resistant to disease and pests, including many of other cucurbits. In the wild its only enemy seems to be a caterpillar that eats its way into fruits lying on the ground. In several experiments with other cucurbits, it proved the one most resistant to nematodes (*Meloidogyne incognita* and *M. javanica*). It is also ignored by the pumpkin fly (*Dacus bivitattus*), a fruit fly that is the bane of curcubit agriculture in Africa.

Nonetheless, diseases can be a problem. Israel has encountered several viruses (notably, zucchini virus), and perhaps bacteria causing “water spots” on the fruit. Also, especially in a wetter climate, fungi can be problematic.⁷

When grown in greenhouses the crop needs a pollinator, such as bees. Beehives also help when horned melons are grown in the open. Bees, however, are not naturally attracted to the flowers, and visit only when nothing better is around.

HARVESTING AND HANDLING

Fruits reach full size about 40 days after pollination and the main ripening phase (sugar accumulation and color change) is complete about two weeks later. Harvests exceeding 40 tons per hectare have been reported under ideal conditions. During ripening, fruits exhibit no extra output of carbon dioxide or the ripening hormone ethylene, which in part explains their long shelf life. They are sensitive to ethylene, however, and applying it accelerates ripening, softening the peel and turning it orange in a few days.

As already noted, the horned melon is a food-handler’s dream—at least as far as shelf life is concerned. Provided a dry atmosphere is maintained, the fruits will keep for at least six months at temperatures between 17° and

⁷ “The plants get all the usual things like mildews,” wrote contributor Aliza Benzioni.

24°C. Shipments from New Zealand remain at sea over three weeks at temperatures of 20-22°C and normally arrive beautifully orange, their prongs firm, and without the loss of a single fruit. The only problem likely to be encountered under normal marketing conditions is a slight dehydration, which may be prevented with a light coat of wax.

As noted, refrigeration must be avoided. Chilling kills the taste, softens the skin, and allows even the rounded horns to puncture neighboring fruit. In addition, dividers must be used to separate the layers and keep the fruits from spiking each other. New Zealand exporters separate the layers with cardboard and cushion each fruit in wood wool. Israeli growers pick directly into the final shipping boxes.

LIMITATIONS

All the new plantings and international movements of a spiky fruit crammed with seeds have caused some observers concern that the horned-melon trade is exposing the world to a rampant, vigorous vine that will become an irrepressible weed. So far there have been no reports of serious outbreaks, but for at least 60 years the plant has been naturalized in tropical Australia and is said to be a nuisance, and at odd times a curse. In Queensland, for instance, the plant is a sometime pest of sugarcane fields and farms,⁸ although it is not regarded as a weed in South Africa or Botswana.⁹ It is also considered a nuisance weed at one location in South Carolina (the USDA Vegetable Laboratory near Charleston) but has remained very localized. So far at least, there has been no evidence of calamitous outbreaks. "After years of production we see no problems," the Morrisises reported in New Zealand, a country traumatized by disasters with exotic plants. And Israel has not encountered problems with the crop turning pestiferous.¹⁰ And one of our contributors writes "Not in Europe," either.

As noted, the fearsome spines are a hazard. Pickers must wear gloves. In New Zealand, warehouse workers also used protection to push the fruits against brushes and blunt the botanic weaponry, although that process has now been automated.¹¹

As has been also noted, many people initially find the horned melon unappealing as a foodstuff. The appearance certainly can be disconcerting.

⁸ *Weeds of Queensland* adds, "it is controlled with herbicides and by disposing of the fruit to prevent reseeding." Kleinschmidt, H.E. and R.W. Johnson. 1977. *Weeds of Queensland*. Government Printer, Queensland.

⁹ One of our contributors wrote: "I have never seen it become a pest in Africa. It occurs only in small quantities, and most are widely scattered. The fact that it is sought after by goats and other livestock diminishes its chances of reaching pest status. In any case, it is nutritious, people would eat it if it became common. I have yet to see an edible melon turn into a pest—a ridiculous notion to my mind."

¹⁰ Information from Aliza Benzioni.

¹¹ Sandpaper and even files are also used in smaller operations and home gardens.

One cynic has written that it “is roundly unloved on first acquaintance, and tepidly liked by only a few.” Nonetheless, this exotic orange-spiky edible is continuously gaining adherents, and not everybody dislikes it at first bite. Taste may be improved by selection, mutation, hybridization, or autopolyploidy, and new selections may be already changing this attitude. Reportedly, even Californians are beginning to enjoy it for its flavor.

In selecting wild fruits, it is important they be of the “sweet” type. Some wild plants yield fruits that are bitter, purgative, and emetic. Details of what these off-types contain are incomplete, but the bitterness comes largely from the toxic cucurbitacins and, probably, other compounds common in cucurbits. One contributor to this chapter wrote, “The wild ones in Botswana are seldom, if ever bitter.” Yet, another wrote, “When uncultivated types from Queensland were sold in Australia, the market slumped.”

At least some of the plants are daylength sensitive. In temperate zones, they set fruit so late in autumn that they cannot mature before winter strikes. This has been noted in Israel, for example, where it was found that the seeds had to be sown in March or April; sowing in May or June was too late.

Although many seeds are unavoidably swallowed while eating the flesh, and they are also reported as edible when eaten alone, their safety needs greater substantiation, especially if the horned melon is to be developed as a melon-seed crop. There are reports that, as in many plants, the sprouting seed produces a toxic substance in its embryo.¹² In addition, seeds are traditionally also ground into a fine flour and taken with water as a vermifuge to expel tapeworms or other parasites.¹³ As noted, the flesh can range from bitter to sweet, and the same is probably true of the seed.

NEXT STEPS

Although proponents may see horned melon as an international success story, the crop is barely beyond its formative years and its domestication has hardly commenced. The future could see it trail away almost into economic nothingness, but that seems unlikely. It might also see horned melon transformed into a mature and respectable resource, one that perhaps is very different from the often tasteless, spiky oddity common today. Actions likely to help include the following.

Breeding Better Fruits Currently, some consumers don’t like eating horned melons. However, improvements are certainly possible. Breeding programs aimed at improving their taste without losing their looks are having a big impact. Already, it seems likely that far better types than today’s are within reach. For example:

¹² Frohne, D. and J.A. Pfänder. 1984. *A Colour Atlas of Poisonous Plants*. Wolfe Publishing Ltd., London

¹³ Chiej, R. 1984. *Macdonald Encyclopedia of Medicinal Plants*. Macdonald, London.

- Seedless forms have been created.¹⁴ These are small but nonetheless promising. They change the fruit from “a bag of seeds” to a glob of green jelly that is unique. Indeed, researchers in both France and Israel are growing the crop in winter under glass to produce seedless (i.e., parthenocarpic) fruit.
- Manipulating ploidy level (as done in watermelon, for instance) could be a means toward both improving flavor and inducing seedlessness.
- Improvement of taste may be achieved by combining genetic material from various sources.¹⁵
- Spineless forms of the fruit are also known, and it seems probable that these, too, might prove useful. They could be a new foodstuff altogether—less of an oddity but easier to handle and something like a cucumber with a lime jelly interior.

It is also possible to breed in other directions, toward more seed for example. Although the genetic potential is unknown, the disease-resistant and already seedy horned melon could become a premier crop for producing melon seed on a commercial scale. Also needed are better techniques to remove any fibrous seed coating and, as noted, confirming their edibility after processing (they are usually roasted, which detoxifies many seeds).

Also as mentioned, emphasizing traits already useful in the fields of Africa should not be overlooked. These include types for pickling, or that have even longer storage lives, retain water reserves longer when left on the ground unpicked, or perhaps that even have greater spininess so their fruit with its precious liquid is saved for humans and not slurped down by foraging animals. Many believe its brightest future is as a new “cucumber.” Finally, its genetic potential as a leafy vegetable should also be explored.

Indigenous Biodiversity It is highly important to create as wide as possible a collection of different genotypes from as much of Africa as possible to broaden the available genetic variability. It would seem logical that where this plant grows wild, explorers will find a wealth of genetic diversity.¹⁶ Remarkable diversity has been noted at the USDA Vegetable Laboratory, where some introductions are daylength sensitive, some show excellent resistance to nematodes, and there are varying degrees of spines on

¹⁴ Information from J.-Y. Peron.

¹⁵ “We found some lines with higher sugar and others with higher acidity, and crossed each of them with the commercial line,” wrote contributor Elaine Solowey. “From that, we got F1 lines with better taste and aroma.”

¹⁶ C.A. Schroeder wrote us, “There are, for example, many fine forms in Malawi.” However, another contributor reported that the *useful* diversity in Africa was limited. “Generally the variation in the species is surprisingly small. We scanned big areas to find some plants with different appearance and none was what we were after.”

fruit from very large to none. It is important that variants be located, and useful types sorted, classified, and evaluated. Getting a better handle on the species' diversity will lay the groundwork for all the developments to follow, and today much needs to be done to outline these genetic features.

Horticultural Development Research to perfect cultivation practices is much needed. Some of this has already begun. In several countries research groups have been intensively studying the crop both under glass and in the open field. Production research needs include the artificial induction of fruit setting as well as optimizing growing conditions. Israeli researchers report getting reasonable yields of quality fruits with brackish irrigation (3.5-4.5 Ds/m), and many believe the salty water enhances the flavor.

The plant's interactions with nematodes, a curse of cucurbits, are certainly worth exploring. Its resistance could prove an important general finding, perhaps even giving this species a role in crop rotations—cleansing the soil of these very destructive soil nematodes. One group of researchers has also shown that using horned melon as rootstock for melon in root-knot infested soils can reduce galling, shoot-weight loss, and nematode levels at harvest.¹⁷ Techniques such as grafting can be important not just in high-value commercial horticulture, but also in the worst of situations where subsistence growers, for instance, have no choice what soils they use for planting their crops.

Helping Other Melons By comparison with its better-known relatives, cucumber and melon, this crop shows exceptional resistance to diseases and pests. Thus, the possibility exists that horned melon could help broaden the gene pool of either or both. All three belong to the same genus, *Cucumis*. Genetically speaking, horned melon is closer to melon than cucumber, but so far no one has successfully crossed any of them.¹⁸ In attempts to transfer pest resistance to cucumber, researchers have found that fruits develop in crosses using horned melon pollen; however, no viable seeds from this chimera have yet been found to carry on these genes.¹⁹

Although gene transfer is undoubtedly difficult, all avenues seem worth pursuing because success would likely reduce costs for producing both crops and benefit the environment as well. In particular, it might dramatically boost the common melon's resistance to nematodes, whitefly, and major diseases such as powdery mildew, downy mildew, and mosaic virus.

¹⁷ Sigüenza, C., M. Schochow, T. Turini, and A. Ploeg. 2005. Use of *Cucumis metuliferus* as a rootstock for melon to manage *Meloidogyne incognita*. *Journal of Nematology* 37(3):276-280.

¹⁸ Information from J.-Y. Peron and P. Nugent, who report that the pollen tube begins to germinate but does not reach the ovules.

¹⁹ Walters, S.A. and T.C. Wehner. 2002. Incompatibility in diploid and tetraploid crosses of *Cucumis sativus* and *Cucumis metuliferus*. *Euphytica* 128(3):371-374.

SPECIES INFORMATION

Botanical Name *Cucumis metulifer* E. Mey. ex Naudin

Family Cucurbitaceae

Synonyms *Cucumis metulifer* Naudin²⁰

Common Names

Afrikaans: rooikomkommer, rooi-agurkie, wilde-komkommer

Bantu: nku, mutete, mugaika, mukaka, uhufafa

Botswana: magabala, mogau

English: spiny cucumber, horned cucumber, jelly melon, Kiwano[®]

French: métulon, concombre africain

German: Horn-Gurke, Hommelone

Israel: Melano[®]

Malawi: cucumber, bitter wild cucumber

Shona: mutete, mugaika, mushonga, mugaka

South Africa: bitter wild cucumber

Tswana: magabala

Venda: mukake

Zambia: mugagachiga

Zimbabwe: mushonga, mugaka, mutete, mugaika (S); ihalabujana; muGumudza' mbga (N)

Zulu: uhufafa

Description

The plant is a sprawling, climbing, or trailing herbaceous annual that scrambles over bushes and trees in the wild. It has slender, hairy stems several meters long. The leaves are long-stalked and heart-shaped, shallowly 3 to 5 lobed, and dark green. Slender, curling, unbranched tendrils arise from the axils. The flowers are small, yellow, funnel-shaped, and opening to 5 lobes. The unisexual male and female flowers grow on the same plant. Seed can be true-to-type unless there is outcrossing. The female flower grows above a prickly green ovary, which enlarges to form the fruit. Honeybees are inefficient pollinators but its natural insect pollinators are unknown.

The fruit is ellipsoid, about 6 x 12 cm, light green at first and ripening to bright orange. The skin usually has a broken pattern of light, scribbly reticulations, punctuated with pyramidal spines topped with a bristle. The “flesh” is translucent, green, and filled with whitish seeds.

²⁰ This binomial, from 1859, is still the most-often cited scientific name (and should for now be used in internet searches). It has been “corrected” to the proper Latin termination under Article 32.7 of the Vienna 2006 International Code of Botanical Nomenclature.

Distribution

Although the botanical literature claims that this species can be found south of a line extending from Nigeria to Sudan and Ethiopia (and across to Yemen), the primary diversity is far south of that. The main concentrations are in Botswana, Zimbabwe (in mopane woodland), Malawi, Zambia, Mozambique, Namibia, Swaziland, and South Africa (lowveld and extending south along the coast to just touch the eastern edge of Cape Province). Commercial lines are exported from Kenya.

Beyond Africa, the plant is currently under small-scale commercial cultivation at least in New Zealand, the United States, Israel, the Netherlands, Italy, Spain, Portugal, and France. It has also been introduced many other places.

Environmental Requirements

As a general rule, suitable sites for horned melon are those where cantaloupes can be cultivated (see Chapter 8, Melon).

Daylength Flowering and fructification can be influenced by daylength. Flowering induction seems to require short days; days longer than 14 hours halt flowering. On the other hand, short days can lead to parthenocarpic fruits, in which the fruits grew directly from the ovule (like pineapples and bananas) without the intervention of pollination. Details are currently uncertain but the optimum length is said to be 12-hour days.

Rainfall The plant is not particularly demanding of water and performs well with as little as 350 to 550 mm. However, dry air during the harvest period is a benefit.

Altitude Although current commercial experience suggests that the plant performs best near sea level, it is probably better to say that it grows well at low to medium altitudes, up to perhaps 1,000 m. Near the equator, however, the upper limit may be closer to 1,800 m.

Low Temperature The lower survival temperature is probably 0°C. However, cool temperatures during the growing period can suppress growth. A report from France notes that optimum germination temperatures were found to lie between 20 and 30°C. Germination was delayed at 12°C and totally inhibited at 8°C.

High Temperature The plant's growth is largely unaffected by temperatures as high as 40°C; however, it seems that temperatures over about 30°C affects flowering. In addition, germination is greatly inhibited at temperatures above 35°C.

Soil This is a rugged plant in most soil types, and likely to survive in most African locations. However, top yields of quality fruits requires well-drained soils with organic matter and balanced nutrients.

Related Species

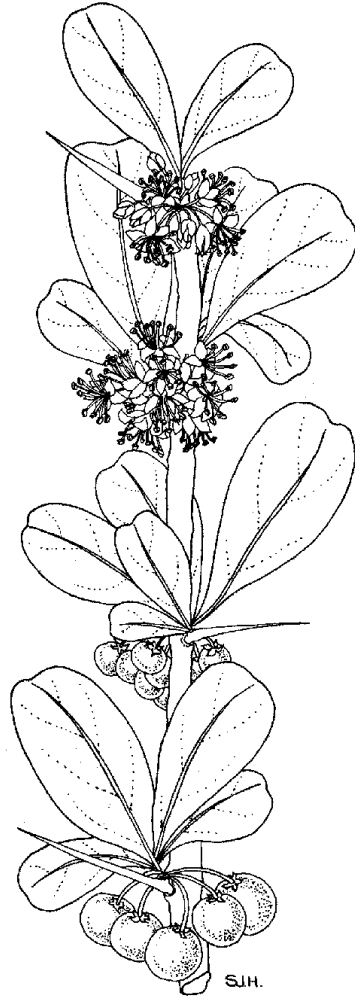
The genus *Cucumis* contains around 30 species of the Old World tropics, mostly Africa. It includes both cucumber (*C. sativus*) and melon (*C. melo*; see Chapter 8 in this section). Although cucurbits are notorious for hybridizing among themselves, attempts over the past 40 years to cross these species with horned melon have almost always been uniformly unsuccessful (see Next Steps, above).

West Indian Burr Gherkin (*Cucumis anguria* L.)²¹ The burr gherkin has long been used for making fine pickles and is called by some the “true” gherkin (the word traditionally applies to immature cucumbers). Although native to Africa, this small fruit is commonly called “West Indian” gherkin because its cultivation and use is so widespread in those islands. It is also grown, and has also naturalized and sometimes spread as a pest, in other parts of the tropics. In Africa, wild types grow down from Tanzania and across to Namibia, and the cultivated West-Indian forms have been introduced in many places. The small fruits (about 5 cm long) are covered with burrs like horned melon, except the spines are fleshy. Though usually bitter, nonbitter types have been selected in several countries and, in addition to pickling, are eaten fresh, dried, and in soups. The leaves are also eaten. Both cultivars of the West Indian gherkin and the wild types of Africa have drawn the attention of scientists because of potential disease and pest resistance (especially whitefly), but little has been done to explore and improve the horticultural potential of these productive fruits. It is possible that its yield potential is higher than for pickling cucumbers.²²



²¹ Also once called *Cucumis longipes*.

²² Information from Plant Resources for Tropical Africa, at www.prota.org.



S.H.

Dovyalis caffra

6

KEI APPLE

Kei apple (*Dovyalis caffra*) is indigenous to the southern regions of Africa, including Malawi, Zimbabwe, Mozambique, and South Africa. Its fruits look something like small golden apples. Produced in abundance, inside their thin, tough skins is a yellow, melting, juicy pulp with a fruity aroma. Although a cultivated crop, horticulturally speaking this plant is poorly developed, and the fruits are basically underexploited. Partly this is because the plants are very thorny. Partly it is because many people don't like the fruit's smell. And partly it is because the pulp can be **very** sour.

Kei apples are sour for the simple reason they have more vitamin C than oranges. Because of their tartness, they are most commonly converted into jams or other preserves soaked with sugar. However, sweeter types that are pleasant to eat raw are becoming available, and this alone seems likely to open new horizons for the crop.¹

A tall and vigorous shrub with rich green foliage, kei apple² is sometimes cultivated in orchards, but mostly grown in hedgerows and as solitary dooryard plants. It is commonly seen in hedges, forming countless rural corrals in southern and eastern Africa. In some climates the untrained plant takes on a rather scraggly appearance, but still makes an excellent hedge. Being evergreen, it provides a year-round screen, while its long sharp thorns deter both people and animals. For this reason, in the 1800s it was introduced, and is still planted, in northwestern Australia, St. Helena, littoral France, Algeria, and Italy, as well as Costa Rica, California, and elsewhere.

This tough shrub does well in almost any soil, including limestone, but cannot tolerate damp sites or high watertables. It is extremely drought resistant and also tolerates salinity, even ocean spray. For this reason, it is especially valued near the sea. It is used as a windbreak and ornamental in coastal California, for example.

¹ Even these selected types do not appeal to everyone. One of our contributors wrote: "I have had sweet forms of this fruit; they tasted like cold oatmeal."

² The word is pronounced "kye," and refers to the river in eastern South Africa that forms one border (and the name) of Transkei. There, this fruit is known as "umkokolo."



The shrubby, thorny, kei apple plant produces fruits that resemble little golden apples. Indigenous to the southern zone of Africa it produces fruits in abundance. (Cori Ham)

Though unexacting in its requirements for survival, the plant produces fruit best in subtropical climates and on humus-rich soils. There, it can become laden with its little golden “apples,” in some locations bearing them almost continuously year-round.

In the past, the sourness of even the ripest fruits seemed a barrier to the crop’s wider acceptance. But even the sourest kinds could now have a future. In today’s markets, fruits need not be sweet to be successful. Cranberry, for example, is biting sour and is increasingly used in the United States just for that reason. It gives “zest” (and color) to drinks, candies, jelly desserts, and many other food products.

The sweet kei apples now coming available add a new dimension. For instance, one southern California nurseryman, D. Silber, has selected a type with what he says are large, sweet fruits. He has named it “Arcadian zulufruit” and propagates it by rooting softwood cuttings. Since the plant is so productive, he claims that a single male/female pair can fill a household’s fruit needs throughout its fruiting season, which at least in southern California is most of the year.

This is perhaps a glimpse of the potential inherent in this species, but the key for opening the door to the kei apple’s future is genetic selection (as is the case for most fruits). However, much more still remains to be done

before the true extent of this species' promise can be glimpsed, let alone fulfilled. The fierce spines are helpful in a hedge but a hindrance in an orchard. Over the years less spiny strains have been selected, but undoubtedly awaiting discovery and development, especially in Africa itself, are even less spiny ones.

PROSPECTS

All in all, a start has been made. However, this plant needs much more research attention before it can contribute significantly to commerce. Needed are better tasting types that are easier to produce as crops. Until then, its major role will be limited to areas where the environment will not permit better-known fruits to be grown.

Within Africa

As of now, the kei apple in Africa is generally restricted to subtropical areas of South Africa.

Humid Areas Prospects uncertain.³ In South Africa the plant seems to thrive best where annual rainfall is 1,000-1,700 mm. However, there are good hedges of it almost everywhere in the Republic, even in the winter-rainfall Cape region.

Dry Areas Prospects fair to good. The plant seems to prefer dry warm summers, but it has grown well at the Desert Botanical Garden in Arizona, where most of the year is exceedingly dry and exceedingly hot.

Upland Areas Prospects good where the climate stays warm enough. Although the tree itself survives frost, the fruit crop can be lost when a late-winter freeze nips the flowers or flower buds. In the highveld of Gauteng (about 1,500 m elevation), black frosts can go further and wither the branchlets and cause the leaves to fall.

Beyond Africa

As above noted, the kei apple has grown well in several warm parts of the world beyond Africa. There, however, it has not yet generated much enthusiasm as a food resource. In Israel, for instance, it was once extensively cultivated as a hedge around citrus groves, but people did not like the fruits, which accumulated on the ground and became hosts for the Mediterranean fruitfly, a much-despised pest. Therefore, nearly all the plants were destroyed. Such experiences, however, do not necessarily indicate the potential of the selected kei apple strains of today or the future.

³ Some contributors said the species would do okay; others said prospects were poor.

USES

The kei apple is not an apple of course, it is a soft, apricotlike fruit with a character all its own. However, it does have similar uses.

Fresh Fruit At present, most people peel the fruit, cut it in half, scoop out the seeds, sprinkle on sugar, and allow it to stand for a few hours before serving it in desserts or fruit salads. In Africa, many people (the Pedi of South Africa, for instance) add kei-apple juice to boiled grains (usually pearl millet, sorghum, or maize) to make a colorful, tasty, and nutritious porridge. This is the fruit's greatest humanitarian potential, and is especially useful in areas where market-quality fruits can't be grown.

Many people do not like the fresh fruit at first; however, a fully ripened sample usually finds good acceptance. Unripe fruits—even “sweet” types—are so exceedingly acid they can be served as “instant pickles.” Indeed, in South Africa the young “pickles without vinegar” are served in this manner.

Creative cooks also use the fresh fruits in glacés, drinks, and pastries.

Processed Fruit Because of their abundance and acidity, kei apples are often prepared as preserves. They make amber-colored jellies, jams, compotes, and marmalades. The pulp is high in pectin, so only small amounts are needed to jell other fruit juices, including the most recalcitrant.

A few minutes' cooking turns kei-apple halves into a sauce that adds a fruity tang to meat, fish, or other foods. Simmered briefly in syrup the fruit produces tasty fillings for pies, cakes, or puddings. The cooked slurry can also be diluted with water and sweetened to make very refreshing drink. It is also dried into fruit leather.

Slight heating helps separate the pulp from the seed. Typically, the fruits are covered with water, heated gently (far short of cooking), and pushed through a coarse sieve to remove skins and seeds.

The Living Plant This plant's use as a security hedge has been mentioned. Landowners often intertwine the shoots of young kei apple plants to form interlocking, living latticeworks that are impenetrable. These make excellent barriers against trespassers, four-legged and two-legged, and were formerly relied on around homes in South Africa's sheep and cattle country to ward off wild predators. It is still used for this purpose in the Kenya highlands, where it is one of the most common fencing shrubs.

Other Uses The plant provides good cattle fodder, made more valuable in harsh locations by the plant's resistance to extreme heat- and drought. Because of the spines, livestock leave the foliage untouched until the desperate times arrive. This “bankable” fodder feature is invaluable. In Transkei, for example, kei-apple stock enclosures become critical for saving animals from starvation in the depths of the dry season.



Inside the thin, tough skin of a kei apple is found a yellow, melting, juicy pulp with a lively aroma. The pulp is highly acidic for the simple reason that it contains more vitamin C than an orange. (Cori Ham)

The plant makes a good support for epiphytes. In Natal, the professional and amateur growers of gorgeous orchids (such as *Mystacidium capense* and *M. venosum*) favor it as their “host.”

NUTRITION

The fresh ripe fruits are rich in vitamin C (80-120 mg and more per 100 g), as well as potassium (more than 600 mg).⁴ Sugars generally exceed 15 percent, with pectin levels nearly 4 percent. Although the protein content is low, generally below 1 percent, the balance of essential amino acids is reported good.⁵ Beyond that, little of this fruit’s food value is yet known.

HORTICULTURE

To produce fruit on a commercial scale, the trees either are laid out orchard style or are double-set in hedgerows. They can also be espaliered, training the branches onto horizontal supports. With this technique, kei apples can be grown along walls. It works well.

For fruit to form both male and female plants must be present. One properly placed male is sufficient to pollinate at least 10 females.

Kei apple can be propagated from seed, but this is not recommended for purposes of fruit production for several reasons: The resulting plants can

⁴ Wehmeyer, A. S. 1986. *Edible wild plants of southern Africa: data on nutrient contents of over 300 species*. Council for Scientific and Industrial Research, Pretoria.

⁵ Abdel Fattah, A.F., D.A. Zaki, and M. Edrees. 1975. Some investigations on the pectin and amino acid composition of *Dovyalis caffra* W[arb]. fruit. *Qualitas Plantarum* 24(3/4):311-316.

take 5 years to flower. There is a gross excess of males. The fruit size, shape, and sweetness can differ widely between the plants. And the thorns tend to be of evil prominence.

Vegetative propagation gets around all of these difficulties. The plant can be propagated from semisoft cuttings, air-layers, or budding. Such techniques assure the plant's sex, fruit quality, and relative thorniness. Also, vegetative propagation yields fruits about 2 years earlier than seedlings because the planting materials enjoy an adult's flowering hormones and don't have to endure prolonged adolescence.

Grafting kei apples presents no difficulties. Branches from selected plants can be grafted onto nondescript plants. Male branches can even be grafted onto female rootstock. Indeed, there is graft compatibility with an entirely different genus, *Flacourtia* (best known for Madagascar plum or governor's plum, *F. ramontchi*).

Kei apples bear consistently year to year. For optimum fruit production they need heavy pruning, no easy task with such a spiky species. For one thing, the crown needs frequent thinning because the branches tend to crowd toward the center, ending up in congested tangles of unproductive shoots. For another, the plants become cluttered at the base, making it hard to gather fallen fruits (horticulturists recommend removing all branches up to about 1 m from the ground). For a third, as many spines as possible should be pruned off to ease the harvesting and reduce the likelihood of injury to both pickers and fruits.

Plants grown orchard style should be set about 3 m apart. Males need to be placed so prevailing winds blow the pollen onto the female plants.

HARVESTING AND HANDLING

Kei apples can be hand harvested when bright yellow and tinged with green shadowing. At this stage they are quite tart but will ripen if held at room temperature for about two weeks. As it ripens, the bright yellow skin deepens to gold and the flesh turns almost translucent. The ripe fruit's sugar content has been estimated at averaging 15-18 percent, but even the ripest has some tartness lingering near the seeds in the center. This is not necessarily bad. Indeed, many enjoy the kei apple specifically because of this tang in the center.

Fruit left on the tree will ripen to the firm, all-yellow stage, and then drop. Although classified as a soft fruit, it is remarkably bruise resistant. Small surface blemishes can be avoided by covering the ground beneath the bushes with straw or other soft material. Deeper wounds can be avoided by reducing the spines along the lower branches.

An unusual quality is that once the kei apple is ripe, it resists decay. It then becomes easy to handle and has a long shelf life. However, damaged fruits soften and rot quickly, especially in a rainy, hot, and humid climate.

LIMITATIONS

The kei apple obviously has inherent promise. It has not been more fully realized because of sourness and thorniness. Many people just do not like it. In countries such as Kenya, which know the hedges well, the fruits are all but unused. In Israel (as noted) the plant grew outstandingly, but the fruits were enjoyed only by fruit flies, and this led to its rapid demise at the hands of outraged orchardists. In Florida, too, it has been far from a rousing success.⁶ Despite its productivity and hardiness and the promotion of less-spiny, less rampant plants, few Floridians have welcomed it, and its position has remained static for almost a half century.⁷

The juice stains fingers and fabrics a light yellow. Although not permanent, this can be a nuisance.

This does not seem to be a good crop for agroforestry. The plant exhibits allelopathy, its roots excreting chemicals that discourage the growth of other plants in its vicinity. In addition, its roots are shallow and spreading and compete with crops for soil moisture. It is said, however, that deep-rooted crops are unaffected, so perhaps there is a place for kei apple plants in mature tree plantings.

NEXT STEPS

This crop deserves research and development support. It is very important to the lives of some of the world's poorest people. The "zing" that the fruit gives to porridges and gruels cannot be overemphasized. In addition, the nutritional contribution can be important. Nonetheless, much needs to be done before the true potential of this crop can be properly judged and fully availed of. Pressing needs toward that end include the following.

Superior Planting Materials Kei apple awaits a dedicated selection program, particularly to find specimens that bear fruits with less acid and better flavor. Selections can be made from already-selected germplasm of course, as well as from large seedling population derived from selected trees in the wild. Plants producing fruits more appealing to the palate can then be propagated asexually.

A less thorny strain would also be important for both the fruit farmer and the nursery industry. "Many of my customers are turned away by the thorns," reports a contributor. In addition, selections for stress and disease resistance should be sought.

⁶ The plant explorer David Fairchild brought large amounts of seed from the botanic garden in Durban, South Africa, to his home near Miami in 1903. For decades rare-fruit growers showed great interest in it, but this has since dwindled. An old plant is still at his home (The Kampong), but few people eat it, preferring instead the hybrid between its relatives *D. abyssinica* and *D. hebecarpa* (ketembilla).

⁷ Information from the late Julia Morton. Most were grafted on *D. hebecarpa*.



Despite (or perhaps because of) its sourness, kei apple can give a bite as well as color to drinks, candies, jelly desserts, and many other food products. (Cori Ham)

If true breeding is needed to create elite plants, it could be profitably be directed at combining high fruit quality with thornlessness, productivity, and stress and disease resistance. In this regard, it would be instructive to know more about the inheritance of thornlessness and the inheritance of low acidity/high sugar content in the fruits.

A related, perhaps less urgent, line of improvement would be selection to upgrade the hedges. These might involve upright plant habit, various degrees of thorniness, sterility (so no fruits form), and ornamental value.

Perfect-flowered plants are known to exist. These very rare specimens have *both* male and female flowers on the same plant. In commerce these self-fertile specimens may have particular value because they remove the complexity of obtaining, placing, and planting males for pollination. These dual-gender plants should be sought out, studied, and developed.

Combining this species with others in its genus holds the potential for creating hybrid fruits of high market and culinary appeal. This challenging area offers more than merely interesting possibilities. Innovative amateur and professional horticulturists could find highly satisfying endeavors awaiting them here (see p. 111).

Market Development A crop at this stage of development will not sell itself. For success, various individual efforts are needed. Likely, there are instructive experiences already in its native range. The most promising entry-level market is processed kei-apple products...pastries, preserves, things like that. One California contributor wrote, "Tina, my wife, and I are now doing this in a small way. Results are surprisingly good. Tina's jam is a hit; 80 percent of first-time tasters like it. I've also sold fresh fruit to Japan and received requests for increased supply."

Horticulture With this crop virtually all horticultural features require investigation. Among pressing needs are:

- *Growing-System Research.* Various avenues to maximize production need to be evaluated. Research should focus on such things as watering, fertilizing, pest control, pruning methods, and measures such as trellising.
- *Harvesting Methods.* Possibly something could be devised for shaking the fruit off, perhaps into a cloth screen laid below the bushes.
- *Security Hedges.* This plant's effectiveness as a security hedge is important to document. Theft is a major problem in orchards. Will kei-apple hedges keep really dedicated thieves out of cherimoyas, mamey, or mango patches? Avocado growers in southern California are desperate for a cheap way to protect their investments. If this species works, there will be a lot of interest. Although hedges are normally grown from seed or seedlings, it is noteworthy that planting hedges of male trees would avoid problems with unwanted fruit littering the area.

Food Technology With this fruit, food technologists could have a field day. Everything needs to be determined from the basic to the most sublime.

Post-harvest handling studies are a particular need. Issues to document include the point at which to harvest the fruits, the ideal storage conditions, and the best packaging methods.

The pectin deserves some study, also. It might well prove to have commercial potential.

The use of kei apple for souring foods should be explored. In recent tests in South Africa, juice from some fruits had a pH as low as 2.5.⁸

The general processing of the fruits offers many special challenges.⁹

⁸ Information from Cori Ham.

⁹ "We have tested kei apple for cold storage and the results were very discouraging," wrote contributor Cori Ham, of Matieland, South Africa. "Kei apple blended with guava makes a very nice fruit roll (leather), but consumer tests suggested that pure kei apple is only acceptable as a jam."

SPECIES INFORMATION

Botanical Name *Dovyalis caffra* (Hook.f. & Harvey) Warb.

Family Flacourtiaceae

Synonyms *Dovyalis caffra* Warb., *Aberia caffra* Harv. & Sond., *Aberia edulis* T. Anders.

Common Names

Afrikaans: kei apple, keiappel, wilde-appelkoos, appelkoosdoring

English: kei apple, Dingaan's or wild apricot

South Africa: umkokolo, kei apple, kei appel, Dingaan's apple

Zimbabwe: munhungura, musvisviroondo, mutsvoritsvoto (Shona);
umqokolo (Ndebele)

Zulu: umkokolo, iQokolo (fruit), umQokolo (tree), umbambane

Other: motlhono (Sotho); muwhamba, ngundo (Vanda)

Description

Kei apple is a shrub or small tree that grows 3-5 m tall. The trunk and branches are a silvery gray and the leaves are borne on knobby twigs in clusters of two to five. The trees are deciduous but seem evergreen because the old leaves persist until the young ones appear. There are many sharp thorns about 5 cm long, occurring more often on untrimmed shoots than on the older branches.

Cross-pollination of flowers is necessary, as staminate and pistillate flowers are produced on separate plants. Both types lack petals and are inconspicuous. As noted, occasional perfect-flowered specimens exist.

Kei apples are spherical or slightly flattened (oblate) fruits. The diameter is typically 2.5-5 cm. They contain 5 to 15 pointed seeds. When ripe, they are golden yellow, velvety skinned, and crowned with a short stalk and short styles that persist from the female flower. The flesh is juicy and fragrant, with a scent that can become quite pronounced and even repugnant when the fruits get overripe.

Distribution

This native of southeastern Africa is abundant in the wild around the eastern Cape, Ciskei, Transkei, and Natal. It is cultivated in Gauteng (the Transvaal highveld). Mostly, however, it is planted in dooryard collections. It is rare in Zimbabwe, though sometimes cultivated there. In Mozambique, Malawi, Kenya, and Zambia it has been introduced and is cultivated to a small extent.

As noted earlier, it has been introduced into Florida, California, Australia, and the Mediterranean basin. It reportedly has been introduced to Iran and probably other nations as well.

Horticultural Varieties

There are few established superior cultivars, but many good ones could be quickly developed by selecting from wild or seedling populations.

Environmental Requirements

Rainfall Currently, the plant mainly grows where annual precipitation is 1,000-1,700 mm. However, it withstands dry conditions. In the wild, it is found mostly in areas of summer rainfall, where the mean annual precipitation is under 700 mm.

Altitude Usually this species is found in low-lying subtropical areas, from near sea level to about 1,200 m. However, in Kenya it is found up to 2,450 m.

Low Temperature This shrub grows best where the mean temperatures (especially daytime temperatures) are high. However, it is fairly hardy and tolerates brief exposure to cold. In Central Florida, for example, it has withstood -5°C undamaged.

High Temperature The plant's tolerance to high temperatures is seemingly unlimited.

Soil Apparently it grows well on most soil types. However, before investing in large plantings the matter should be investigated because the limits have not been clearly identified. The crop certainly needs good drainage and may perform poorly in heavy clays.

Related Species

In this chapter, we have concentrated on only one species, *Dovyalis caffra*. However, it belongs to a genus with other candidates for fruit crops. Interested amateur and commercial horticulturists could do a lot with this group, which is at present virgin horticultural territory. Various *Dovyalis* species offer possibilities for creating new crops or even hybrids. There is a wealth of germplasm in the genus; Africa, alone, contains at least 13 edible species of *Dovyalis*. All are shrubs or small trees with hairy or smooth fruits. Examples follow.

***D. abyssinica* (African gooseberry, koshum)** This fruit looks, tastes, and smells something like apricot. It comes from a bushy shrub that is common in forests of East Africa (Ethiopia, Somalia, Uganda, Kenya, Tanzania, Zambia, and Malawi). In Ethiopia the plant is commonly used as a hedge. The fruits provide a welcome income for young Ethiopian boys who sell bowlfuls to travelers on the main highways. The fruits are rich in vitamin C, and eaten both fresh and in jams, jellies, and desserts.

The plant occurs naturally in upland rainforest and humid lower highlands (at 1,000-3,000 m in Ethiopia, and between 2,000-2,700 m in Kenya). It is frequently seen along river courses and in dry evergreen forests; sometimes in open wooded grassland. It is said to grow on most soils, provided they are well drained. For purposes of planting, ripe fruits are cracked and allowed to decay for a week before the seeds are removed. There are about 20 seeds per fruit. Ideally, they should be sown immediately in nursery beds, since they germinate readily when fresh but lose viability within a few months.

It has been said that this species “produces fruit superior in quality to those of the closely related kei apple and kitembilla [South Asia’s *Dovyalis hebecarpa*] for eating out of hand, and when it becomes better known it will probably become more popular than either of these.”

***D. hispidula* (bristly dovyalis)** Not much has been reported about this or the other wild relatives, so the information is skimpy. This one bears spherical fruits up to 2 cm diameter. They are bright red when mature with harsh bristly hairs. The flesh is sweet tasting.

D. longispinus Bright orange to red fruits.

D. lucida This tree reaches 7 m in height. Its fruit is a glossy orange red. Its flavor is reportedly “sourish but not bitter or acidic.” It is said to be good for jam.

***D. macrocalyx* (shaggy-fruited dovyalis)** This species is a tree that grows on the forest margins. The fruits hide within an enlarged husk, which is hairy. They are bright red in color, and make excellent preserves.

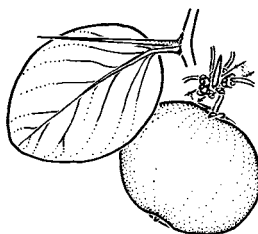
***D. rhamnoides* (Cape cranberry)** This South African shrub produces an ovoid berry that is orange to scarlet when ripe. It is good tasting and makes fine preserves. The fruit can be used for making a thin, very tart wine, and has been used for fruit brandy.

D. rotundifolia Fleshy, bright red fruits sold in the streets of Port Elizabeth and East London in South Africa.

***D. zeyheri* (wild apricot, red milkwood)** Fruit an ovoid berry turning orange to red when ripe. The flesh is sour and strongly flavored. The tree reaches 10 m the leaves are long and lanceolate, the flowers white and delicate. The fruits are described as astringent when raw but good for jam.

Interspecific Hybrids Two hybrids between *Dovyalis* species are known. One appeared at USDA-Miami in 1951 when a female plant of *D. abyssinica* was pollinated by a nearby male *D. hebecarpa*. The progeny (sometimes called Florida gooseberry) are more vigorous, productive, and cold tolerant than either parent. The plants form massive mounds of vegetation (up to 4.5 m high), with all the branches weighted down with excessive crops of the brown fruits. One practical disadvantage is that when the fruit is picked its calyx remains on the plant. This leaves a cavity in the base of the fruit, making it unmarketable as a fresh fruit. However, it can be used to make syrup, jam, or other preserves.

This natural hybrid has been distributed by the USDA as seedlings of P.I. 112086, *Dovyalis abyssinica*. The seedlings show considerable vigor, with many producing heavy yields of large-size fruits. The plants either produce perfect flowers or male and female flowers on the same plant. The fruit is yellowish brown in color and less acid than the kitembilla. Selections have been made and are being propagated by layering or grafting on seedlings of *Dovyalis hebecarpa*. The fruit is used like other *Dovyalis* species.





S.H.
Sclerocarya birrea subsp. *caffra*

7

MARULA

Not for nothing is marula (*Sclerocarya birrea*) dubbed “food of kings.”¹ In the giant triangle from Cape Verde in the west to the Horn of Africa in the east and to the Cape of Good Hope in the south, its prized fruits and macadamia-like seeds are in demand. Many Africans consider a gift of marula nuts a sign of signal friendship. In some societies, the tree ranks as a major food supplier, its economic and social importance being such that they are said to have a “marula culture.”²

Marulas are plum-sized stone fruits with a thick yellow peel and translucent white flesh. Many are eaten fresh but most are processed into things such as beverages, jams, and jellies. Although the succulent pulp has its own flavor, writers searching for a frame of reference have variously described it as being like litchi, apple, guava, or pineapple. Regardless of taste, the juice is nutritionally important, containing as much as four times the vitamin C of orange juice.

The kernels inside the stone that is found at the center of the fruit are also eaten. They too have high nutritive value, not to mention a delicate taste and such exceptional oil content that they burn like a bright candle. These nuts provide tasty sustenance for both human and beast.

Given these products, marula is at once a fruit tree and nut tree—a sort of tuck shop on a trunk. It is also a good food-security resource. Especially significant in this latter regard is the fact that it provides food during the season when grain stocks are low and other crops have yet to reach harvestable form. It is also significant that the nuts store so well they provided nutritious food long after all else is gone.

The living tree is remarkable in its own right. When fully grown it is large and shady. People genuinely like having it around for its shade and beauty as well as for its fruits. When farmers clear the land, these trees are often all they leave standing. Marula has long been also planted deliberately.

¹ This is a common Bantu description of marula. It is, for instance, the name given it by the Tonga, who live in Mozambique as well as in the neighboring parts of South Africa and Zimbabwe.

² This has been said of the Phalaborwa, for example. Krige, E.J. 1937. Note on the Phalaborwa and their marula complex. *Bantu Studies* 11:357-366.



Oshakati, Namibia. Throughout much of Africa marula fruits and seeds are in high demand. In some regions, the tree ranks as a major food supplier. The large and spreading tree is treasured for its shade and beauty, not to mention its foodstuffs. This is an exceptionally drought resistant species, and its resistance to heat, harsh sunlight, and difficult conditions is legendary (Klaus Fleissner)

It grows with great vigor. It thrives under exceptional heat. And it tolerates some of the most inhospitable terrain known to horticulture.

Marula fruits are not picked: they harvest themselves by conveniently falling off while still green and hard. They hit the ground without bruising, and subsequently ripen within about five days. It is common for farmers to build elaborate fences or to pile thorny branches around their trees to keep animals from reaching the fruits first.

Although when fully ripe the pulp turns pleasantly sweet-and-sour—something like an orange—most of the fruits tend to be tart. Some marulas come with a slight turpentine aftertaste, a feature not universally admired. The scent is applelike and rather pleasant, but can become overpowering where there are large quantities of over-ripe fruits.

But few of these fruits are eaten raw. Most end up in various kinds of drinks. Adding the juice to water, for instance, produces a refreshing squash. If set aside for a few days this liquid ferments into a hard cider. Although both tasty and nutritious, the result can be also highly intoxicating. Marula-juice beverages—both soft and hard—have been commercialized in South Africa. The amounts produced are surprising (at least considering that this is a “lost” crop and as-yet is little grown in organized production). In a recent year, for instance, about 500 tons of marulas were commercially processed for juice and 2,000 tons for liqueur just in South Africa. Beyond drinks, the

fruit is popular for amber-colored jellies. These are so treasured that purveyors charge gourmet prices and peddle them to upscale food fanciers.

Marula is in the same botanical family as cashew and pistachio (not to mention mango) and, like those famous relatives, could become a widely grown nut tree. Indeed, the kernels inside the seed are often more sought-after than the flesh around them. In flavor, they resemble macadamia, and are considered a treat special enough for serving revered guests. Furthermore, marula nut is nutritious enough to outscore even southern Africa's acclaimed mongongo nut.³

An important feature is that marula seeds keep for months without deteriorating (at least if clean and completely ripe). Throughout the plant's range, and especially where cereal crops grow unreliably, piles of them can be seen in the villages as emergency food caches. As long as the seeds remain dry, they stay wholesome: neither fungi nor insect are capable of penetrating the rock-hard shell.

As earlier noted, the kernels are rich in oil, averaging about 55 to 60 percent. The oil itself is high in unsaturated fatty acids, typically containing 70 percent oleic acid and 8 percent linoleic acid—excellent numbers indicating an elite vegetable oil.

Beyond good lipids, the kernel contains considerable amounts of protein (23-31 percent). The nut also provides minerals such as calcium, magnesium, phosphorus, and (to a lesser extent) potassium and sodium.⁴

Given all these nutritional components, marula nuts could be a big-time commercial resource—perhaps even globally enjoyed like cashews. However, breaking them out of the shell is a major problem. The seed's woody outer coating is both thick and hard, making the nuts difficult to extract intact.

Although the plant yielding this wealth of foodstuffs occurs over a range of southern and tropical African habitats, it is concentrated mainly in patches of hot, dry, open woodlands. It comes in two distinct types: one indigenous to the southern region is botanically known as subspecies *caffra* and the other, native further north, is subspecies *birrea*.⁵ The southern type constitutes the main subject of this chapter. More limited in location, it is nonetheless more developed as a crop.

Although not domesticated in the standard sense, marula is indeed cultivated. For hundreds of years, Africans have planted it, and in places its distribution overlaps almost perfectly with human migration patterns. In

³ Marula nuts can produce up to 750 calories per 100 gm, compared with about 640 for mongongo nuts. They also have higher protein and fat contents. Compared to mongongo nuts, of course, marula nuts are less abundant, harder to extract, and much smaller in size.

⁴ Wehmeyer, A.S. 1966. The nutrient composition of some edible wild fruits found in the Transvaal. *South African Medical Journal* 40:1102-1104.

⁵ There is also a subspecies *multifoliata*, which is intermediate between the two. It is found in Tanzania and probably Kenya.



Marula soaks in the unrelenting sun of arid climes, where it grows with great vigor. It thrives under exceptional heat and tolerates some of the most inhospitable terrain known to horticulture. Marula fruit can be eaten fresh but most is made into beverages, jams, and jellies. The flavor is described as being tart, sweet, and refreshing, with a similarity to apple or pineapple. The kernels inside the seeds are often compared with macadamia nut. (Elaine Solowey)

other words, people liked it so much they carried seeds with them and planted it along the wayside as they went. Moreover, in countries such as Namibia, the majority of trees that appear to be scattered around in the wild are actually owned by particular families. And the fact that the trees are mostly females indicates a human influence, because only females bear fruits. The practice of growing elite genotypes from cuttings is part of traditional knowledge as well.⁶

Given such features it can be said that marula (i.e., the southern type) is at least on the first rung of the ladder to domestication. Moreover, horticulturists in South Africa have selected and cloned superior types over the past 25 years. Indeed, some of those clones are entering intensive cultivation in both South Africa and Botswana. This crop is also undergoing trials and horticultural development at introduction orchards established at four locations in Israel's Negev Desert.

There are good reasons for thinking marula worthy of further development. For one thing, the species can be extremely productive. In South Africa, as many as 91,000 fruits have been counted on a single tree in a good year.⁷ In Namibia 4.5 tons of fruit have been measured in single season on a single large tree.⁸

⁶ Information from Pierre du Plessis.

⁷ This figure is in Quin, P.I. 1959. *Foods and Feeding Habits of the Pedi*. Witwatersrand University Press, Johannesburg. This is by no means an average yield, however.

⁸ Information from F.W. Taylor and N. Baker.

For another, shelling the nuts provide work for thousands of rural women with hardly any other source of income.

And for a third, there exists considerable commercial demand for both fruits and nuts. In Namibia, Botswana, Zimbabwe, and South Africa, many fruit are collected and sold by villagers to the rising number of facilities that have been established to process marula, with some handling over 1,000 tons of fruit a season. Pulp is already appearing in mainstream commerce in the form of juices, jams, jellies, puree, and liqueur. Oils are also extracted from the nuts and put into pricey skin products, a process pioneered in Namibia, which even exports marula oil for this purpose.

PROSPECTS

Presently marula is considered a subtropical crop of limited adaptation but considerable promise. Both its adaptation and commercial possibilities may soon be much clearer because the rising popularity of a fruit-juice drink and a liqueur has stimulated horticultural interest all across southern Africa. Although the fruit's clingstone quality means that it is best for processing into such things as juice, jelly, and beverages, its pleasant apple-like odor and litchi-pineapple-guava flavor, not forgetting its nutrient content, would seem to justify confidence in its prospects for much wider use.

Within Africa

How well the southern marula will do in the other parts of Africa is presently unknown. Possibly it will perform in stellar fashion. Here are likely scenarios.

Humid Areas Uncertain prospects. The southern subspecies appears ill-adapted to high humidity. The northern counterpart, however, is a possible new resource for hot and hard conditions. Already, it is being planted quite extensively in Zambia.

Dry Areas Excellent prospects. Marula tolerates saline water and grows with vigor in desert heat. The trees continue bearing even during droughts, although dryness makes the fruits somewhat smaller. Once established, however, the trees are almost never killed by desiccation.

Upland Areas Uncertain prospects. The plant is somewhat frost-tender, but there may be locations where it safely fits the climate.

Beyond Africa

How well this plant will perform and how well its fruit and nut will be accepted in lands beyond Africa is unknown and uncertain. Nonetheless, small-scale trial plantings are warranted in locales to which it is suited.



Marula fruit pulp serves as a flavorful natural base for fruit soft drinks, nectars, and teas; alcoholic beverages such as brandies, liqueurs, beer, wines and punches. Marula is already also appearing in commerce in the form of juices, jams, jellies, puree, and liqueur. (Cori Ham)

USES

Marula primarily provides fruits and nuts, but those are really just a start. Consider the following.

Fresh Fruits The fruits are eaten fresh in many parts of subtropical southern Africa. They are sometimes cooked. The juice not only makes an agreeable drink; it is often boiled down into thick black syrup, used mainly for sweetening sorghum gruel. The flesh can also be dried and stored for later use, when it is typically added to cereal porridge.

Processed Foods Drinks made from marula are everywhere popular. Many places boast of their local marula beer.⁹ In southeastern Zimbabwe, for example, it is called “mukundi” and it is much liked. In Swaziland, a very potent marula drink is so popular it drastically affects the local

⁹ The fruits ferment so fast there is a common belief they intoxicate wildlife. However, this is now thought possibly untrue or even a ploy to entice tourists. See, for example, de Klerk, W.A. and T.G. Watson. 1974. Baboons and marulas. *Custos* 3(9):33-37.

breweries' beer sales during the fruiting season. In Namibia there is an official marula wine season during which no one is allowed to carry traditional weapons and crimes are punished with double the usual punishment. A distillate for the more sophisticated palate has been developed in South Africa. An "Amarula Cream" liqueur is now available not only in local markets but in international trade.

Nuts Marula nuts are used to flavor dishes of meat, greens, and porridge as well as being pounded into flour and pressed into cakes. The kernels can also be used like walnut or pecan in baking. They are especially used to provide protein and dietary energy during the "hungry season"—the time before the staples can be harvested.

Vegetable Oil The oil extracted from the kernel has a fatty acid profile similar to olive oil. It is not only high in monounsaturations, but is relatively low in tocopherol and thus has exceptional stability. On the basis of its chemical makeup, marula oil is well suited for use in frying, cosmetics,¹⁰ or coatings on foods such as dried fruit.¹¹ Presently, it is too expensive to succeed as common cooking oil, but might find a niche market as a specialty salad oil. It may also find greater use in cosmetics; it is "non-drying" and reportedly seems to have properties that combat the aging of skin. Because of its reputed antibacterial action marula oil is used to treat wounds and burns. It is also used as a preservative for biltong (dried meat).

Forage Stock farmers love having marula trees dotting their property. This big, leafy tree provides great shade and its fruit, leaves, and bark make excellent fodder, especially welcome during times of drought. For wildlife, the marula is also important, constituting a living, renewable pantry for hordes of herbivores and omnivores—from elephant, rhinoceros, giraffe, and kudu to warthog and hedgehog. Baboons are particularly fond of picking up the ripe fruit scattered under the trees.

Flowers Flowers produce nectar in quantity, making the tree an important resource for beekeepers. The honey is light-colored with excellent flavor.

Wood The wood hardens as it seasons, eventually becoming durable and strong. Although dirty white, with red and brown streaks, it turns a pretty pink when polished. Carvers make it into drums, stamp-blocks, troughs, spoons, stools, bowls, and more. Because it is easy to work and does not splinter, it was once popular for toilet seats—so popular in South Africa that the tree almost became a threatened species.

¹⁰ Information from Cyril Lombard, CRIAA SA-DC, Namibia.

¹¹ Burger, A.E.C., J.B.M. de Villiers, and L.M. du Plessis. 1987. Composition of the kernel oil and protein of the marula seed. *South African Journal of Science* 83:733-735.

Other Marula root brews have renown as antimalarial tonics. In some villages, parts of the tree are apparently employed against lice.

NUTRITION

Although marula fruit pulp is an important source of micronutrients, vitamin C is what makes it nutritionally interesting. The flesh commonly contains 180 mg vitamin C per 100 g, but the concentrations can go even higher. In this regard, the marula outshines orange, grapefruit, and lemon. At 2 mg per ml of juice (about the amount of juice found in one fruit), it is an especially important source of this essential nutrient.

Carbohydrate levels of between 7 and 16 percent have been recorded in the fruit pulp.¹² The carbohydrate consists mainly of sucrose, with smaller quantities of glucose and fructose. The acidity is due mainly to vitamin C (ascorbic acid) and citric acid.¹³

Nutritionally speaking, marula has something oranges lack—a good-tasting nut. Rich in food energy, the kernel normally contains around 700 calories per 100 g and surpasses the nutritive content of globally famous nuts such as almonds, chestnuts, and hazelnuts.

Because of their fine taste, marula nuts are described as a delicacy. Their fat, protein and mineral contents make them a useful dietary supplement during winter or droughts. They are exceptionally nutritious, with 28-31 percent protein, 56-61 percent oil, 2.02 percent citric acid, malic acid, and sugar, phosphorus, magnesium, copper, zinc, and B vitamins (thiamine and nicotinic acid). Protein levels of 54-70 percent have been reported for de-fatted nutmeat.¹⁴

HORTICULTURE

Seeds mature (inside the fruits) in late summer, and, after a few months of dormancy, are easily germinated if subjected to heat (around 30°C) and moisture.

Vegetative propagation is in its infancy, but Israeli horticulturists have found that propagation via root cuttings is very easy.¹⁵ Such techniques can be used to clone elite specimens as well as to avoid the long juvenile periods that growers of seedlings must suffer. The plant can also be propagated by

¹² Jaenicke, H and M.K. Thiong'o. 2000. Preliminary nutritional analysis of marula (*Sclerocarya birrea*) fruits from two Kenyan provenances. *Acta Horticulturae* 531:245-249.

¹³ Weinert, A.G.I., P.J. van Wyk, and C.L. Holtzhausen. 1990. Marula. Pp. 88-115 in Nagy, S., P. Shaw, and W.F. Wardowski, eds., *Fruits of Tropical and Subtropical Origin*. Florida Science Source, Lake Alfred, Florida.

¹⁴ Burger et al., 1987, op. cit.

¹⁵ Information from A. Nerd.

jabbing sections of large branches into the ground during the wet season. These so-called truncheons are usually about 2 m long and 10 cm in diameter, and are planted 60 cm deep. If cut at the time of bud swelling they strike readily, putting out abundant roots with speed and vigor.

Grafting branch wood from one plant onto seedling rootstocks of another (using terminal grafts) is reportedly very successful. The operation is made just as new spring growth is beginning. Such grafts, covered with sealant, have resulted in almost complete success (98 percent with one cultivar).

Marula trees in general have few pests or diseases. Indeed, they are thought to be infused with insecticidal ingredients. However, a pesky fruitfly invades the ripe fruits, which are also attacked by the caterpillars of at least two moth species.

HARVESTING AND HANDLING

By and large, the fruits are easy to handle because they are firm when they fall from the tree. At that point the skin is tough enough not only to resist bruising from the fall but to give the fruit a good shelf life. Observations in Israel indicate that although different trees drop their fruits at different times, each drops 80 percent of its fruits within two weeks.

Yields can be outstanding. As much as a ton of juice has been obtained from the fruits from a single tree. The juice can be separated by standard techniques, such as the rack-and-cloth press method. Using modern technology, the South Africa's National Food Research Institute has developed a process for making marula juice on a large scale.

Not unexpectedly, storage temperatures affect the way the fruits ripen. In tests, fruits kept at 12°C and at 20°C developed a yellow color and were suitable for juicing. Those stored at the higher temperature were the ripest. They had a deeper yellow color, a higher juice content, and lower acidity. Fruits kept at 4°C remained green and firm for 14 days, and seemed undamaged, but after five days at room temperature (20°C) they developed brown spots and an off-flavor.¹⁶

The nuts, on the other hand, are difficult to handle. Shelling the peach-stone-like seeds and extracting the kernels inside is almost an art. Some experienced locals use thorns for the task; others employ special metal, wooden, or bone "teaspoons" or extractors (often even suspended from a necklace in marula season) after they have opened the seeds—either by bashing them between two stones, or by chopping off one end against an axe. They become quite deft at winking the kernels out; boiling or lightly roasting the seeds makes the whole process easier. Boiling causes the cap sealing the embryo chamber to expand so it can be more easily removed, while roasting makes the stone so brittle that striking it makes the caps jump out to expose the kernels inside.

¹⁶ Information from A. Nerd.

LIMITATIONS

Marula fruits and seedlings are favorites of many animals; all plantings therefore need careful protection. In southern Africa, elephants are among the principal seed-dispersing agents. Elephants also sometimes debark trees, which nonetheless heal themselves well. Giraffe and antelope (notably kudu, and nyala) also browse both leaves and fruits. Goats are such a serious threat to young trees that no self-sown seedlings are found anywhere near villages.

Although most people consider the fruits delicious, some are disappointed that there is not more pulp and *less* juice. This could be corrected through selection, but supreme juiciness is also a virtue. Clearly, it depends on what one wants, likes, or expects.

A more serious limitation is that fact that the flesh adheres firmly to the stone. As in mangos or the peaches of earlier times, soft fibrous strands attach the pulp to the stone. The size of the stone is another flaw; it is quite large for the overall volume of the fruit. In addition, the thick skin detracts at least a little from the volume of pulp.

Given that most marulas are currently planted from seeds, there is a long delay between planting and production. This is a major limitation to new plantings, which is avoided with clones.

The ripe fruits can have a strong smell, which one either likes or dislikes. In over-ripe specimens, fermentation can make it worse.

Although the nuts have exciting promise, a major problem is their relatively low productivity. The kernels are small compared with the size of the woody shell around them. As a result, stones weighing 1 ton yield only 40 kg oil and 40 kg edible protein.

NEXT STEPS

This species seems a great resource for alleviating poverty and diversifying rural livelihoods. It has a recognized commercial value and it keeps people and animals alive by providing vital nutrients during times of famine. However, although it is not quite a “lost” crop, there are still many uncertainties about its products and vast unknowns about its performance. This opens different research opportunities, not all of them requiring professional researchers. The following highlights areas of need.

Commercial Development For this much-beloved plant, achieving greater production lies less with science than entrepreneurship, motivation, and investment. The horticultural side is relatively straightforward; processing is in need of some work but it is also basically in hand. However, the market remains underdeveloped and still needs lots of development.

Marula need not be grown only in orchards or for strictly commercial ends. Indeed, it represents a major income opportunity for rural communities throughout Africa, and development work should focus on systems that will



Although oils are extracted from marula nuts and put into pricey skin potions around the world, currently marula's juicy pulp yields the most commercially successful product—a cream liqueur. Whole fruit is collected from the veld by local villagers, providing them seasonal income. Next, skin and stone are separated from the flesh, which is then carefully fermented like grapes. The resulting marula wine, mixed with fruit solids, is distilled in copper pot-stills and matured in small oak casks for about two years, capturing the unique flavors of marula in concentrated form. The final step is blending the liqueur with fresh cream. The result is a smooth, stable, luscious cream liqueur marketed in about 150 countries. (Distell Group Limited)

facilitate community-level production. Nonetheless, bigger commercial markets will provide income opportunities for rural producers lacking the space or capital to plant thousands of trees for commerce. And beyond that, marula can contribute to rural development on many levels, not to mention nutrition and food security for people lacking the money to buy food.

Fodder This is one of the most ancient of all fodder trees and yet the leaves' feed value is all but unknown. Needed now are standard nutrient analyses. These are often an excellent way to get a crop developed. Practical

developments are likely to follow spontaneously, as farmers with livestock are exceptionally motivated to follow up on promising forages because for them no feed means no livelihood.

Selection As far as commercial progress is concerned, this is the most powerful area for research endeavors. Further selection of outstanding wild trees for production of fresh fruit, processed fruit products, and nut is needed. A larger fruit having a smaller stone and perhaps a thinner skin would obviously be more desirable for most purposes. Also, selections with improved precocity and higher yield would be most welcome.

Vegetative Propagation Cloning, including truncheons, is key to making this crop work. For one thing, it improves fruit quality and dramatically reduces the delay between planting and first harvest. The techniques seem to be on hand already. For instance, hardy but inferior fruited trees can be used as rootstocks for selected scions of superior plants. Needed now is engagement by the nursery trade and amateur horticulturists so that top selections become widely available to backyard and orchard-level growers.

Control of Pests While this plant is not normally pest ridden, reliable methods for combating marula fruit fly (*Ceratitis cosyra*, also a mango pest) would strengthen its future.

Food Technology Many food technologies remain to be applied to marula. A key one is the processing of the nuts. Practical methods for extracting the kernels need to be developed. They need not involve a high-tech decorticator. A cheap and simple—but still relatively labor-intensive technology suitable for rural homesteads—would be ideal. Rural women could then decorticate their own seeds in their own time.

Genetic Development There seems to be much genetic variation in the species, and this is a good time to establish gene banks wherein differences between promising specimens can over time be observed and exploited.

It is difficult to prefigure a crop's future direction, but four possible directions have been especially suggested for developing marula by combing through the existing germplasm and selecting types whose fruits are:¹⁷

- Large (over 80 grams) with good taste and thick pulp (for use as fresh fruit and for making fruit leather and marmalade).
- Very juicy (for things such as nectar, syrup and fruit drinks).
- Rich in sugar (for production of alcoholic drinks).
- Large-seeded (for oil production)

¹⁷ These suggestions are primarily from one of our contributors, Elaine Solowey

In addition to the selection and propagation of superior individuals, it is valuable to alter the sex ratios in the stands, from the usual male predominance to roughly one male to five females.

Reforestation Marula is excellent for revegetation purposes. For instance, in Israel marula is becoming widely planted. For years the Jewish National Fund's reforestation department has distributed saplings for land reclamation, roadside groves, and windbreaks. Nowadays, this small African tree is to be seen binding up scars of deforestation and desertification in many locations.¹⁸ This particular use is poorly appreciated within Africa, where it deserves immediate inclusion in trials and reforestation programs.

Physiology In these early stages of the plant's commercialization, no one knows the outer limits of the marula's adaptability to climate and soil. Tests are warranted throughout much of the African continent. The key finding has less to do with the plant's survival than with its commercial viability.

Phenology Marula could become a great agroforestry species. Rural Africans love the tree and millions would plant more of it on their farms. Needed, though, is a better understanding of the timing of leafing, blossoming, fruit drop, and other seasonal features at various likely locations. The tree's compatibility with neighboring crop plants also needs general assessment. It is especially important to find male plants that provide pollen at the very time that superior female plants are in blossom.

Subspecies performance Botanists have divided this species into subspecies based on observations of visual differences. Now is the time to better understand the true genetic differences and performance requirements of each. Out of this likely will come many surprising and intriguing facts that could greatly enhance marula's use in the hotter, drier, more northern African regions. Perhaps, too, hybrids between subspecies *caffra* and subspecies *birrea* are possible, bringing great benefits to both.

¹⁸ Information from Elaine Solowey.

SPECIES INFORMATION

Botanical Name *Sclerocarya birrea* (A. Rich.) Hochst. especially *S. birrea* subsp. *caffra* (Sond.) Kokwaro¹⁹

Family Anacardiaceae, the Mango Family.

Synonyms *Sclerocarya caffra* Sond.; *Poupartia birrea* (A. Rich.) Aubrev.; *Spondias birrea* A. Rich.

Common Names

Afrikaans: maroela, olifantsappel

Arabic: homeid

Bantu: mupfura

Botswana: morul

Burkina: noabega (Moré)

English: marula or elephant plum, morula, cider tree

French: prunier

Mali: kountan, kountango (Bambara); bi (Dog.)

Malawi: mefula

Mozambique: mudângwa (center), canhu (south)

Niger: eedi, diné, dinéna (Sonrai)

Senegal: bire (Wolof), beur, biét (Ouol.); aritj (Sér.)

Setswana: morula

Shona: mutsome, mupfure

Swaziland: buganu (name for both tree and the drink made from fruit)

Zambia: musebe, muongo, msewe

Zimbabwe: mganu (Matabeleland), managahn, bufuna, musomo

Zulu: unganu (which means friend)

Namibia: Omuongo (Oshiwambo)

Description

This handsome, shapely, deciduous tree is often but not always single-stemmed and sometimes reaches 20 m in height. The mature tree's bark is distinctive—rough and mottled in appearance because it peels off in disc-shaped flakes. The compound leaves are aggregated at the end of short branches and blunt twigs. They are pale green on the lower surface and shiny dark green on the upper one.

The species is dioecious, meaning there are separate male and female trees. However, cases of self-fertile hermaphrodite trees producing some

¹⁹*Sclerocarya birrea* subsp. *caffra* occurs naturally in Southern Africa; subsp. *multifoliolata* in central Tanzania; subsp. *birrea* in West Africa and into Tanzania.

fruit have been reported. The female flowers are located at the end of short twigs. One to three flowers occur in a cluster.

The smooth, ovoid fruit sometimes reaches 5 cm in diameter, but is most often about half that size. On average, they weigh 30 g but selected trees yield fruits weighing up to 100 g. As they ripen the leathery green skin turns pale yellow and develops inconspicuous minute rough spots (lenticels). The flesh is white and juicy. The flesh covers a large attached stone, which is usually two-chambered, each chamber containing a seed.

The root system is well developed and the roots are succulent. They store quantities of water and starch, lending tolerance to drought and hard times.

Distribution

Species *Sclerocarya birrea* has a wide distribution in Africa—from Senegal in the west to Sudan and Ethiopia in the north and to the Swaziland and coastal Natal in the south. However, the particular subspecies (*caffra*) that has attracted the most horticultural attention is native only to the southern part of this range, mainly Botswana, Mozambique, Namibia, South Africa, Swaziland, and Zimbabwe.

Horticultural Varieties

A number of improved clones producing large fruits weighing up to 100 g and with a variety of skin colors are known in South Africa and neighboring nations.

Environmental Requirements

This is an exceptionally drought tolerant species, and its resistance to heat, harsh sunlight, and difficult conditions is legendary.

Rainfall Generally speaking, marula is found in arid to semiarid areas with a (mostly summer) rainfall, varying from 250 to some 1,000 mm. In South Africa, the plant is said to be best suited to the 250 to 800 mm rainfall zone. In Botswana, it is found naturally within the 400-650 mm rainfall range. In Namibia, 250-350mm per annum is the norm. The roots store water and the rainfall of the previous season is possibly more important to the harvest than is that of the current fruiting season.

Altitude Low to medium altitude, seldom up to 1,000 m or 1,200 m. The limit is dictated largely by the severity of frost in winter.

Low Temperature Marula grows and bears best in warm to hot subtropical to tropical climates, but (when leafless in winter) can tolerate light frosts. Young trees are more susceptible to frost damage, but even mature trees can be badly damaged by air (“screen”) temperatures of -4°C , but it will grow in favored locations in areas with heavy frost.

High Temperature This is a heat-loving crop, remarkably tolerant of high temperatures. No visible damage was observed when summer temperatures rose to 45°C in Israel’s blistering Arava Valley.

Soil Swampy soils do not suit this species. Other than that, though, marula occurs on a wide range of deep, well-drained sites from sand to loamy sand to sandy clay (usually sandy loam). Acidity does not seem to be a problem: Analysis in Botswana showed the soil under 13 trees to be pH 4.7-5.5. Nor is alkalinity a problem: marula can become dominant on basalt or dolerite soils in parts of the eastern Kruger National Park. In Israel, the trees showed high tolerance to irrigation with brackish water (EC 32 dS/m).





8

MELON

The melon (*Cucumis melo*) is one African fruit that is already known around the world. All the warm regions produce it, and every day millions enjoy a melon for breakfast, lunch, or dessert. Certain countries—among them Iran, Pakistan, Japan, and the United States—look upon themselves as “mothers of the melon,” little realizing that the real parent is Africa. Few Americans, Australians, Chinese, Russians, Italians, or Iranians realize that the cantaloupe, muskmelon, or Persian melons on their plates originated from wild (and often impossibly bitter) fruits of Africa’s drylands.

Like ourselves, melon is African in ultimate origin. Quite a few species of its genus, *Cucumis*, occur across the continent, and the wild plants that gave rise to today’s melon are native in subSaharan eastern tropical Africa. Probably, it was domesticated after other major crops but, when it left Africa, widely different forms quickly arose in various corners of the world.

The crop succeeded first in the drier, longer-season parts of ancient Persia, India, and Southwest Asia (including Egypt); in fact it naturalized in India, which is regarded as a secondary region of novel germplasm. From “Persia” it spread East and West, including all the historic Mediterranean world. It captured the French imagination after reaching there about the fifteenth century; one intellectual produced a treatise enumerating fifty different ways to eat melons, including in soup, fried, or served simply with salt and pepper. The English aristocracy prided itself on the perfect melons their gardeners produced in glasshouses. From Europe, the melon journeyed on westward to the colonies of the Americas.

Melons are reasonably priced and seasonably available across countries that span many climatic zones, such as Russia and the US. While lacking a long shelf life, many varieties are tough enough to ship long distances at cool temperatures. Although most people consider it a sugary nothing in nutritional terms, it can be an important source of some nutrients, especially provitamin A.¹ Combined with its welter of flavors, textures, sizes, and colors, melon is one of the most promising fruits for further development.

Despite its international success, however, the crop is far from being exploited to its fullest, even in the areas that know it best. Indeed, today’s

¹ One contributor did write, “Let’s face it, melons are eaten for their taste and sweetness, not nutritional quality. Let’s enjoy it for what it is and be happy we have such a luxury.”



Melons are high-value products in some parts of the world. Shown here is a small specimen in a Nakatsugawa, Japan supermarket, priced (in 2006) at US\$25, next to a \$15 apple. In most places, melons are more reasonably priced and are seasonally abundant. High in provitamin A, many have rinds robust enough to handle long distance travel. The scope and complexity of flavors, sizes, flesh colors and textures makes the melon one of the most interesting of all fruits. (Karen Rei Pease)

melons are based on seed carried out of Africa centuries ago (probably by camel caravans moving across the Sahara to Pharaonic Egypt). The true wealth of its diversity was not only left behind, it remains untapped and unappreciated; at least part of it almost certainly remains undiscovered.

This wealth of genetic diversity results from the fact that the melon is perhaps the most horticulturally plastic of all fruits. Few others, if any, can match the range of extreme types that have already been selected. Consider the following range of fascinating features:

Size Some melons found in different parts of the world can weigh as much as 30 kg, so large a normal person can hardly lift one; others are no larger than small plums. A type in Australia is the size of a grape.

Shape Many melons are not round. One, for example, is about 3 cm in diameter and a meter long, coiling in all directions like a spastic snake. An Algerian type splits into sections, like a half-opened tulip blossom.

Color Melons can span at least half the colors of the rainbow: there are types with skins that are red, green, yellow, or mottled; and types with flesh that is red, orange, green, yellow, or white.

Eating Quality Most melons have thin skins and a delicious, melting, honey-like flesh, but some have little or no sweetness at all. Certain ones are hard to distinguish from cucumbers and are eaten as vegetables. One is actually sold under the name “Armenian cucumber.”

Other Uses Some melons are grown exclusively for their large, oily seeds, which are roasted like nuts and eaten as snacks. For centuries, “senat” seed was a major export of the Sudan (for more on seeds from various melons, see the Egusi chapter in the companion volume on Africa’s vegetables). In Africa, oil is still often extracted from the seeds of the *agrestis* subspecies and used as cooking oil. A number of melon types are used as leafy vegetables, boiled and eaten like spinach.

Nonfood Uses Some melons are inedible. A few are valued solely for their sweet fragrance, and are used as natural air fresheners.

With all these different genetic versions, melons are “designer fruits” *par excellence*. The possible combinations of shapes and sizes, tastes and textures, colors, and culinary qualities that might be fashioned out of this single species seemingly approaches the infinite. Undoubtedly, some of tomorrow’s most useful melons have yet to be created. These include types especially suited to African conditions, with qualities such as higher nutrition, more rugged exteriors, longer storage times, greater resistance to pest or plague, greater water-thriftiness or heat tolerance, or any of numerous other desirable genetic characteristics that have already been discovered in this amazingly polymorphic plant.

Even with the limited germplasm on hand, taxonomists have divided the species into at least eight groups, also considered as subspecies.² These are:

- *Cantaloupenis*—the cantaloupe (as defined in Europe);
- *Reticulatus*—the netted or nutmeg muskmelon; cantaloupe (as defined in the United States);
- *Inodorus*—winter, honeydew, casaba, or Persian melon;
- *Flexucus*—snake or serpent melon;
- *Conomon*—Oriental pickling melon;
- *Chito*—mango melon, garden melon;
- *Dudaim*—pomegranate melon, Queen Anne’s pocket melon;
- *Agrestis*—a form grown for its seeds.

It seems probable that once Africa’s native melon resources are fully plumbed, this list may have to be revised or expanded, perhaps extensively.

² These forms are not the type of variety (cultivar) that represents horticultural selections; they are types found in nature and that are differentiated botanically.

PROSPECTS

Melons are already more popular than most people think. In the U.S., for instance, they are second only to bananas as the most consumed fresh fruit per person. Despite this, though, the melon has a far greater future ahead. Africa's raw genetic resources include many remarkable melons, and dozens of new versions of this well-loved worldwide food are likely to be developed. For another, there are also possibilities for greatly increasing local use in dozens of nations. These robust plants not only adapt well to many different situations, they are fast growing, quick maturing, and extremely tolerant of heat, drought, rains, and other climatic stresses. By and large, melons transport well; a few having six-month shelf lives. Indeed, there is already a growing international trade in melons—some of it by air—and this also seems likely to increase.

Within Africa

For Africa, both the undeveloped local types and the foreign highly developed types have much promise.

Humid Areas Moderate to excellent prospects. In spite of the fact that the melon is now a warm-temperate or subtropical crop, it has potential for the monsoonal lowland tropics.³ However, it is susceptible to serious fungal diseases (such as *Fusarium*), and it generally does best if grown in the drier seasons when heat and humidity are more reasonable.

Dry Areas Excellent prospects. Melons probably have their greatest prospects in the drier regions. Most require plenty of sunshine and do well in the hot, dry season. For all that, however, they require plentiful water for the best yields of large fruits. Thus, in truly arid areas they must usually be given at least supplemental irrigation.

Upland Areas Fair prospects. This seems to be low elevation crop. Near the equator, however it can be grown at moderate altitude.

Beyond Africa

Although Africa is the melon's center of origin, a secondary region of diversity occurs in Asia—specifically in the region covering Iran, the entire Central Asia area,⁴ India, and parts of China.⁵ The former Soviet Union,

³ In Indonesia, for example, it is commonly cultivated, especially in East Java and along the northern coast of Java.

⁴ One of our contributors, Henry Shands, emphasized that all Central Asia has great melons: "I have screened melons from Uzbekistan, Turkmenistan, and Kazakhstan and they all have extensive and impressive amounts of genetic variation in size, shape, taste, sugar, etc."

alone, had more than 1,000 named melons, and Turkey has hundreds...each said to have a distinct flavor.

Perhaps nowhere has this fruit's genetic potential been expressed to a greater degree than in Japan, where melons with elegant shapes and individual aromas sell at astronomical prices and are considered among the most desirable and delectable taste treats.

USES

Melon has many more uses than most people imagine. Consider, for instance, the following.

Fresh Fruits Melons are mostly eaten fresh. The flesh is consumed directly from the rind, occasionally with a little salt, sugar, or maybe powdered ginger. Many Westerners may consume them mainly for breakfast, but in France, they are commonly consumed as an appetizer at the beginning of the evening meal. Most Africans and many others eat them fresh anytime. Melons are also often sliced and peeled to eat with other foods or diced into salads. The fruit may be canned or boiled down into a syrup or jam. A few types are used only as preserves.

Processed Foods Not all melons are eaten fresh. Many are dried into a sweet and tangy form of fruit leather that will store for months or years without deteriorating. In Uganda, for example, ripe melons are crushed, the seeds separated, and the flesh dried in the sun. Later this melon leather is washed and boiled in water until soft, then peanut paste is added. The melon leather also may be cooked with dried fish or meat, to which peanut paste is often added. The resulting fragrant sauce is served with millet bread. In Central Asia, dried melon fruit are also eaten year round.

Water Melons (native or cultivated) are an important source of water in certain regions of Africa. Some are grown in the fields just for consumption by farm workers seeking relief from the heat of the day. This happens commonly in central Sudan, for example.

Vegetables As noted, a number of melons are grown specifically as vegetables. An example is the conomon or melofon,⁶ grown in parts of Southeast Asia. Fruits are green with yellow stripes, and much more like cucumbers than cantaloupes. Cooked as a vegetable, they are said to make

⁵ This is perhaps the place where most of today's *cultivated* variants originated. Probably, there was independent domestication for subspecies *agrestis* and *conomon* in China, India and Japan, and for subspecies *melo* in Southwest Asia.

⁶ *Cucumis melo* subsp. *conomon*. In English this is usually known as melofon, Oriental pickling melon, or Chinese white cucumber. In Chinese it is ts'it kwa or vet kwa.

an excellent stir-fry. In France, most of the time, cantaloupe muskmelons are eaten as vegetables. Many old local varieties exist but are now unexploited.

Seeds Even the types with inedible fruits have uses. They (as well as many edible types) are grown for their seeds. Beyond being roasted and eaten as snacks, melon seeds yield edible oil. In various parts of Africa this liquid is used for cooking and other purposes; some is even exported to Europe. In past years, for instance, Senegal produced 60,000 kilos of melon oil. In Sudan and Ethiopia it is still commercially important. One type of melon⁷ grown specifically for edible seed (senat) once was a major export.

Rind There are melon types that are grown only for the rind, which is used in pickling and preserves.

Other Uses In Cameroon, types with small fruits are cultivated almost exclusively for their edible leaves. The fruits of some cultivars are so bizarre-looking that they are grown for use as household curiosities. The dudaim melon⁸ of equatorial Africa is particularly unusual. Its fruit is all but inedible and no larger than a lemon. However, it has a strong and very pleasant smell. It will keep a kitchen or even the entire house smelling sweet and fresh for weeks.

NUTRITION

The edible portion can constitute up to 80 percent of a melon. The flesh contains mostly water (about 90 percent) and carbohydrates (10 percent). The carbohydrate is essentially all sugar. As it grows, the fruit accumulates fructose, glucose, and sucrose.⁹ Upon ripening, it softens and its fruity, aromatic essences are formed.

Melons are excellent sources of provitamin A (beta-carotene)—almost as good as mango, with over 3,000 International Units (170 RAE) per 100 grams fresh edible portion. Not unexpectedly, yellow and orange-fleshed melons are the best sources. As to vitamin C, the type known in the United States as cantaloupe contains about 45 mg and honeydew 32 mg per 100 g edible portion, making them a good source of that vitamin as well. Levels of potassium can also be high but highly variable, averaging about 265 mg per 100 g of fresh flesh.

The seeds are good sources of energy and protein. The kernel contains approximately 46 percent oil and 36 percent protein.

⁷ Usually designated *Cucumis melo* subsp. *agrestis*, this type occurs wild in tropical Africa but apparently was not domesticated there; it seems to have come back from Asia.

⁸ *Cucumis melo* subsp. *dudaim*. Also known as pomegranate melon or Queen Anne's pocket melon.

⁹ As with many cucurbits, the carbohydrate formed in leaves and translocated to fruit is stachyose, a tetrasaccharide. However, the fruit accumulates neither stachyose nor starch.



Today's melons are derived from seed carried out of Africa, probably on the backs of camels swaying northward across the Sahara in the time of the pharaohs. Melon has "quickly" become one of the most popular fruits. They are second only to bananas as the most consumed fresh fruit in the United States, for example. Despite this, melon could have a far greater future in the daily life of millions, especially given all the untapped biodiversity still in Africa. (USDA, Scott Bauer)

HORTICULTURE

Because the cultivation of this crop is so well known we need say little. Melons are propagated by seed, of course. Depending on cultivar and soil conditions, they generally require 85-120 days to go from sowing to harvest.

Pollination is by insects. Male flowers open first and are the more numerous of the two. If insect pollinators are too few, hand pollination can improve fruit set. However, hand pollination is very inefficient and cannot compete with a hive of honeybees.

Yields vary depending on cultivar, planting density, and location. They can be very high. The nationwide average in the United States is 18 tons per ha. Under irrigation a good harvest is 20 tons per ha; without irrigation (but grown on a trellis), 8 tons per ha can be obtained. Perhaps the champion yielder is the Charentais European-type cantaloupe cultivated under glass, mostly on a trellis using plants that are pruned. Production comes in two waves: 25 tons per ha for the first wave, 10 tons per ha for the second. Yields using high intensity "fertigation" can reach *70 tons per ha*.

Melons are grown in very diverse cropping systems, including many in which it is cultivated concurrently or in rotation with a variety of vegetable

and field crops. Some are grown as a means for making unused scraps of soil productive. Javanese farmers, for example, sow the seeds on dikes between rice fields as well as in the land left to rest and recover following sugarcane.

HARVESTING AND HANDLING

Although some melon varieties have excellent shelf lives, most must be handled with skill and care. A few demand special attention because their skins are thin and easily bruised. Once ripe, melons decay quickly and become difficult to handle. Lacking starch reserves, they do not ripen or become sweeter after harvest. For the grower this creates a dilemma, because the later they are picked, the shorter the shelf life but the better the taste. Fresh melons may be stored at cool temperatures.

LIMITATIONS

Melon is still under-collected in Africa and elsewhere. The unusual types are poorly known, and breeding and planting materials are difficult to get.

Many African wild melons are bitter. Some *Cucumis* species are also toxic, although apparently not *C. melo*.

Melon is often susceptible to soil-borne diseases. Heavy losses are often reported because of a premature collapse of the vines. Major causes are fungi, such as fusarium wilt, powdery mildew, and downy mildew.

Numerous insect species can be found on melon plants. Only a few are economically important, but they can be devastating. A major pest is the melon aphid. Others include crickets, cutworms, leafminers, armyworm, loopers, borers, and whitefly—a major and evolving problem.

High-intensity production of high quality melons requires assured pollination by honeybees or other pollinators. Though not usually a problem in subsistence or backyard horticulture, in many places beehives are brought in and placed in or around large fields to ensure pollination. This creates logistic difficulties as well as potential conflicts with control of insect pests.

NEXT STEPS

Research needs of conventional, commercial melons do not concern us here. Beyond the periphery of those pressing problems, however, lie fascinating opportunities that can employ African knowledge and genetic resources to open new horizons for production and use of melons within Africa and without. In this sense, then, there are outstanding opportunities for collaborative research between Africans and scientists worldwide.

Genetic Diversity An international effort to collect melon germplasm should be mounted. Emphasis should be on unusual types. Many of those are of course to be found in Africa. However, to assess fully the germplasm available for breeding programs, types grown in other regions also need

collection. Special examples of these are the landraces of subsp. *melo* (Southwest Asia, Egypt, Arabia, Asia Minor, Russia, and the Central Asian Republics) and of subsp. *agrestis* (Indian Subcontinent, Southeast and East Asia, tropical Africa), and undomesticated material.

Genetic Details One of the mysteries behind this crop is the identity of its wild ancestor. African plants now wild may not be true progenitors. Whether these types originated in that locality or are feral escapes from human control is still an open question. A lot about this worldwide crop could be discovered by the unequivocal identification of wild ancestors and the interrelations of all the various diverse melons now found around the globe.

Better knowledge of the genetics of *Cucumis* species—*C. melo* varieties in particular—would also boost development of all future melons, conventional or exotic. The situation parallels that with *Brassica* species, in which genetic details have been exploited to create new and commercially viable vegetables related to cabbage, cauliflower, broccoli, and so forth. Melon is a similarly plastic species and carries the potential for creating types with strikingly different qualities. And a better understanding of the genome will help scout the routes to an even greater future for the crop.

Melons for Developing Regions Although many improved cultivars have been developed in the United States and other temperate regions, little or no work has been done on improvement of melons for the rigors of field conditions in most developing countries. Plants could be selected whose fruit have less water and more nutritional components, adaptation to tropical climatic and pest conditions, and better fit with local tastes and traditions.

Root Fuel The roots of some cucurbits, especially buffalo gourd (*Cucurbita foetidissima*), are dug and used as “firewood.” The possibility of turning melon roots to this end should also be assessed, especially in areas where fuels are in short supply.

Nutritional Improvement There is insufficient work on melon’s overall nutritional qualities. A complete assessment of variation in the divergent types is needed. Also, there is great potential for improving nutrient levels through plant selection or breeding. The levels of both vitamins A and C, for example, can likely be increased with targeted research and the selection of individual plants with high levels of these important nutrients. However, the current ones are already good, and programs to take better advantage of the already available germplasm are very much needed also.

Melon Breeding Objectives of melon-breeding programs could be manifold, but might include targets such as improved disease resistance, smaller fruits, better pest resistance, or increased drought tolerance. With

proper research many types of melons can be developed with improved storage qualities. Micropropagation could be used in conjunction with such a breeding program to speed the mass-propagation of rare types.

SPECIES INFORMATION

Botanical Name *Cucumis melo* L.

Family Cucurbitaceae

Common Names

China: heung kwa, t'im kwa

Dutch: Meloen

English: cantaloupe, muskmelon, sweet melon, honeydew melon

Ethiopia: yek'ura-haresa (Am)

French: cantaloupe, melon

German: Melone

India: kharlruz, karbuja

Indonesia: blewah

Kenya: mageye (Swa?) malange (name also used for pumpkin)

Malawi: kayimbe (Ch), mpombe (Y), luwimbe (Ng)

Malay: blewek

Philippines: katimon

Spanish: melón

South Africa: spanspek

Sudan: agur, ajur, fagus, senat-tibish, shammam (Ar)

Tanzania: mageye

Thai: ma-teng-lai

Uganda: akobokobo, akolil (Ts), olujo (Bar), kuluji (Rl)

Zambia: mankolobwe, shikaka, vitanguz (wild cucumbers)

Zimbabwe: spanspek

Description

Melons are annuals with climbing, or trailing vines up to 3 m long. The leaves are usually shallow lobed and more or less rounded. The plants are either monoecious (male and female flowers on the same plant) or andromonoecious (male and hermaphroditic flowers on the same plant). Flowers are fragrant, edible, and usually large. Most are yellow; some white.

As noted, the fruits are extremely variable. They may be ellipsoid to globose, with or without longitudinal grooves. The skin may be soft or hard, yellow, green, cream, or orange in color; and plain, netted, or prickly in texture. The flesh varies from white to cream-yellow, orange, or green. Most of today's commercial types have thin skin and thick orange pulp.

Honeydew is an exception. Most melons are many seeded. The seeds are flattened, and may be cream or light yellow.

Distribution

Melon is grown worldwide. Its exact origin is unknown, but the wild species of *Cucumis* occur in Africa, so it seems clear that it originated there. Melon's primary diversity seems to be tropical and subtropical West Africa, where at least 40 *Cucumis* species are endemic. Many other wild and semicultivated types are found throughout Africa. So too are cultivated types, many of them returnees from Asia, Europe, or the Americas.

Although the melon was introduced into Asia at a comparatively late date, well-developed secondary regions of variation now occur in India, China, Iran, and Central Asia.

Horticultural Varieties

The classification of this highly polymorphic species is confused. A number of species and varieties have been erected from time to time, but this may not be justified as all the forms hybridize readily and there are many intermediate types.¹⁰ The most commonly cultivated types are:

- Cantaloupe melon of Europe (*Cantaloupensis* group). This has a thick, scaly, rough rind, often deeply grooved.
- Muskmelon (*Reticulatus*; called cantaloupe in the trade), grown mainly in the United States. This has smaller fruits and rinds that are finely netted to nearly smooth, with very shallow ribs.
- Casaba, Persian, or winter melon. Produces large fruits that mature late with good storage quality. The rind is usually smooth, yellow, and often striped or splashed in green and white. The flesh is firm with little musky odor or flavor. The Honeydew cultivar group, America's best-known winter melons, with ivory skin and green flesh, is of the *Inodorus* type.
- Vegetable types. As noted earlier, a number of forms, often with elongate fruits resembling cucumbers, are grown in India and the Far East and used as vegetables. These are mostly domesticates of subspecies *agrestis*, and were used in Egypt, Palestine, and throughout the Fertile Crescent from ancient times until about 50 years ago.¹¹ In recent times they have attracted research attention in Israel and the United States.

¹⁰ One author put it: "Melons are the despair of taxonomists. The exaggerated friendliness of melons makes it difficult for taxonomists to arrange them in categories with any degree of fixity, but they have bravely tried all the same, though sometimes a new variety has to be assigned to one category or the other more or less by guess and by golly."

¹¹ A contributor commented on this: "There was an attempt at the University of Arizona to develop a muskmelon for use like cucumbers. I have seed and am evaluating them now. The first crop looked promising. Pickles made from these were excellent. They seemed to be crisper than cucumbers."

Environmental Requirements

Melons tolerate a wide range of environmental conditions but require relatively high temperatures—higher than those needed by cucumbers. Optimum growth is obtained during dry periods with high temperatures, moderate humidity, and little diurnal variation. Large fruited types produce well only if supplied with reasonable water and soils.

Rainfall Usually rainfall of more than 500 mm is required. It should be well distributed during the period of fruit formation. As noted, under humid conditions melons are prone to leaf diseases. In addition, flowering is reduced and fruit quality is affected.

Altitude Elevations below 500 m seem to favor best growth and development, and the conventional types are usually found below about 300 m, even in the tropics. However, melons grow well at 1,500 m in South Africa. In temperate areas, at least, the crop seems restricted by temperature and the length of the growing season rather than by altitude. Certain special types are grown at higher altitudes. For instance, subspecies *agrestis* thrives at altitudes up to 1,100 m in Ethiopia.

Low Temperature The plants are killed by frost.

High Temperature Full exposure to the sun is beneficial; melon plants require plenty of sunshine and heat. Optimum growth is obtained in dry periods with temperatures above 24°C. Although much higher temperatures are tolerated, some fruits (winter melon, for example) often need protection from sunburn. (Dry plant material can be used as a cover.)

Soil Melons produce best on deep, fertile, neutral to slightly alkaline, well-drained soil. The plant is sensitive to acidity. It can grow well on soils poor in nutrients, but prefers light soils well supplied with organic material with a good moisture-retaining capacity. The root system is sensitive to direct exposure to sun.

Daylength For the most part there is no daylength problem in melons, although some cultivars from China and some breeding lines do not set well under shorter daylengths.

Salinity Two salt-tolerant cultivars have been developed in Israel. Both have good fruit quality, appearance, and taste and can be irrigated with moderately saline water or survive in salty soils.¹² The tang of the salt reportedly enhances the flavor by increasing the percent sugar of the fruit.

¹² S. Mendlinger, D. Pasternak, and Y. De Malach, Ramat Negev Experimental Station, Ben-Gurion University of the Negev.

Related Species

Cucumis is a genus of about 25-35 species, mostly African. They include the fruit we call cucumber (*C. sativus*). Among other African types worth exploring as fruits are *C. metulifer* (the horned melon, see Chapter 5), and *C. anguria* (both cultivars of the West Indian gherkin and wild types).





Tamarindus indica

TAMARIND

Tamarind (*Tamarindus indica*) is one of the great trees of the tropics. Its feathery foliage is common from Senegal to Singapore, Suriname to Samoa. Everywhere it grows, people enjoy the curiously sweet-sour pulp found inside its brittle, gray or cinnamon-brown pods. That pulp is sucked out as a refreshing treat, or mixed into myriad drinks and sauces. Its tang especially blends with the fire of chilies, a marriage lending many tropical dishes their distinctively tart, sweetly biting savor. The famous cuisines of South India (e.g., vindaloo) and Java (satay ayam) are good examples. Westerners recognize the tamarind taste mainly from the well-known Worcestershire® sauce, Jamaicans from their world-famous Pickapeppa® sauce. It is also a common “secret” ingredient in barbeque sauces.

History books often say this plant hails from India. The common name, too, derives from the Arabic tamar-u'l-Hind, or date of India. Even the scientific epithet “*indica*” reflects this old belief in its place of origin. But for all this literal association with India, tamarind is actually African. The wild version is a common savanna tree and can be found over a huge area stretching from the Atlantic to beyond the far edges of Central Africa. The capital of Senegal is named for this native favorite, which in the local Wolof language is called “dakar.”

This tall legume has long been integral to African culture. For millennia, people have crushed the fruit pulp in water to form a paste, which they then employ for “souring” their bowls of sorghum or millet gruel. Women in the Sahel, for example, slip in some tamarind when making the gel-like porridge (normally called toh) that is a daily staple of millions.

Although its main product may seem like a rather minor food, tamarind has been called a tree of life. In this regard, an important feature is that its fruits can be stored away and served later—especially during the dry season when fresh fruits are scarce or nonexistent. Fulani nomads, for example, preserve the sugar-rich tamarind pulp in the form of sun-dried cakes, which they rely on for sustenance while moving across the Sahara sands.

Modern Africa has been far from backward in advancing this fruit. Already, tamarind-based soft drinks are favorites in many places. In Mali and Burkina Faso, for example, such drinks (both fresh and carbonated) rival the ubiquitous Coca-Cola® in popularity. Among other things, they are



Wild tamarind, Cape Verde. This species is cultivated throughout the tropics, where it is appreciated for its shade as well as for the sweet-and-sour pulp found inside its brittle, gray-brown pods. What is not widely known is that tamarind is actually African. The original wild version can be found over an area stretching from these islands off Senegal to beyond the Central African Sahel. (Peter Longatti)

featured in up-market restaurants. And Mali's own concentrated tamarind syrup is said to sell better than fancy fruit syrups imported from France. The country is itself exporting tamarind drinks to Europe, where they can be seen selling well on the streets and even in the bars of Paris and Rome.

Although the processed pulp has a notable commercial future in sauces, syrups, drinks, jams, and confections, there are also forms that can be enjoyed out of hand. These "almost sweet" types have their own separate future. However, in the short term they are unlikely to become large-scale international commodities because outside their traditional range, people just aren't accustomed to sucking a gummy dark-colored paste from a pod.

The living tree has great value too. It withstands the assaults of city smog and, thanks to a deep and extensive root system, weathers violent storms. It also tolerates the salty air of coastal locales. Its crown of drooping branches bears graceful, feathery foliage, giving it a handsome appearance and making it outstandingly useful for beautifying parks, backyards, boulevards, markets, and country roads. It is a much-loved shade tree, both on account of its evergreen foliage and its dense crown. In India, for instance, stately tamarinds throw shade over thousands of villages and millions of grateful travelers every day. For these reasons, alone, it holds much promise in tropical reforestation, especially for plantings in places where people live, work, congregate, and crave a spot of refreshing shade.

And the living tree offers many more possible benefits. It is especially promising for reclaiming deforested and damaged lands and restoring them

to health and productivity. In Nigeria, for example, tamarind is used in anti-desertification programs because it has an ability to grow in arid climates and to resist savanna ground fires. In India also, strips of tamarind are planted among forest trees to act as firebreaks. And tamarind trees have notable promise for sequestering carbon from the atmosphere, because they typically stand for centuries—not just because their physiology permits it, nor because they also resist droughts, fires, typhoons, and salt spray, but because people hate cutting down tamarind trees.

PROSPECTS

For all its widespread use, tamarind still remains largely unimproved and unappreciated as a horticultural crop. This is especially true across its African homeland. Indeed, although commercial tamarind plantings have sprung up in Thailand, the Philippines, Indonesia, Sri Lanka, Belize, Brazil, Guatemala, and elsewhere, only India exploits it in a nationally organized way. As a result, India now exports tamarind to the world. The species, however, has promise for vastly increased use in most parts of the tropics. A major portion of its future lies in a range of cultural situations, including subsistence farming, agroforestry, urban forestry, industrial plantations, and plantings established for humanitarian and environmental benefit.

All in all, the tamarind is so superbly adapted to both dry savannas and monsoonal regions that it deserves greater research attention and extensive organized plantings in such locations. It is hardly a rocket-fast grower, but it is resilient, able to thrive in poor soils, and tolerant of abuse from people, pollutants, and powerful natural forces. The fact it meets two great needs of the tropics—food and shade—endears it to the populace of the hot zones. That is why it has already spread so widely without formal help. Incidentally, it also means grateful growers will protect it almost with their lives. And that in turn means that plantings can be permanent and contribute to food security and human nutrition for decades or even centuries.¹

Within Africa

Long ago, tamarind marched beyond western Africa to find new homes across the continent. Further east, in Uganda for example, there is a broad tradition of mixing it into the local millet porridge known as ugali, and tamarind pulp is sold in almost every market. Still, when considered in Africa-wide perspective, tamarind is a much-neglected resource.

¹ Many of these ideas, and much more about tamarind, are elaborated upon in a recent monograph, El-Siddig, K., H.P.M. Gunasena, B.A. Prasad, D.K.N.G. Pushpakumara, K.V.R. Ramana, P. Vijayanand, and J.T. Williams. 2006. *Tamarind* (*Tamarindus indica* L.). Fruits for the Future 1 – Revised. International Centre for Underutilised Crops, Southampton, UK; see www.icuc-iwmi.org. Tamarind was also covered in our 1979 report, *Tropical Legumes*.



Mauritius. Although it may appear to be quite a minor food crop, tamarind has been called a tree of life because its sugar-rich fruits can be stored away without refrigeration and safely served weeks or months later—especially during the dry season when fresh foods are scarce or nonexistent. (Madeleine Philippe)

Humid Areas Excellent prospects. Although considered a dryland species, the fact it thrives in places such as the Philippines, Indonesia, Singapore, Thailand, and Hawaii shows it can have high tolerance for humidity. It is indeed a tree of both parched zones and humid lowlands. Thus there are many parts of tropical Africa into which it could smoothly fit.

Dry Areas Excellent prospects. Savannas are the plant's original African habitat, so the tree is endowed with the potential to perform on seasonally dry, semi-arid sites. Of course, in such locations it grows more slowly than on better watered ones, but its deep taproot and natural ability to shed its leaves when stressed means that it survives even long droughts and lives on to thrive another day.

Upland Areas Limited prospects. Tamarind requires tropical or near-tropical temperatures. Any promise for the highlands would likely be restricted to equatorial latitudes and elevations below, say, 1,500 m, where the climate never falls below freezing.

Beyond Africa

The tamarind, a tree of many uses, has an especially attractive future for producing drinks, jams, and confections on an industrial scale. As noted, the tree adapts so well from dry savannas to well-drained monsoonal areas that greater plantings seem in order for much of the tropics.

USES

People both rural and urban utilize every part of this species: pulp, seeds, leaves, flowers, wood, and the whole tree itself. Among the wealth of tamarind products, the main ones are the following.

Fruit As noted, the pulp is commonly eaten fresh. In addition, it is blended with sugar, and pressed into loaves, balls, or cakes. Even still on the tree this fruit is almost dry, and that alone endows it a long shelf life. Indeed, it may keep almost indefinitely. One preservation method involves pressing shelled fruit into rounded cakes and storing in a cool place. Another entails packing fruits into jars, using alternate layers of whole tamarinds and sugar.

No matter whether fresh or preserved, tamarinds offer many culinary applications: They can be used to sweeten and season foods such as:

- Cereal products—including Africa's many types of porridges, gruels, and pablums (fufu, ugali, toh, ogi, kisra, pap, couscous, and the rest).
- Soups, sauces, chutneys, curries, fish. This is currently the main use for which European and North American countries import the pulp, especially to add to condiments such as steak and barbecue sauces.
- Confections, preserves, ice creams, syrups. Markets in tropical America often carry a sweetmeat of pressed tamarind and sugar. The fruits are also dipped in powdered sugar and eaten for dessert, like strawberry.
- Drinks. Shelled fruits—cooked in syrup until soft and then put through a sieve—are made into refreshing drinks popular across the tropics. “Tamarind-ades” are enjoyed throughout much of Africa (for instance, Sudan, Egypt, West Africa, and coastal East Africa). Some are sold in cans and are even carbonated. Such tamarind beverages are also especially popular in Guatemala, Mexico, indeed most of the American tropics.

Seeds Tamarind seeds are edible, usually roasted or boiled and eaten after shucking the seedcoat. In roasted form they are said to taste “better than peanuts.” In composition, they contain about 60 percent starch. In the form of a flour, they are added to cake- and bread mixes as well as other edible products. A purified pectinlike gum useful for stabilizing processed foods is made from them as well. In addition, an oil resembling peanut oil can also be extracted from the abundant seeds.

Other Foods Young leaves, flowers, and baby pods are all agreeably sour, and in some countries are used to season rice, fish, or meat in curries, soups, or stews. Immature pods are also used like common beans: roasted or boiled, and served as a vegetable, pickled, or added to salads.

Fodder Tamarind is a vital fodder tree for arid and semiarid lands. Further, ground-up seeds make a palatable, high protein “concentrate” for livestock feed.

Raw Materials The powder and concentrated juice from the fruit’s pulp are promising raw materials for the food-processing industry. Products from the seeds are promising industrial resources too. Purified seed-gum may be used for sizing textiles and paper products; it also has potential as filler for the adhesives used in making plywood. In addition, the seeds yield a semi-drying oil. This resembles linseed oil, and is said to be suitable for making paints and varnish.

Wood The dark, purplish-brown tamarind heartwood is heavy and dense (weighing around 1,000 kg per cubic meter). Strong and termite-resistant, it takes a fine polish and makes excellent toys, tool handles, turnery products, furniture, and decorative paneling. It is very strong and stable and can be used for boatbuilding. It is widely employed in the camel-powered oil presses in remote rural areas such as Western Sudan. Although sold in North America under the name Madeira Mahogany, it is costly and hard to work, and the tree’s typically short bole limits its use as sawn timber.

Fuel Tamarind wood is a valued fuel, and it gives off an intense heat. The heat output approaches 5,000 calories per kg. In India it is the fuel of choice for firing brick kilns. The charcoal can be of such high quality that it has long been used to make gunpowder, and it was also a major fuel for producer gas (“gasogen”) units that powered many Indian vehicles during World War II.

Ornamental Use One of the world’s finest shade trees, tamarind is particularly valued in semiarid regions, where its huge dome of graceful foliage is all that enlivens many a dreary scene. To find this ornamental along a hot, dusty road or a public park is truly a joy.

Miscellaneous Uses In Africa, tamarind is a host of one of the wild silkworms (*Hypsoides vuillittii*). It also is a good host plant for *Kerria lacca*, a shellac-providing insect. The flowers are reportedly a great source of honey. The trees make good firebreaks because the abundant leaf litter and deep shade beneath their dense canopies suppress most undergrowth. Some

parts of the tree supposedly have curative properties, including fungicidal and antibacterial agents reportedly found in various tamarind products. Concentrated doses of the raw pulp are also used as a gentle laxative, and when boiled into a drink is considered good for inflammations. It is also mixed with salt and used to polish brass, copper, and silver. The seed testa can be used in tanning leather, while the seed husks have been found to make effective fish poisons.

NUTRITION

Up to half the pod weight consists of pulp, which contains both sugars and tart organic acids. Though reputedly richer in sugar than any other fruit (30-40 percent), the pulp usually tastes quite tangy. The acidity is largely due to tartaric acid, whose levels sometimes approach 12 percent of the pulp. However, there is much variability among different trees; some fruits are almost acid free, others so sour as to pucker the mouth. Notably sweet cultivars have been selected in Thailand, and these are highly prized.

As the pod ripens its acidity hardly decreases, but sugar levels increase until they more or less match the sourness. Hence tamarind is said to be simultaneously the most acidic and most sweet of fruits.

The dry pulp also consists of about 4 percent protein, and 1 percent fat. Though it contains negligible provitamin A, it is a good source of the B vitamins thiamin, niacin, and riboflavin. While the high acidity might suggest a good antiscorbutic, numerous tests have found that neither the ripe nor the green stages contain significant quantities of vitamin C.

As to minerals, the calcium value—sometimes above 0.1 percent—is reportedly the highest for any fruit. The phosphorus and potassium contents are also unusually high, averaging respectively about 165 and 900 mg per 100 g dry weight. Pods can also be high in iron, averaging about 4 mg per 100 g dry weight. This could make them useful in countering anemia.

The leaves, with a protein content of 3-4 percent, make a vegetable of modest nutritional merit. They are supposedly, however, a good source of provitamin A, calcium, and phosphorus.

The seeds are about as high in food value as maize or wheat. They contain about 60 percent starch, 15 percent protein, 5 percent oil, and small amounts of sugar. The protein is high in essential amino acids.

HORTICULTURE

The tree is easily propagated via direct seeding or transplantation from nurseries. Handled carefully, seeds remain viable for years and germinate rapidly after being scarified or soaked in warm water overnight. These treatments break the dormancy, with good germination occurring in about a week. However, seedlings are inherently slow growers, taking a year or so to become big enough for planting out. Fruiting then begins in 7-8 years.

Outstanding mother trees are propagated asexually, a process providing many advantages. Vegetatively propagated specimens come into bearing within 3-4 years. They produce more fruits as well as more-uniform fruits than seed propagation. Trees also seem to remain smaller—making them easier to harvest and handle. Shield and patch budding and cleft grafting are fast, reliable vegetative-propagation methods used on a commercial scale in the Philippines. Trees can also be started from branch cuttings, and superior clones can also be grafted onto seed-propagated rootstock.

Globally speaking, tamarind trees receive minimal care, and tend to get very large. But in Thailand's central delta they are intensively cropped and kept to convenient size by planting them close together (about 500 trees per ha) and by pruning (which also rejuvenates the fruiting wood). Even though tamarind is something of a "blue-collar crop," Thai orchardists treat it with as much respect as their mango, pumelo, durian, and other quality fruits. They pamper their valuable tamarinds with such "white-collar" treatments as irrigation, heavy manuring, and thorough pest and disease protection.

Tamarind is shade intolerant and does not appear to regenerate beneath its own canopy. Although slow to mature, the trees are long lived. On average they continue fruiting 60 years, but individual specimens may remain productive 150 years or even much longer.

HARVESTING AND HANDLING

Average annual yields vary tremendously, depending on conditions, the inherent quality of the tree, and the care it is given. One review gives average yields from adult trees as 10 to 50 kg per year.² Another reports 150 to 200 kg, or about 12 to 16 ton per hectare.³ A third refers to average yields between 500 and 800 kg for domesticated trees in India.⁴ And there are also claims of well-grown trees producing up to 2,000 kg of fruits per year.

If whole pods are for market, they are best harvested by clipping, which avoids damaging the pod's shell. Fully ripe tamarind fruit can reputedly be left on the tree up to 6 months without loss of quality. Eventually, though, they abscise naturally, or are lost to pests, especially various beetles.

The mature fruit has exceptional keeping qualities and is often sold—unshelled but without other protection—in village markets frequently notable for dirt, filth, and flies. Even when the shells have cracked or broken open, the sugary pulp can remain edible several months. Pulp destined for processing is separated from shell, seeds, and fiber before being compressed and packed (commonly in palm leaf mats) for storage, shipment, and sale.

² Forestry Fuelwood Research and Development Project (F/FRED). 1992. *Growing multipurpose trees on small farms*. Winrock International, Bangkok.

³ Information supplied by the Royal Tropical Institute, Amsterdam.

⁴ International Centre for Research in Agroforestry (ICRAF). 1992. *A Selection of Useful Trees and Shrubs for Kenya: Notes on Their Identification, Propagation and Management for Use by Farming and Pastoral Communities*. ICRAF, Nairobi.



Tamarind promises to boost rural development in most parts of the tropics. The sour-sweet pulp is very versatile, mixing easily into sauces and drinks. Its tang blends well with the fire of chilies, lending many tropical dishes their distinctively tart, sweetly biting flavor.

(Glenn Kopp, Missouri Botanical Garden)

LIMITATIONS

There are conflicting claims about the need for a long dry spell around harvest time. Some contributors—basing their conclusions on African experience—declare this is a necessity for growing tamarind as a fruit. In humid areas of Southeast Asia, however, orchards receiving more than 1,500 mm of rainfall annually are possibly the most productive anywhere.

For the first few years of life, the young tree needs protection from grazing animals such as goats.

Harvesting the fruit is difficult because the stem connecting the pod to the tree stays tough even when the fruit is ripe.

Although a legume, the tamarind apparently fixes no nitrogen. Nodule-like lumps are often seen on the roots, but active nitrogen fixation has yet to be detected, despite many attempts.

Insect pests can attack the pods, especially any left on the tree for some time. Seeds are prone to insect attack as well. Beetles and weevils are the worst antagonists. Ripe seeds should always be kept in airtight containers.

Most African countries lack the marketing channels and information to develop substantial operations, but those could be quickly instituted.

Not everyone loves this fruit at first sight. In fact, some take a long time getting used to its lowly looks. The pulp is not colorful or immediately

attractive but usually a rather sticky, somewhat fibrous mush, a sight that is not alluring to those who have yet to learn the secret of its flavor.

NEXT STEPS

There is a broad spectrum of focused actions that could help the world take better advantage of the tamarind.⁵ Below are just a few examples.

Basic Studies Filipino researcher R.E. Coronel wrote us: “The much-appreciated qualities of the tamarind and its adaptability to different soils and climates enabled it to conquer the tropics in the remote past; the tree and its fruit are still highly prized today. It is therefore all the more surprising that so little is known about tree phenology, floral biology, husbandry, yield, and genetic diversity....”⁶ The list could be expanded; there is much to learn.

Selection Few of the tamarinds now growing throughout the tropics result from horticultural selection—they derive from seeds picked up perhaps at random. There is therefore excellent potential for markedly improving the crop. Much variation in fruit characteristics—such as yield, sweetness, acidity, and the size and shape of the fruit—exists in nature and in millions of casual plantings. Some trees bear exceptionally large pods well filled with pulp; others are so lacking in acid they are referred to as “sweet.” Superior types such as these should be sought out and vegetatively propagated.

In addition, budsports are common in tamarind. These isolated branches bear fruits different from those on the rest of the tree. Once identified, budsports can be readily propagated asexually to advance the crop.

Germplasm Collections The greatest diversity of tamarind occurs in the African savannas stretching from Senegal into Sudan. There, specimens can be found exhibiting tolerance to waterlogging, persistent drought, extreme soils, high and low pH, and heavy grazing. These unique individuals need to be identified, tested, shared, and generally made available for use.

There are also foreign tamarind collections that offer great possibilities. The Institute of Plant Breeding in the Philippines maintains a large number of accessions. In addition, India, Thailand, and other Southeast Asian countries have recorded many interesting types. The University of Florida has a collection near Homestead. From these, outstanding plants with fast growth, large fruits, and sweeter and juicier pulp are also likely to arise and help transform world appreciation for this overlooked crop.

Windbreaks The tamarind is one of the few fruit trees—because its branches are so strong and pliant—that can be grown in locations subject to

⁵ A full range of examples is in El-Siddig, et al. 2006, op. cit.

⁶ Information from R.E. Coronel.

the full blast of tropical storms. Its very extensive root system also seems to contribute equally to its unusual resistance to horrific winds. The need here is not so much for research but for demonstrations, nurseries, and programs to educate people and initiate planting projects.

Commercial Development Tamarind's commercial promise may merit plantation expansion throughout the tropics. As long as quality varieties are planted, it should prove to be a profitable crop that, once established, can require little care and provide benefits for centuries.

Husbandry Tamarind horticulture deserves special attention. Very little is known, for instance, about growth rhythms in various parts of the tropics. Pruning and other manipulations could create, for example, low-growing specimens, manageable in normal orchard practice and reachable from ladders. In such ways, tamarind might produce on a more intensive scale.

Reforestation Every person concerned with the greening of the tropics should consider tamarind. The tree is magnificent for bordering streets and highways, for shading backyards, for farm and village boundaries, and for reforesting denuded slopes.

Global Cooling As a tree to combat any greenhouse effect, this evergreen has the advantage that it may grow (and accumulate carbon) for two or more centuries. Unlike many tropical trees, it normally reaches a ripe old age: people resist cutting it because it provides food to eat and products to sell. Moreover, they are grateful because it turns hot, baking streets into shady, cool boulevards. Whole cities and hundreds of thousands of kilometers of roadsides could be planted with tamarinds. Individuals wishing to help an overheating world could hardly find a better tool among the trees.

Harvesting It seems unlikely that plantings of tamarind orchards will increase in any major way until better methods of harvesting are found or developed. For example, pods today are often just knocked off with sticks.

Other This brief chapter can only touch on the myriad things that could make a difference with a crop as versatile as tamarind. An international website could stimulate further developments and keep the world informed of progress. Beyond food, there are medicinal uses as well as industrial and other applications that could appeal to specialists.⁷ Documentation of indigenous knowledge—with local participation—on uses and conservation should be undertaken throughout tamarind's distribution. Specific technical aspects deserving research include genetic resources, breeding, agronomy, harvesting methods, postharvest practice, and processing. There are, too, the economics of production and marketing to be explored.

⁷ These too are discussed in the *Fruit for the Future* monograph previously quoted.

SPECIES INFORMATION

Botanical Name *Tamarindus indica* L.

Family Leguminosae (Caesalpinioideae)

Common Names

Afrikaans: tamarinde, suurdadelboom

Arabic: tamar-u'l-Hind

Bambara: tomí, tombi

Bantu: omukooge (tree), enkooge (fruits)

Burkina Faso: bu pugubu

Arabic: tamr hindi

Dutch: Tamarinde, Tamarindeboom

English: tamarind, Indian date

Ethiopia: hemor, honor, humar, komar, tommar (Am), aradeb (T),
b/roka, rucahu, dareho, dindie, ghroma, gianko, omar (G/O)

French: tamarin, tamarinier, tamarindier

Fulani: jtatami

Hausa: tsamiya

Kanouri: tamsugu

Kenya: mkwaju (Swahili), ol-masamburai (Masai), epedur (Turkana),
roka (Bor), chuzaa, chua (Luo), kinthumula (Ka), muthithi (Meru),
orn (Poko), arwo (Tugen), Loisichoi (Njemps)

Malawi: ukwaju, bwemba (Ch), mkwesu (Y), nkwesu (Nk)

Niger: bossé, bossaye (Djerma), djatube (Peuhl)

Nigeria: Icheku oyibo (Ibo), ajagbon (Yoruba)

Peul: dabe, ngatabbi, n'jabi, n'jame, yammere

Portuguese: tamarindo

Senegal: dakar (Wolof)

Somalia: hamar (Som)

Sonrai: Bóssó

Spanish: tamarindo

Sudan: aradeib, tamri hindi (Arabic), shekere, kuashi, danufi (Nuba)

Swahili: mkwaju

Tamachek: basoro, bassasu, bochocko, tchimic

Tanzania: mkwaju (Swa)

Uganda: esukuru, esuguguru (leaves, Ts); fruit: e/apeduru (Buk/Kmj/Ts),
iti (Bar/Md), chwa (A), cwa/o (Ach/Lng), pitei (Kk/Ach)

Zambia: mushishi (B), mwemba (Ny), b/musiika (To)

Description

Tamarind is a massive, slow-growing, long-lived tree with dark-gray bark and strong supple branches that droop gracefully at the end. It may reach 25 m in height. The trunk can exceed 7 m in diameter but is usually short even in old trees. However, in the wet tropics trees seem to grow taller and can produce a fairly long clear bole. The bark is strongly fissured and scaly on the trunk and smooth on the branches. It exudes a blood-red gum.

In most growing areas tamarind is evergreen; however, severe drought causes massive leaf drop. At flowering, the trees burst with showy clusters of pale-yellow, pink-veined blossoms. These are cross-pollinated, probably by insects (such as, in India, the honeybee relative *Apis dorsata*) and wind, although the flower structure does not exclude the possibility of selfing.

The tree produces heavy crops of fruits, typically every other year. Trees are known still producing fruits at a reputed age of 200 years. Fruits are long, flattish, gray or rusty colored, bean-like pods, usually irregularly curved, sometimes with constrictions in the spaces between the seeds. They contain 2-10 seeds embedded in sticky pulp. At maturity, the shell turns brittle and is easily cracked open to expose the dark-brown, pasty pulp that surrounds hard, shiny, brown seeds, each in a parchment-like “envelope.”

Distribution

This species is a native of the dry savannas of western Africa but it now reaches the southern limit of its range in Mozambique and Natal, where it has become naturalized around Durban.

Tamarind performs so well in semi-arid and humid monsoonal climates that it is already truly pantropical. It is found across South Asia, where traders or travelers introduced it centuries ago. It is also common throughout the American tropics, especially the Caribbean. In Puerto Rico, as one example, it is fairly common along roadsides, around houses, and on hillsides in the dry, coastal regions.

Horticultural Varieties

Many different types exist depending on the form and quality of the fruits. But at present there are few standard varieties.

Thai orchards grow cultivars of a sweet type (*makahm wahn*) named ‘Muen Chong’, ‘Nazi Za’, and ‘Si Chompoo’. ‘Manila Sweet’ is a similar cultivar from the Philippines.

Environmental Requirements

In their native African habitat, wild tamarind trees mostly grow alone, rarely in small groups, sometimes along rivers (which may be seasonally dry) or lakes, as well as in often rocky, lowland-woodland. The species is a

light demander, very sensitive to frost, and withstands drought. Although happy on plains and stream banks subject to frequent flash flooding, it cannot withstand long-term inundation or stagnant waters.

Rainfall In Africa tamarind thrives where annual rainfall drops as low as 750 mm and sometimes below 500 mm. It also can thrive in areas of Southeast Asia receiving more than 1,500 mm. Generally speaking, it seems to avoid regions exceeding 1,900 mm.

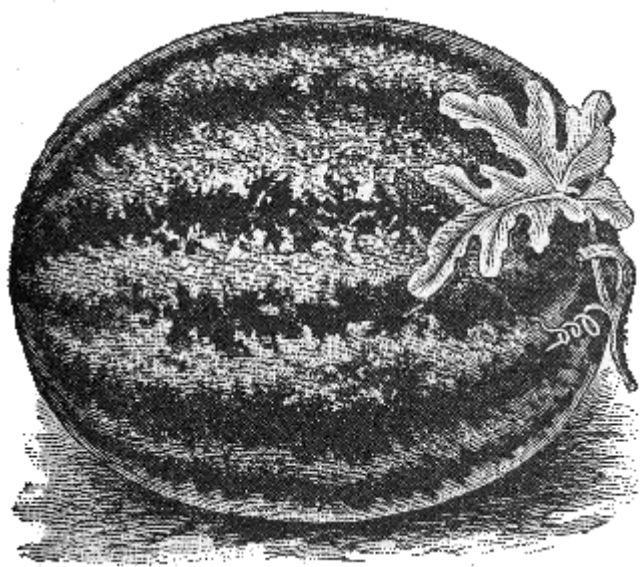
Altitude By and large, it is found between sea level and 1,500 m elevation. In the Machakos district in Kenya, for instance, it can be seen growing well at about 1,200 m above sea level.

Low Temperature Tamarind cannot tolerate persistent cold; even brief frost can cause severe damage or death. Anywhere mean annual minimum temperatures fall below about 7°C is too cold to cultivate tamarind reliably.

High Temperature This tree seems undaunted where mean annual maximum temperatures can exceed a blistering 50°C.

Soil Some writers claim tamarind prefers slightly acid (pH 5-5) soil. In Fiji, though, successful growth has been reported in highly acid (pH 4.5) to highly alkaline (pH 8.7) soils. In India, the tree also grows in alkaline soils (pH 8.5). Truth is, this species (or its genotypes) tolerates a diversity of substrates. Although growing best where soils are deep and well drained, it can flourish in poor soils and even rocky terrain. It is also frequently found beside termite mounds or in sands near the seashore. In the Sahelian zone, it commonly grows in association with baobab (see Chapter 2).





WATERMELON

Other than botanists, few people consider that watermelon (*Citrullus lanatus*) is African. Yet this is so: the crop's wild ancestors occur abundantly in the dry zones of the continent's southern region. The African origin may come as a surprise only because watermelon spread around the globe so long ago that for most people it has become part of the wallpaper of life.

Today, this African fruit is cultivated throughout the warmer parts of the world—from the searing tropics to temperate latitudes and even beyond.¹ Global annual production is approaching 100 million tons. Yet Africa scarcely registers in statistics: the largest producers are Turkey, Iran, and Egypt, the United States and Mexico, and—especially—China, which produces over two-thirds of the watermelon in the world. While consumption in the United States has been fairly stable over the past 25 years, elsewhere demand is increasing, and indications for the future suggest ever-greater global production.

Given all this success, it is intriguing to consider that only a few watermelon types emigrated out of Africa. The descendents of those select few rose to a place among the best known of all the world's fruits. With their colorful flesh and luscious sweet juice, they have been called the food of heaven. Mark Twain once wrote, “The true southern watermelon is a boon apart and not to be mentioned with commoner things. It is chief among this world's luxuries, king by the grace of God over all the fruits of the earth. When one has tasted it, he knows what the angels eat. It was not a southern watermelon that Eve took; we know this because she repented.”

The homebound watermelon types that remained in southern Africa's arid regions are not at all like that. To naive outsiders they can look like miserable waifs, fully deserving their neglect. But that impression is false. Wild watermelons are useful in their own right, and always have been, their rinds, flesh, and moisture sustaining many inhabitants through waterless times. “The most surprising plant of the South African desert,” wrote David

¹ It is abundantly grown, for instance, in parts of Java, providing farmers a substantial income. Major sites for production are also found in the semi-arid parts of coastal Peru and Ecuador. A state-record watermelon grown in Alaska, USA—located above 55° N—weighed 65 kg.



Few people realize that watermelon is African. Yet this crop's wild ancestors are scattered abundantly across the dry wastes of the continent's semi-arid southern hinterland. In Africa's Kalahari Desert the undomesticated watermelons are an important source of both food and water. In times of drought African farmers have traditionally relied on them for emergency use. (© Roland Bischoff / botanikfoto)

Livingstone in 1857, "is the kengwe or keme, the watermelon. In years when more than the usual quantity of rain falls, vast tracts of the country are literally covered with these melons. Some are sweet and wholesome, and others so bitter that they are named by the Boers the 'bitter watermelon.'"

They are also plentiful. Wild watermelons still bespeckle millions of hectares of semi-arid African hinterland. Passersby see them alongside thousands of kilometers of roadsides and bushtracks, particularly in the Kalahari Desert of Botswana and Namibia. But few who spy the tiny nondescript orbs lying amongst scraggly vines beside the road or trail can appreciate that, botanically speaking, they are indistinguishable from the big beloved fruit in their own life. The difference is too great to be grasped at a glance. "This is a salutary lesson in the hidden potential of so many superficially unpromising wild fruits," one of our insightful contributors wrote; "selection and domestication can improve them out of all recognition in a few [plant] generations."

Although their domesticated descendants have been cultivated for over 4,000 years and were old news to the ancient Egyptians, the progenitors that gave them life basically remain strangers to commerce and horticulture. Now is the time to better recognize these orphans of the wilderness. They have value for both direct and indirect use.

Direct Use

African watermelons deserve attention solely on the basis of their own qualities. Many are prolific and productive. They exist on the absolute outer edge of human settlement, where all life is tenuous. They are so important to some people as to literally stand between life and death. And they can be made even greater contributors to the African outback as well as to the world. Examples follow.

Vegetable Watermelon Among all the variants within the species, types with small, hard, unsweetened fruits are among the least developed. In Africa they are grown exclusively as vegetables—cooked like pumpkin or squash. So far, these are unknown to most of the world. In India, though, one type has become a widely used vegetable.² Its small, round fruits (up to 10 cm in diameter) look more like bloated cucumbers than watermelon. They are either pale or dark green in color, and are eaten fresh like cucumbers, pickled like gherkins, or candied like apples. The seeds may be dried and eaten like nuts. This type of variant appears to be a crop with considerable potential in its own right...and not just for one nation but for dozens.

Edible-Seeded Watermelon Certain other types are grown solely for seeds. In parts of West Africa—particularly Senegal, but also Nigeria, Niger, Chad, and Cameroon—these are crucial articles of food and of commerce, and are sold in countless markets.³ The seeds are prepared in different ways. Most are dried, roasted, and eaten as nuts; some are pounded into a paste resembling peanut butter; others are ground and baked into bread, to which they add a nutty flavor; a number are used in soups or stews or parched and eaten with cereal products. The Yoruba of Nigeria ferment the kernel to produce a favorite food flavoring known as ogiri.

Watermelon seeds appeal to more than just local taste preferences, and eating watermelon seeds is not restricted to Africa. West Africa already exports them to France for snack food, to be eaten out-of-hand. Sudan exports them as well. And this is not a new phenomenon: for centuries, Sahelian Africa shipped watermelon seed out of the deserts to populated areas far and wide, including Egypt and beyond. In certain Asian countries, they are also an important snack food. In China's southern province of Guangdong, for example, toasted watermelon seeds are a common fare and an essential part of special occasions, including weddings, funerals, and New

² Its common name is tinda, tensu, or tendi. Although botanically called *Citrullus lanatus* var. *fistulosus*, it may not even be a watermelon. Most botanists now claim that it more correctly belongs in a related genus, *Praecitrullus fistulosus* (Stocks) Pang, and say it is unlikely to exchange genes with *C. lanatus*. Even if they're right and this proves not a true watermelon variant, it still is an interesting crop, and one with a bigger future.

³ These melons normally goes by the name "egusi." The companion volume on African vegetables devotes an entire chapter to the use and potential of their edible seed.

Year celebrations. Indeed, China is yet another nation exporting watermelon seeds, as are India and Pakistan.

Pickling Watermelon In many localities, a hard, white-fleshed form of the fruit is used for pickling and jellies. Known as the citron or preserving melon,⁴ this watermelon variety is not edible in the fresh form. It is used exclusively for processing. Each year the United States, alone, employs over 3 million tons of this otherwise inedible fruit to prepare glacé and sweet preserves, both of which are major contributors to the culinary phenomenon called “Christmas cake.” Because of its high pectin content the citron is also used for making jams, jellies, and preserves. The white fleshy rind that occurs between the outer green skin and the inner edible portion of ordinary watermelons is used that way too. Even wild African watermelons are used for a similar purpose: flakes are boiled in sugar to make a tasty jam.

Cooking Watermelon In Botswana the wild fruit is baked in the coals or cooked fresh as a relish. Some traditional types store so well they are still useful for cooking even a year after harvest.

Food Security Such watermelons can be a foundation of the food system. It has been said, for example, that in olden times people couldn’t cross the Kalahari Desert except during a good melon season. These wild watermelons sustained not only the travelers, but also their livestock.

In times of drought, traditional African farmers have long relied on them for emergency use as well. Sometimes the fruits become the sole source of water for their cattle—and even for themselves—for months on end. They also sustain the wild creatures in the Kalahari. Moreover, in addition to leaving the fruits in the desert, people also pile them up near their dwelling as a convenient store of food and water. The fruits keep a surprisingly long time—up to a year in some cases. In such areas, watermelon can be an important source of both food and water, as well as income.

Indirect Use

The ancestral genes to be found in the wild and cultivated African watermelons seem likely to provide tools for creating valuable new watermelons for use around the world, including forms that are presently inconceivable. Although the large green globe with the crimson flesh is likely to remain the main type, some of the changes that could occur in future decades include the following.

Downsizing In a sense, most watermelons today are too cumbersome for convenience. Even the most affluent consumers can barely squeeze one into

⁴ *Citrullus lanatus* var. *citroides*.



Though Africa is home, China grows more than two-thirds of the watermelon in the world, followed by the Middle East and warmer parts of North America. Yellow-fleshed varieties, once more common in Europe and the United States, are now surging in popularity throughout Asia, such as in this Chinese market in Yangon, capital of Myanmar. Although the varieties of flesh- and seed-type watermelons already seem overwhelming, scientists have really only begun to tap the genetic diversity available. (Greg Martinez and Francie Zant)

their large refrigerator, some can barely lift the very large fruits, and it takes a big gathering to get one down at a single sitting. Small “icebox” melons—the smaller ones often called “palm” melons because they can fit in the palm of the hand—are becoming increasingly popular in the United States, and even smaller ones are available in Asia—in China, Taiwan, and Japan, for instance. Though watermelons grown around the world are getting smaller, most are still too large (2 to 3 kg) or have other shortcomings such as poor texture, flavor, or durability; vast new markets might open up worldwide if even smaller, very user-friendly types can be developed.

This is not far-fetched, and Africa’s untapped watermelon resources could be a key to this. Those wild and feral watermelons can be as small as 2 cm in diameter, and likely contain “downsizing” genes that innovative horticulturists could employ to create fruits of less than 1 kg. The resulting “microwatermelons” might be small enough to be conveniently carried—maybe even in a lunchbox or backpack. They would be cut open only when

eaten, a feature that would end the annoyance of juice dribbling into a lunch pail. They would also end the waste of having half a giant fruit sitting around softening and spoiling. And they could be consumed at a single sitting by an individual or small family—a feature particularly important in homes in hot regions with no refrigeration.

Designer Colors Today's watermelons are, in a manner of speaking, caught in a time warp. They are much the same color as in the era of the ancients: usually green on the outside and red on the inside. A returning Pharaoh would know them at a glance. But this is just one form out of dozens of possible color combinations: watermelons can be yellow or orange on the outside; white, yellow, pink, or orange on the inside; or any mix of those colors, including striped, speckled, or patterned.

Yellow-fleshed types today are actually preferred in parts of Asia. They are gaining popularity in a number of nations and could soon have a global impact. In China, some varieties with orange rinds and golden flesh are already produced on a large scale. Their shiny bright skins and deep-yellow flesh make them extremely attractive. In the United States, too, golden watermelons are showing signs of catching on with consumers.

Seedless Fruits Scattered as they are throughout the flesh, watermelon seeds are generally considered nuisances. They cannot (as in melons) be easily scraped out, and many rules of etiquette exist for spitting seeds. Seedless watermelons have of course been created, but the complex genetic manipulations required are often difficult to perform repeatedly.⁵ Another approach is searching among the array of Africa's wild types, seeking variants with edible or inconspicuous seeds. Some of those might bear naked seeds (entirely lacking a seed coat), seeds with soft-coats that are chewable, and there might even be a few with seeds too small to bother anyone. West Africa already has a soft-seed type, known formally as subspecies *mucospermus*, so this path seems to merit exploration.

Unusual Plant Forms Vines are always wasteful of space and awkward to cultivate. A dwarf, bush habit that still fruits on the ground could be extremely valuable to growers. This would be especially so if the plant were not too compact (because the shady dampness beneath a dense canopy tends to encourage diseases and pests). The possibility of such types occurring in the vast genetic wealth within Africa deserves exploration. Other horticulturally useful forms also probably await discovery.

⁵ Production generally involves crossing a tetraploid plant (four sets of chromosomes) with a normal diploid (two sets). The resulting triploid (three sets) is sterile and its ovules small and empty of seed. To complicate the procedure even more, a diploid plant must be present to pollinate, fertilize, and trigger fruit-set in the tetraploid pistillate flower.

PROSPECTS

Within Africa itself, as well as for other parts of the world, the watermelon's unprepossessing ancestors have more potential than might be imagined. Considering the genetic wealth to be found in wild African types, even the places that supposedly know the crop best would have to concede they have hardly tapped its many potentials. Further, it is possible that—with or without incorporating genes from wild types—a watermelon rebirth will occur across Africa by returning home with types already known elsewhere.

Within Africa

As we've indicated, watermelon seems to have untapped promise in many parts of the continent, including, in this case, those parts that lie to the north of the Sahara.

Humid Areas Fair. At first sight, the prospects in Africa's lowland tropics are moderate because humidity enhances leaf diseases such as powdery mildew and root rot. On the other hand, though, cultivars bred to resist these fungal afflictions have made Florida and contiguous parts of the humid South the main watermelon-growing region of the United States. Such resistant types hold the key to greatly enhanced watermelon use in the even more fungus-challenged quarters of the globe, including Africa.

Dry Areas Excellent. Because of its deep-roots, watermelon is a particularly good crop for dry season use or drought-prone areas.⁶ It is commonly planted as a relay crop in sorghum fields; the species being so drought tolerant that if the sorghum crop—or even the millet crop—fails for lack of water, there still can be a fair harvest of watermelons.⁷

Upland Areas Moderate; perhaps excellent. The prospects here depend on the elevation and the latitude. Watermelon requires a long growing period with high temperatures and much sunlight. For humid sites disease is a concern, and resistant cultivars should be employed.

Beyond Africa

Although many millions of tons of watermelons already are grown each year, prospects for boosting global consumption seem good. One indirect indication of their rising popularity is the observation that watermelon festivals continue to proliferate. The fruit ships well and has a reasonable shelf life. It has been suggested that sweet, small-sized, pink-fleshed

⁶ One contributor wrote, "I have seen it growing well in North Kordofan in the summer surrounded by pearl millet that was dead or dying."

⁷ This is done in south-central Mali, to mention just one location out of many.



A roadside watermelon vender holds market in Ghana. Watermelon fruits offer prospects for rural development almost anywhere they can be cultivated because they are generally easy to grow, easy to transport, easy to store, easy to sell, and easy to eat. (Scott Mori)

specimens would find an almost limitless market in Europe. Dried or roasted seed, already popular in parts of Africa and Asia, also has promise for much greater use as a foodstuff.

USES

This is another crop offering multiple products. The edible parts are notably the crisp flesh of the fruits, but also the rinds, seed kernels, tender young leaves, and flowers.

Fresh Fruits Watermelons are of course mostly eaten fresh as snacks or desserts. Many places make a refreshing drink from the juice, often incorporating a dash of lime or lemon juice. In Russia especially, the juice is boiled down into sugary syrup. In Namibia, the juice is fermented into a refreshing, lightly alcoholic drink.

Rind In parts of Africa, the rinds are sliced and dried. The resulting brown circlets are sweet, and are eaten cooked. The fresh rinds are also often carved as table decorations—typically, the fruits are cut in half, scooped out,

and then heaped with colorful mixtures of edible treats. Pickled watermelon rind is widely eaten in parts of the southern United States. In much of Asia, watermelon chunks are similarly preserved in brine.

Seeds In parts of West Africa, particularly Senegal, seeds are used in food preparation. Usually after roasting or frying (which imparts a nutty flavor), the small dried kernels are cracked between the fingers to extract the oily white seeds. These are ground into a smooth meal that supplements cereal flours (such as for use in couscous), or mixed as a pasty thickener to form soup broth. Roasted, pounded seeds are also wrapped in green leaf, steamed, fried, and marketed as a snack with red pepper sauce. In Nigeria, seeds are squeezed into melon-seed balls that are fried (robo) or steamed (monu).

Vegetable Oil The oil in the seeds is yellowish, edible, and semi-drying. It is suitable for cooking and salad oil. It is extracted locally in West Africa by boiling a mass of pounded seeds and decanting the oil off the top, or by applying pressure to seeds that have been pounded and steamed. In Israel, where seedless fruits are sold in the markets, the fruits of the male pollen donors are collected and their seed extracted for snacks.

Leaves The young leaves and shoots are widely cooked as vegetables, added to soups, or used as a relish. In East and southern Asia they are often a component of salads.

Flowers These are edible and said to be delicious battered and deep-dried (like pumpkin flowers).

Animal Feed Wild watermelons are often the only source of moisture for animals, both wild and domestic. Moreover, the seedcake left after the oil has been extracted can be used as a livestock feed.

NUTRITION

At first sight, watermelon fruits are hardly nutritious; no one eats them for their health.⁸ The edible portion, which typically constitutes about 60 percent in the modern types, is about 90 percent water and 8 percent carbohydrate, essentially sugar.

Watermelon, on a dry-weight basis, could be considered a significant source of provitamin A (more than 300 RE per 100 g for some red types) and vitamin C (nearly 100 mg per 100 g). However, since watermelon is mostly water, not everyone will sit down and eat their quota ... though many

⁸ "Lets face it, it is not broccoli!" a contributor wrote. "It is nothing more than a sack of water with a high sugar content that is a gift from the gods. No one really cares what vitamins or minerals it has. They appreciate it for what it is, and are thankful."

people do. Nonetheless, a “normal” serving provides a good nutritional boost, up to a quarter of daily needs. Red types may have more provitamin A activity than yellow or white forms, as the red color comes from the pigment lycopene, a carotenoid of special interest these days as a potent antioxidant. At about 80-100 mg lycopene per 100 g dry weight, the red flesh can contain half-again the lycopene of fresh tomatoes. As for minerals, watermelon is a fair source of potassium (about 120 mg per 100g), but not as good as banana (about 400 mg) or tomato (about 220 mg). It is low in sodium, high in fiber.

Unlike the fruit, the seeds seem very nutritious even at first sight. They contain 20-50 percent or more oil and 20-40 percent protein as well as good quantities of minerals and B vitamins. More detail is given in the Egusi chapter of the companion volume on African vegetables.

HORTICULTURE

The watermelon’s cultivation is too well known to require great detail here. The plant is grown from seed. On dry sites, planting is done as the rains begin; on moist sites the crop is sown as the rains end. For good germination, soil temperatures must be at least 20°C. Seeds, in groups of 1-3, are sown 2-4 cm deep in trenches, on mounds, or in widely spaced planting holes. Later, the seedlings are thinned to one per station. Alternatively, seedlings may be raised in containers and transplanted when 10-14 cm high. Ideally, the fruits should be matured on a pad of grass or straw for protection against soil pests and blemishing. Pollination is by insects, notably honeybees, though other bees may be more effective.

The viney crop is often inserted into a rotation following the harvest of a staple such as maize, millet, or sorghum; in many Asian and African countries, it is also commonly grown as an intercrop, directly with the main crop. In Africa, some watermelons are never planted at all; after a field is cultivated, some are left to sow themselves the following season. However, the selected types used for cooking or eating fresh are always planted, also usually as an intercrop. The wild strains used as emergency food and for their seeds are left to sow themselves on the edges of cultivated fields and in unfenced areas.

Pests of the growing plants include melon fly (*Daucus* spp.)—the most serious pest in Africa, but some wild strains apparently remain unaffected. Root knot nematodes are also problematic.

Major diseases include bacterial fruit blotch, damping off, anthracnose, powdery and downy mildew, *Fusarium* wilt, gummy stem blight, and various viruses (e.g., watermelon mosaic virus). The viruses are transmitted by aphids and cucumber beetles, which must be controlled. A number of watermelon varieties show resistance to *Fusarium* wilt and these should be employed where soils are infected with this fungus. As in tomato, calcium deficiency can result in a disorder called “blossom-end-rot.”

HARVESTING AND HANDLING

Yields are usually extremely high—at least when measured on the basis of wet weight. Each plant of the cultivated types generally produces 5-10 fruits—some of which can be very large. Production ranges from 5,000 to 7,500 fruit per hectare for standard varieties and commercial cultivation methods. This usually equals about 37 to 75 tons per hectare. With the adoption of newer production practices, yields of 120 to 175 tons per hectare are achieved using plastic mulch, row covers, drip irrigation, and hybrids.⁹

Watermelons reach maturity approximately 45 days after blooming, although the timing is highly dependent upon cultivar. They typically are harvested when the tendril nearest the melon is wilting and the “ground spot” on the bottom of the fruits turns from white to yellow. They are hand harvested and should be cut cleanly from the vine to avoid stem damage and prevent stem-end rot.

Because of their minimal starch content, watermelon ripens very little after harvesting. Optimum storage temperatures are reported to be 7-10°C.¹⁰ Below that, they are subject to chilling injury and loss of quality. The fruits are generally consumed within 2 to 3 weeks after harvest, primarily because of the gradual loss of crispness. Quality is determined largely by sugar content, color, and texture, all of which depend on maturity, cultivar, and handling methods. Commercial melons for distant markets are usually harvested when slightly less than fully mature.

These details all of course relate to watermelon cultivated for its sweet flesh. No figures are available on the yields or handling of the wild plants, but in Botswana it has been noted that they produce around 8 fruits per plant. Wild strains are harvested after other crops, and long after the vines have died. Some traditional types will store well for several months and still be edible for a year, and sometimes longer.

NEXT STEPS

In advancing the watermelon to new heights, there is an excellent role for African leadership. As the primary center of genetic diversity, Africa could become the seedbed for change. Many opportunities for improving the strains remain. Two factors are favorable: 1) the cultivars are very heterozygous; 2) inbreeding does not seem to reduce vigor. For the adventurous African plant breeder looking for a challenge, the search for unusual watermelons offers opportunities for satisfaction, perhaps profit, maybe the chance to open up new markets, and possibly enhancing the security of many people. Even individual growers could set up test plots,

⁹ About half of China's crop is cultivated using plastic film covering the ground. This is said to increase yields 50-200 percent, raise sugar content 0.7-1.5 percent, and reduce the maturing period 10-15 days.

¹⁰ Nonnecke, I.L. 1989. *Vegetable Production*. Van Nostrand Reinhold, New York.



Small watermelons—often called “palm” melons because they fit into the palm of the hand—are becoming increasingly popular in the United States, and even smaller ones are available in Asia—in China, Taiwan, and Japan for instance. At 2-3 kg, however, most are still too large (or have other shortcomings such as texture, flavor, seediness, or durability) for them to reach their full market potential as “single-use” fruits. Africa’s wild watermelons can be as small as 2 cm in diameter, and likely contain “downsizing” genes that innovative horticulturists could employ to create handy fruits of less than 1 kg. (George Boyhan)

challenge types from around the world to local diseases and harshness of all kinds, indeed, become the global go-to experts for the future of the crop. Examples follow.

Upgrading Watermelon In addition to direct use, there is the possibility of employing genes from Africa to influence the watermelons used around the world, so now seems a good time to pay more attention to the cultivated watermelon. In cost-per-kilo it is usually the most economical fruit, and it is already changing its spots in industrialized nations, where new varieties with potential to help farmers and consumers in less fortunate regions have also been developed. Further, much has been learned in recent years about the genetics of drought tolerance, disease resistance, and other desirable traits, making “new” genes even more valuable. Today, watermelons are taking on whole new looks, as yellow, seedless, and small-sized types grab increasing market share. Public demand for greater variety has led to more intensive breeding efforts, which in turn greatly increase the possibilities that totally unexpected qualities will manifest themselves to the alert breeder.

Food Security In particular, watermelon can become a more productive and more reliable source of both sustenance and water for the people, livestock, and wildlife eking out life under some of the world's most tenuous circumstances. While improved types can help, in appropriate drought-stressed parts of Africa the wild watermelon areas might also be protected from commercial over-exploitation; they are primary means of survival for desert peoples and wildlife during periods of drought.

Genetic improvement Genetic improvement might include such things as the following:

- Plants with vigor, earliness, high yield, exceptional sugar content, and resistance to disease (*Fusarium* wilt or anthracnose, for instance);
- Fruits whose rinds are thin and yet strong enough to withstand damage during handling and storage;
- Fruits whose flesh is crisp, sweet, and free from stringiness;
- Fruits with few or no seeds; and
- Plants producing high yields of seed and seed oil.

An intriguing possibility is hybridization with other species in the genus, especially *Citrullus ecirrhosus* and *C. colocynthis* (see below). Both contain useful genes, especially for drought tolerance and perhaps for disease resistance as well. Watermelon landraces in Niger already appear to contain genes from the latter, presumably from natural hybridization.

Nutrition Although food value is not a paramount virtue of this crop, nutritional analyses should nonetheless be done on each of the cultivars. The carotene and lycopene contents should especially be compared. This would help to encourage higher production of the more nutritious types and a search for even better ones.

Genetic diversity There's no telling what strange types might be found from the wilds of the Kalahari as well as the Sahel. The future is wide open to discovery. These are also excellent opportunities for sharing the benefits of such biodiversity with the communities living in these areas.

Vegetable Types Many Africans eat watermelon seeds as an important source of protein and vegetable fat, so large-seeded varieties are also useful. The seeds of these special types are promising sources of oil and protein, nutrients that are especially valuable in drought situations when watermelons are often the only crops left growing. Investigations to enhance the "vegetable" characteristics of the flesh might also seem in order.

SPECIES INFORMATION

Botanical Name *Citrullus lanatus* (Thunb.) Matsumara & Nakai

Family Cucurbitaceae

Synonyms *Citrullus vulgaris* Schrad. ex Eckl. & Zeyh.; *Colocynthis citrullus* (L.) O. Ktze.

Common Names

Afrikaans: wartlemoen, waatlemoen

Botswana: marotse/makatane (an orange-fleshed type for cooking only), mmamonwaane (a white-fleshed type eaten raw), mokgatse (a yellow/white type cultivated for stock feed), tsamma (wild type)

English: watermelon, edible-seed melon

Ethiopia: hab-hab (Am/O)

French: pastèque

German: Wassermelone

Kenya: mtikiti, masindi

Malawi: chimwela/o, mavwende (Ch), litichiti (Y), chimwamaji (Tu)

Mali: zéré, zere (bambar)

Mauritius: melon d'eau

Namibia: oontanga (Oshiwambo)

Nigeria: ibara, bara, egusi ibara

Somalia: Kare (Som)

Russian: arbut

Sudan: khujar, batech, buttiku (Arabic)

Tanzania: mtikiti, maji/mkubwa, masindi

Zambia: chimwanyanza, chivwembe, ntanga (Ny), ntanga, chitatakunda (B)

Zimbabwe: muvembe, mugibe, munwisi, munwiwa, muvise/i (C), inkhabe (Nd), makavatya (H), budzi (W)

Description

The plant is an annual climbing or trailing herb with long runners. Some have a fetid musky odor. Its pinnately lobed leaves distinguish it from melon and cucumber (*Cucumis*) and pumpkin and squash (*Cucurbita*). Watermelon is monoecious, with the pale yellow male (staminate) flowers blooming first. Insects, especially bees, transfer the pollen from male flowers to female flowers, making fruit set possible.

The vines carry anything from 2 to 15 fruits weighing up to 50 kg or more. Seeds may be white, green, yellow, brown, red, or black in color. Wild watermelons look like conventional watermelons in size and shape,

except for the wild tsama, which is small and round (average diameter 15 cm or less), with flesh varying from orange to white.

Distribution

This native of southern tropical Africa is now widely spread throughout the tropics, subtropics, and warm-temperate zones.

Horticultural Varieties

There are hundreds of varieties, and most countries have local cultivars; numerous websites list their merits.

Environmental Requirements

Watermelons are a warm-temperature crop requiring a relatively long, hot growing season (usually about 4 months of frost-free weather). Although drought-tolerant, they require a steady supply of water for best fruit production. A committed grower needs the right kind of soil, long warm summers, and not too much rainfall.

Rainfall The plant may require only a small amount of rainfall (250-500 mm), since the root system can usually exploit deep soil moisture. Excessive rainfall and relative humidity reduce flowering, and encourage development of leaf diseases. Waterlogging kills the plants.

Altitude Watermelons grow well up to 1,000 m in the subtropics, and may reach 1,500 m above sea level at tropical latitudes.

Low Temperature For growing watermelon the optimum temperature range is 23-27°C. Growth stops below about 18°C and the plants are very susceptible to frost. This limits their production in regions with cool summers or sharp nights. For germination of seeds, the minimum soil temperature at 5 cm depth is 15°C.

High Temperature Wild melons of southern African deserts grow where the temperature is often 36°C. While temperatures over 30°C during blooming may reduce fertilization in many types, most plants tolerate higher temperatures for short periods. Temperatures of 40°C and above have been measured in Botswana, though extremes can also damage ripening fruit.

Soil Watermelons grow on any type of soil, but do best on well-drained, sandy loams, with good moisture-retaining capacity and high organic matter. They grow successfully on soil of low fertility. Soil depth should be at least 10 cm. They tolerate both acidity (pH as low as 5.0) and alkalinity (up to 8.0); the optimum range, however, is pH 5.5-7.0.

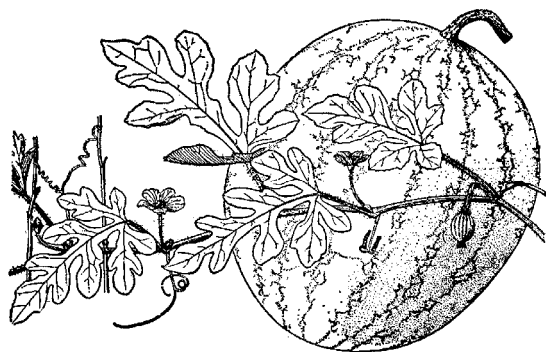
Related Species

Watermelon belongs to the family of climbing plants that includes gourds, melons, gherkins, cucumbers, and loofahs. The genus *Citrullus* contains three or four species, native to tropical and subtropical Africa, one (*C. colocynthus*) being also native to South Asia and perhaps Australia.

In Namibia, the word tsama (or tsamma) is used not only for the wild watermelon, but also for *Citrullus ecirrhosus* Cogn., or “bitter apple.” This desert perennial lives where rainfall is almost nonexistent, and it has a tremendous capacity to survive drought. Not only does it employ water from the very occasional rainfall, it has a remarkable ability to reach moisture deep underground and possibly to employ morning fogs as a moisture source. Its fruit is inedible unless reboiled many times, but its genes might be useful in helping the watermelon crop survive drought even better. Though cucurbitacins are in the seed (as well as the fruit), the oil can be decanted from crushed seed to remove these bitter substances in times of dearth. It has been successfully crossed with watermelon, opening the possibility for new genetic advances in one of the world’s special crops.

Another “bitter apple,” native from Africa to India, is *Citrullus colocynthus* (L.) Schrad., also called the “vine of Sodom.” Growing at the edge of rainfall, this perennial has edible, even nutritious, seeds, which are often found in archeological digs. However, the unripe flesh contains an exceptionally bitter alkaloid and resin that combined creates one of the most violent purgatives known. For this reason, it has been studied in some detail, but its potential contributions to watermelon—in the future and perhaps even in the past—still await the curious to discover.

Both species have great bitterness, something they share with the ancestor of watermelon. The fact that our ancestors worked with such a raw ingredient to create today’s watermelon, the epitome of sweet summer juiciness, bodes well for the future of many such “unpromising” fruits.



LOST
CROPS
of
AFRICA

volume III part 2
Wild Fruits

INTRODUCTION

Most of Africa's edible native fruits are wild. One compilation lists over 1000 different species from 85 botanical families and even that assessment is probably incomplete.¹ Among all those fruit-bearing plants, many of the individual specimens growing within Africa are sheltered and protected, some are even carefully tended, but few have been selected to bring out their best qualities, let alone deliberately cultivated or maintained through generations. They remain untamed.

Despite the vastness of the resource, wild fruits are rarely included in development activities. At most, they get only sketchy horticultural attention; seldom, if ever, are any grown in organized plantings. Indeed, apart from listings in the tomes of taxonomy, Africa's wild-fruit wealth is essentially unknown to science.

For all the lack of research, wild fruits still play a crucial role in Africa's rural areas, yielding the very young a key link that helps a fragile nutritional chain from parting. This is because, unlike most grains and vegetables, fruits generally do not need cooking and—requiring no adult intervention and being tasty to boot—they are sought out especially by children. This is important because children are malnutrition's greatest victims.

In this sense, these wild fruits are Africa's most nutritionally important resource, critical to everyone during their founding years. Gathering fruit has been a routine of growing up throughout the millennia of our existence. In rural areas everywhere on earth, wild fruits contribute to nutrition and health during the most vulnerable period of human life. During the crucial years when young bodies and brains are developing, wild fruits can provide the vital nutrition.

In addition, scavenging for fruits is exceptionally important to youngsters in the many cultures that prepare meals fewer than three times a day. Often, adults have neither time nor means to prepare supplementary snacks, so youngsters, whose small stomachs can barely hold enough to sustain their daily needs, rely on the fruits of the field, woodland, wetlands, forest, savanna, or hillside to fill the voids and carry them through. The amounts consumed may rarely have been large. But even a few small fruits that are nutritionally dense can deliver big benefits when the rest of the diet is deficient in vitamins and minerals, which is especially the case when it is overly dependent on starchy staples.

¹ See Martin, F.W., C.W. Campbell, and R.M. Ruberté. 1987. *Perennial Edible Fruits of the Tropics*. Handbook No. 642. U.S. Department of Agriculture.

Although nowadays such childhood experiences may seem old-fashioned in cities worldwide, they still pertain in vast rural areas of Africa. A surprising number of wild fruits contribute to countryside nutrition, and also to commerce, as seen in local markets. In Swaziland, for example, surveys found that people eat products from more than 220 species of wild plants; about half fruits.² A similar audit in Cameroon identified over 300 trees whose fruits or seeds were eaten, including 200 forest species.³ In Uganda 105 wild fruits are recorded as still being used.⁴ Similar inventories are documented in enough places to make this a fair reflection of the norm.

Today, however, these wild resources are getting harder to find. Rummaging through the bush around a village may still be important but, taken all round, wild fruits are a vanishing breed. And no one is doing much to counter the trend because today's overwhelming emphasis is on domesticated crops, especially staples. That choice is certainly understandable, but more thought needs to be given to fostering wild fruits and restoring their productive contributions to Africa.

This added priority is needed because times are rapidly changing. In the past, rural communities living near wild growth didn't need to consider propagating these trees; nature satisfied their needs. Yet with dwindling tree cover, the useful species must be brought in from the wild or risk being lost entirely. Arguably, wild fruits comprise Africa's most vulnerable food resource sector and, because of the pre-existing condition of scientific neglect, their shaky status will only worsen unless there is incisive intervention. Nudging nature even a little is often enough to tilt the balance in favor of a wild fruit establishing or persisting in lieu of scrub; research and its application can work wonders. This is why we devote the second half of this volume to the topic.

What could be done to rescue such historically vital contributors from neglect and possible extinction? First and foremost, wild fruits can be rescued from the widespread belief that they represent backwardness—that in a modern society, foraging is demeaning. Certainly, wild fruits are typically smaller, the pits larger, and the flavor more varied than in comparable cultivated fruits, but that does not mean they are unworthy. Publicity and education are needed to quash the common impression that wayside fruits are “simple,” “substandard,” “unfashionable” fare.

² When the survey was made (at the beginning of the agricultural season, a time when food stores often are low) more than 50 species were contributing to the local diet *each* day. Antonsson-Ogle, B. 1990. Dietary use of wild plant resources in rural Switzerland. Pp. 895-910 in *Proceedings of the Twelfth Plenary Meeting of AETFAT, Symposium VIII*. Mitt. Inst. Allg. Bot., Hamburg.

³ Information from J. Vivien and J.J. Faure of Cameroon's Centre Universitaire de Dschang, which has established a native fruit tree arboretum containing 60 species.

⁴ Goode, P.M. 1989. *Edible Plants of Uganda: The Value of Wild and Cultivated Plants as Food*. Food and Nutrition Paper 42/1, FAO, Rome.

Wild fruits also need rescuing from the notion that they are solely for the young or that it is degrading to eat such things. Such attitudes ignore the nutritious resources that are on hand. Ironically, this is an era in which nations almost everywhere are exhorting their citizenry to eat more fruits—the wilder the better it seems. In market economies especially, consumers can have a large influence on what is being studied and sold. Everyday, Africans can also call for emphasis on their popular preferences, many of which are not the fruits of urban life and mass cultivation. That, in turn, may bring support and attention to fruits such as those described here.

Technical interest and professional support for wild fruits are also crucial. Currently, textbooks, the international literature, and foreign advisors rarely mention, let alone promote, resources with names as strange as aizen, icacina, or imbe. As noted, nearly all activities in African agriculture emphasize the top international crops whose qualities are beyond question. While the focus on staples and markets and exports is right and proper, quality remains as desirable in eating as in other spheres of human enterprise. And fruits contribute most to the *quality* of eating. And of course, their nutrients—notably vitamins—act catalytically in tiny amounts to help the body employ the bulky staple foods most efficiently and effectively. From development banks and funding agencies to the peer-reviewers who judge research proposals, decision-makers can open their eyes to the African bounty that nourished people long before wheat, rice, soybean, maize, mango, or avocado were seen by human eyes.

The importance of the wild-fruit resource can be incorporated not only into public perceptions but also into landuse. The disappearance of wild fruits is partly due to the destruction of their habitat. Under the pressure of population or politics or profit, the groves of good nutrition near villages and towns get cut or burned or drained or contaminated by waste. To this extent, the deficiency in childhood nutrition is homegrown, and the value lost is as much to people as to the environment.

In short, the underexploited fruits—the truly “lost” fruits—described in the following chapters can contribute much more to Africa than they do today. Indeed, as the rest of this section indicates, many might well come to prominence. First, they taste good and add variety for the palate. A key advantage is, of course, adaptability to Africa’s climates and conditions. Another advantage is that the plants are already spread across the African continent and are well known to many users, especially those among the destitute, who employ them to add culinary variety, flavor, nutrients, and sometimes even substantial energy to diets derived from bland staples. Some are even used as sources of water.⁵

⁵ It is little-recognized that wild fruits quench thirst safely. Filled with pure water, they contributed to public health long before the concept of Public Health was recognized. Wild watermelons and several other African fruits are even today more appreciated for moisture than for nourishment.

The following 14 chapters highlight a small selection of wild fruits that appear capable of contributing broadly to Africa's future well-being. Their individual potentials are also summarized immediately below. As with the species treated earlier, these have been chosen from the recommendations of hundreds of researchers who participated in the first phase of this multi-part investigation of Africa's promising indigenous food plants. It should be understood that these 14 are *representative* of the wealth to be found among Africa's untamed fruit resources. They are not the only examples, nor perhaps even the best for any given location. Other species should thus not be judged inferior just because they received no mention in these pages. All in all, the fruits described below offer just a sampling of available and practical tools for working on chronic problems such as malnutrition, food insecurity, rural decline, and environmental destruction. They should be brought in from the wild.

SUMMARIES OF INDIVIDUAL SPECIES

Following are short summaries of 14 promising wild fruits selected for treatment in the second half of this volume. Following these summaries are targeted discussions of their potential for meeting development challenges in Africa. Table 2 (page 194) summarizes their potential across Africa. This summary information is also found in the detailed chapters dealing with individual crops.

1. Aizen (Mukheit)

The aizen or mukheit (*Boscia senegalensis*, Capparaceae) occurs in a vast swath across the top of sub-Saharan Africa, from Somalia in the east to Mauritania in the west. Usually a scrawny shrub, it occupies some of the hottest and driest locations faced by plant life. Yet aizen not only survives, it also yields an array of useful products—enough indeed to sustain human life almost by itself. In at least a dozen countries, people at times virtually live off aizen's fruits, seeds, roots, and leaves. Although not unpleasant to eat, the fruits are most notable for being available when little else remotely edible is to be found. In addition, the seeds extracted from within those fruits are cooked and dried, and become such common dietary items that they have been described as desert dwellers' staples.

Climate Arid.

2. Chocolate Berries

Several of the nearly 70 *Vitex* species (Labiatae) found scattered across tropical Africa produce fruits of local importance. These small and rugged trees are quintessential wild food resources. In season, they become bespangled by an abundance of blackish fruits, which passersby eagerly gather up. The reason? Although the uninitiated may disdain the pungent scent and stained lips, almost everyone loves the "chocolate" flavor.

Climate Tropical.

3. Custard Apples

The plant-family botanists call Annonaceae produces fruits crammed with a sweet pulp with a custard-like texture. These tropical delights are sold the world around under names such as "custard apple," "cherimoya," or "sops" of various vintage. They are already among the most beloved fruits in tropical Asia and America, but so far the African members have been neglected and are poorly understood even within their natural habitats. What might be called "the lost sops" deserve further development, not to mention protection from disappearance. One, the African custard apple, has been called "the best indigenous fruit in most parts of tropical Africa." Another,

the junglesop, produces probably the family's biggest fruits—as long as a forearm and as thick as a thigh. A third—perhaps the strangest of all—”hangs like a bunch of sausages,” each fruit a separate bright-scarlet link.

Climate Tropical.

4. Ebony

The jet-black, rock-hard heartwood known as ebony is perhaps the smoothest, shiniest, and most beautiful of all the woods; renowned worldwide for expensive carvings, it is regarded as almost a precious material, and can sell by the gram. But *Diospyros*, the name of these trees' genus, actually means “fruit of the gods,” and outside the tropics ebony species are most renowned for the persimmon. In their domicile in the wild, African members of the Family Ebenaceae also produce widely enjoyed fruits. And they could be much more widely enjoyed. The fruits have advantages: They are suitably sized for marketing on a large scale, attractive to look at, and appealingly succulent and sweet. They are, however, very soft and delicate. This fragility is at present the biggest—perhaps the only—barrier to ebony fruits becoming a valuable, everyday, Africa-wide food.

Climate Mostly tropical.

5. Gingerbread Plums

Within virtually the whole of sub-Saharan Africa—the vast stretch of territory between Senegal and Madagascar—there exist a number of interrelated wild fruits (*Parinari* and kindred genera of the Family Chrysobalanaceae) with agreeable strawberry-like flavors. These so-called gingerbread plums can have a texture firm enough to crunch like a crisp apple. Usually red or yellow in color, these plum-sized delicacies lack the sourness typical of wild fruits (and of true plums, for that matter). Millions of aficionados, notably children, love their crunchy sugariness, and consume them in quantity.

Climate Moist tropical and subtropical.

6. Gumvines

Some of the roughly 17 *Landolphia* species (Family Apocynaceae), occurring mainly in West and Central Africa, bear masses of fruits that make tasty morsels. These “gumvine fruits” or “rubber fruits” look somewhat like apricots, with tough skins that are red, yellow, or orange in color. The plants themselves are common and are obviously at home in the African environment. They are forest lianas and sprawly shrubs nowadays admired for their jasmine-scented flowers as much as for their plentiful fruits or the latex-filled stems that once provided Europe and other parts of the world with much of their rubber.

Climate Tropical savannas and forests.

7. Icacina

Icacina (*Icacina oliviformis*, Icacinaceae) is a small, drought-resistant shrub forming dense stands in the West African and Central African woodlands and plains. Although the species is truly wild, several million people rely at various seasons upon its separate products: fruits, seeds, and tuberous roots. The fruits are usually consumed fresh. Bright red and plum-like, they have a sweet and pleasant flavor. The plants grow so densely and yield so exuberantly that during the season a family can reportedly collect hundreds of kilos of fruits a day, even from untended wild stands. The small, round seeds from the center of the fruits are also edible. And the huge edible roots are so much like a much better known staple that their common name in English is “false yam.”

Climate Moist and seasonally dry tropics.

8. Imbe

Food and travel writers commonly elevate Asia’s mangosteen into the lofty level of “world’s most delicious fruit.” However, the plant producing it happens to be only one of 400 *Garcinia* species found across Asia and Africa. Africa’s best-known member is the imbe (*Garcinia livingstonei*, Guttiferae), a crooked tree whose soft and colorful fruits brighten up markets from Senegal to South Africa. This small, orange-colored delight provides a juicy pulp that has a pleasantly sweet-to-acid flavor. East Africans have dubbed it “King of Fruits.” Even those specimens that are unusually sour prove notably appealing on a hot afternoon.

Climate Moist tropics and wooded plains.

9. Medlars

In East, Central, and southern Africa at least eight species of *Vangueria* (Family Rubiaceae) commonly grow with surprising vigor in dry, eroded, infertile, leached, or otherwise challenging sites. These trees closely resemble one another in both appearance and a propensity to bear lots of fruits. For want of any popular name in English, they are called wild medlars or African medlars. The fruits dry easily (even drying out before they are picked), after which they take on the aroma and flavor of dried apples. Reconstituted with water and a little sugar, they substitute for applesauce as well as being used as fillings in puddings and many more culinary products.

Climate Woodlands, scrub, valleys, stony hillocks, or sandy dunes.

10. Monkey Oranges

Three monkey oranges (*Strychnos cocculoides*, *S. spinosa*, and *S. pungens*, Strychnaceae) produce fruits that are large, flavorful, easy to

handle, and often desperately difficult to find due to overwhelming demand. Farmers appreciate the trees so much that when clearing land they spare the ax—even when that will hinder their subsequent field operations. Of all Africa's wild fruit trees, these are the most “conventional” in appearance and usage. They are similar in size and shape to apple, pear, and orange trees. Given horticultural attention, monkey oranges probably can be raised with equal facility. Already, they bear their fruits in abundance.

Climate Savannas and dry woodlands.

11. Star Apples

In many tropical American countries, especially in the Caribbean, the star apple (*Chrysophyllum cainito*) is a common dooryard tree whose apple-sized delights provide a sweet flesh with small seeds arranged in a star pattern. What is not well known is that the area below the Sahara contains more than a dozen related species. These attractive trees of the genus *Chrysophyllum* and *Bequaertiodendron* (Family Sapotaceae) create their own edible counterparts whose smooth green, purple, apricot, yellow, or copper-colored skin encloses a white, sweet, tasty pulp. This pulp is arranged in segments and, when cut transversely, typically displays the star-shaped seed arrangement that constitutes the family crest.

Climate Lowland tropics and subtropics.

12. Sugarplums

Africa is home to more than 30 species of wild fruit trees belonging to the genus *Uapaca* (Phyllanthaceae; also placed in Euphorbiaceae or Uapacaceae). Several produce flavorful, attractive fruits that engender enthusiasm wherever they occur. These delights add a sweet yet tangy zest to traditional foods from porridges to desserts. Fully ripe, these are plum-sized, yellow-brown in color, juicy, and honeylike in taste.

Climate Seasonally dry wooded parkland.

13. Sweet Detar

Throughout much of tropical Africa the detar tree (*Detarium senegalense*, Leguminosae) is common and its round brown pods well known. At first sight these fruits look like apricots, but physically they are more like tamarinds, with a crisp shell enclosing a rather flaky greenish pulp that makes good eating. As with tamarinds (see Part 1), sweet detars are especially enjoyed in West Africa. Most are eaten fresh, but some are dried in the sun and sold in the markets like dates. The hard shell and dry pulp give them an exceptional shelf life and the sweet-and-sour flavor appeals to most every palate.

Climate Woody savannas and parkland.

14. Tree Grapes

About 40 different trees of the genus *Lannea* (Family Anacardiaceae) are to be found in the tropics of Asia and Africa. The species in Asia have received horticultural attention, but the 20 or so that are native to locations from Madagascar to The Gambia remain unmoved by modernity. Yet at least a dozen of these wild fruits could be valuable future food resources. Although belonging to the same plant family as mango, cashew, and pistachio, their fruits are more like grapes in form. They come in pendulous bunches and are reddish, purple, or black in color with a whitish bloom on the skin. Although some have a resinous taste, many have a pleasant flavor described as truly “grape-like.”

Climate Tropical forests to tropical savannas.

TABLE 2: POTENTIAL ROLES FOR SELECTED WILD AFRICAN FRUITS

	Overall	Nutrition	Food Security	Rural Development	Sustainable Landcare	PRIMARY OCCURRENCE				
						West Africa	Central Africa	East Africa	Southern Africa	
*** = <i>Outstanding</i> ; ** = <i>Notable</i> ; * = <i>Average</i>										
Aizen (Mukheit)	***	**	***	**	***	√				√
Chocolate Berries	***	**	***	***	***	√	√			√
Custard Apples	**	**	*	**	*	√	√			√
Ebony	***	**	***	***	***	√	√			√
Gingerbread Plums	***	**	*	***	***	√	√			√
Gumvines	**	**	*	**	**	√				
Icacina	**	**	***	**	**	√	√			
Imbe	**	**	*	***	**	√	√			√
Medlars	***	**	***	***	***		√			√
Monkey Oranges	**	?	***	***	***	√	√			√
Star Apples	**	*	*	**	***	√	√			√
Sugarplums	***	***	***	***	***	√	√			√
Sweet Detar	***	***	***	**	***	√				
Tree Grapes	**	**	**	***	**	√	√			√

NB: The underlying justifications for these broad rankings are discussed in the following sections on Nutrition, Food Security, Rural Development, and Sustainable Landcare; greater detail is provided in the separate chapters on individual crops.

POTENTIAL ROLES FOR SELECTED WILD AFRICAN FRUITS

To give some idea of their potential to help overcome the great central issues of African humanitarian and economic development we now summarize the above mentioned wild fruits' likely relevance to four of Africa's biggest needs for survival and social stability: nutrition, food security, rural prosperity, and general landcare.

OVERCOMING MALNUTRITION

Wild fruits can contribute to overcoming malnutrition because the plants survive where their more pampered kin perish and thus produce nothing whatever. Additionally, because wild plants are necessarily self-sufficient, they promote well-being for future generations as well as for the present.

It is noteworthy that harsh and difficult locations contribute disproportionately to malnutrition mortality. So, even with their limitations, wild fruits often offer a good at-home solution. And, with better knowledge and more attention, wild fruits can contribute much more.

On the other hand, these species are essentially unknown to medical doctors, nutritionists, bio- and analytical chemists, agronomists, horticulturists, or even the technical literature. Only a few have been analyzed in detail for nutritional components, and whether those results are representative is uncertain. Therefore considerable ambiguity over their true relative worth, let alone their future, is to be expected.

Below is a summary of the merits, *specifically in terms of fighting malnutrition*, of each of the wild fruits highlighted in the second section of this book.

Aizen (Mukheit)

Aizen's nutritional content is poorly known but people existing in the extreme climates where the plant grows can rarely expect foods of high nutrition. They *can*, however, get aizen...and giving them easier access to more of it could prove a key for reducing mortality in the locations that contribute more than most to the suffering caused by extreme malnutrition. The pulp reportedly contains good calcium, phosphorus, iron, and some B vitamins. It is said, however, that its main value is in supplying vitamins A and C. It also provides a little protein. Inside are greenish seeds that resemble peas in appearance and usage. Nutritionally speaking, these are perhaps the better instrument for inducing healthier living. They have as much starch and soluble carbohydrate as the local grains (sorghum and millet). Their protein content is high (relative to cereals) and it is of at least moderate nutritional quality. The seeds apparently are also rich in zinc, a mineral considered important for maintaining and recovering well-being.

Chocolate Berries

Little is presently known of the chocolate berries' nutritional contributions. In Sierra Leone they are claimed to cure a condition—associated with sores at the corners of mouth and eyes—that is described as a nutritional deficiency caused by lack of vitamins B and A. As tools for malnourished children's self-medication they might prove exceptional, seeing the plants are adaptable, rugged, self-sustaining, high yielding, and within the reach of little fingers.

Custard Apples

These are sweet, flavorful, attractive, and likely to provide nutrients in reasonable quantity. Based on analyses of custard apples from other regions, they should possess moderate amounts of calcium and phosphorus (30-40 mg per 100g), modest amounts of vitamin-A precursors, and reasonable amounts of the B vitamins thiamin, riboflavin, and niacin. Their sweet and custard-like pulp should provide a potent means of delivering nutrients to needy small ones because it appeals so much to the young in years.

Ebony

As far as nutrition is concerned, the pulp of Africa's native persimmons can be expected to be rich in vitamin C, with perhaps 25-50 mg per 100 grams. Interestingly, like apples, common persimmons have more vitamin C in their skin than their flesh. In addition, the skin's bright red color likely reflects the presence of lycopene, the nutritionally valuable carotenoid found in tomatoes.

Gingerbread Plums

Gingerbread plums seem like powerful tools for building better bodies. Their colorful skins, bright yellow flesh, and high sweetness endow special appeal. Millions of Africans adore them. When in season, some peoples treat them almost as a daily staple. And the tough-skinned fruits are easy to handle, resisting bruising and shipping damage. Other than crude proximate analysis, little is known of the food value. Nonetheless, they seem likely to be a good nutritional support, especially for the young and the vulnerable.

Gumvines

Juice of these fruits is regarded as extremely healthful, and probably with good reason, although the nutritionally important ingredients are little-known at present. People often substitute it for lime juice to season rice, maize, and other grains; prepare lemonade-like drinks; make a type of beer; and flavor foods such as fish. Thus, gumvine fruits are probably a good means for delivering nutrients to all levels of society.

Icacina

No one yet fully knows the contributions this species makes to nutritional well-being, but also no one doubts that it is positive. *Icacina* is renowned as a living grocery store during normal times and an emergency food during hungry times.

Imbe

This fruit would likely make a good tool for the suppression of nutritional deficiencies because it is popular in the diet. The pulp is yellow and watery, and has a pleasing sweet flavor—described as “not unlike a perfect peach.” It is eaten raw but is more commonly cooked with porridge and other cereal products. Thus, increasing the production and consumption of imbe could boost the basic nutritional status of all age groups.

Medlars

These tasty morsels deliver more than just pleasure, and they deserve to be part of nutrition-improvement programs. Although much remains to be done to clarify the nutritional content of the different species, it is already clear that these rugged, resilient trees amount to self-sustaining tools for reducing malnutrition. Typically, these fruits are stored in dried form, and then boiled into a thick liquid that is used like gravy to flavor staple foods, notably mealies (maize porridge). They are thus a good way to deliver nutrients to both the unhealthy and the unsuspecting.

Monkey Oranges

We're not certain just how to rate these fruits for combating childhood malnutrition. On the one hand, they are among the most popular native wild fruits. On the other hand, their food value is poorly known, and there is the possibility of adverse effects (especially if consumed to excess). Monkey oranges, however, are believed to be rich in the B vitamins and vitamin C. One species (*Strychnos spinosa*) can reportedly be surprisingly rich in food energy—almost one-third fat and an energy level of almost 500 calories per 100g. Even if only verified in rare “sports,” it might become especially valuable against marasmus, mortal malnutrition caused by too few calories.

Star Apples

African star apples remain horticulturally undeveloped and their nutritional qualities are poorly known, though their relatives in the Americas have been compared to orange but with half the vitamin C. Despite scientific neglect, however, they are esteemed in many places and are likely to have nutritional merit of at least a modest nature. As weapons for conquering Africa-wide malnutrition, these seem like long shots. But probably, they are

no less valuable than everyday Western fruits—peaches or plums, say—that by default constitute the yardstick for measuring healthy diets in the best nourished parts of the world.

Sugarplums

Although little is yet known about their ingredients, these fruits are thought to be nutritionally outstanding. The level of vitamin C can be especially high. Indeed, the best known species, mohobohobo, produces fruits whose ripe edible part contains 1.8 mg vitamin C per g—more even than guava. Most are eaten fresh, but some are pounded with water and served as drinks or even as a fragrant fruit wine. In addition, tasty snacks are made from the pulp by adding water, flour, and sometimes egg, flattening the mixture into round cakes, and frying them like doughnuts. These variant products offer delivery systems for adding nutrients to whole societies.

Sweet Detar

Sweet detar is an outstanding source of vitamin C—perhaps among the best of all. In 1988, researchers studying 29 fresh fruits consumed in Senegal discovered its pulp to be the richest in vitamin C. Nothing else came close. In addition, the purple-brown, sweetly scented seeds have edible kernels. Flour made from them is notable for having 12 percent of a protein rich in the botanically rare essential amino acids lysine and tryptophan. The kernels are also crushed to extract their oil for culinary use. Collectively, then, the contributions of vitamins, quality protein, and food energy could make sweet detars powerful preventatives and even possible cures for several types of malnutrition and their associated ailments.

Tree Grapes

These children's favorites are seemingly excellent resources, but so far the nutritional benefits remain unrevealed. Likely, these grapelike delights are good sources of provitamin A, iron, and zinc, and might contribute vitally to child survival. If so, these resilient, self-sustaining, productive wild shrubs could be ideal for achieving long-term nutritional care.

BOOSTING FOOD SECURITY

In rural Africa, many people live near wild fruit-bearing trees and bushes that produce food at times when crops cannot. For this reason alone, these plants should not be neglected any longer. In fact, for the reliable food production necessary to Africa's social security and general stability, such wild fruits hold great promise. Diversified diets offer the best nutritional balance, and diversity can be maintained through the combined exploitation of both domesticated and wild foods. Further, wild plants are necessarily self-sufficient species, which, due to age-old adaptations, need little care. They require, for example, no fertilizer or pesticides (at least for survival). Irrigation is unnecessary and disease problems generally are moderate to minimal. On the other hand, insects and higher-order pests can be a menace. The problem here is not so much the loss of the plant but the loss of the harvest. Fruit flies present a perennial problem that is hardly simple or easy to solve, but which can be minimized. In general, however, wild fruits have minimum management requirements for survival, making them ideal for food security, where their contributions may be episodic but vital.

This is not to say, however, that wild fruits cannot be assisted to produce more or to produce more reliably. Indeed, this is what needs to be done. Raising the productivity of wild fruits will help many people who periodically struggle against starvation—disproportionate numbers of whom live in rural Africa and rely on wild fruits when their lives hang in the balance. Such emergency foods are of course critical in the face of famine, but more often their importance is manifest during that annual recurrence known as the hungry season (*soudure* in French)—an agonizing few weeks or months when the last harvest is eaten and the new one is not yet ready.

Below is a summary of the merits, *specifically in terms of food security*, of each wild fruit highlighted in the remainder of this volume.

Aizen (Mukheit)

A food security gem, this fruit has been a proven lifesaver during famines since ancient days. It preserved many lives, for example, during the 1982-1983 Mali drought as well as during subsequent famine in Ethiopia and Sudan. In both cases there was a large increase in aizen consumption. Livestock and wildlife ignore aizen for most of the year, meaning people have few worries about their trees being devoured by goats or gazelles when they are not looking. Nor will the trees end up being destroyed by the desert. For this multi-layer security, alone, aizen is promising for establishing famine-food reserves. Although seasonal, its fruiting differs from the norm and comes when farm crops are just being planted and things to eat are hard to find. This alone also makes aizen a lifesaver. In the slightly better watered zones, where there are other edible plants to choose from, aizen serves

mainly as a supplement rather than a staple. Even so, it remains a valuable backup for devastating drought emergencies that arise seemingly almost routinely every decade or two. Beyond the fruits, the cooked, dried seeds are also important famine-time fare throughout the Saharo-Saharan zone.

Chocolate Berries

A great intervention for food security. Villagers rely on these trees for much more than just fruits. They boil and eat young leaves like spinach. They depend on the foliage to keep their livestock from dying during the long and trying months when the grass is gone. With more chocolate berries, life might be less hard and more stable in many places.

Custard Apples

Although this is an excellent time to investigate these unusual fruits, food security will probably never be a major merit in their case. They are soft and perishable. Also, the trees are not exceptionally hardy, rugged or tolerant...at least as has been reported so far.

Ebony

Intriguing potentials. In certain areas ebony forests might be established as long-term food reserves, and help save generations of lives. That would be an excellent way to obtain local cooperation for planting and protecting both ebony trees and the environment. Yet it is not just in famine times that these trees become saviors. Every year people store the dried fruits as a reserve to draw on just before the beginning of the next harvest season, the perilous period when food supplies often run low or run out.

Gingerbread Plums

These wild tree fruits are a nice seasonal resource, fruiting when other foods are also normally abundant, but we are unaware of any specific merit for food security during dearth times.

Gumvines

Not recommended for food security purposes at present. In the wild, gumvines do not fruit annually. Also, some species reportedly take as long as 12 months to mature each crop of fruits.

Icacina

This rugged shrub is even now used as an emergency reserve during times when even millet succumbs. It has been known to survive at least *four years* without rain and yields three fundamentally different types of food—fruits,

seeds, and tubers. All three are life savers. The fruits, for example, ripen as the dry season comes to an end, the very moment when the stores of other foods often run out. The seeds can be dried and stored with little fear of loss from mice, mildew, or weevil. And the fleshy, tuberous false yam can be 80 percent starch and sometimes weigh over 60 kg. More programs dealing in African food security should be dealing in icacina. It seems like the finest of food-security instruments for the regions where it will grow...with icacina around people can always eat.

Imbe

Although this rugged little tree survives in locales where food production is tenuous, the fruits don't seem a candidate for food security programs. The trees seem to bear during periods of normal seasonal abundance, and the fruits do not keep well; the seeds, however, may hold more promise.

Medlars

At least in principal, *Vangueria* seems likely to make outstanding contributions to hunger relief. In eastern, central, and southern Africa, at least eight species grow vigorously in sites with challenging soil conditions. Their rather unusual fruits not only dry out and stay aloft on the tree, they remain edible for months. Given their easy desiccation, they can be sun-dried and stored for up to six months and, once reconstituted with water, taste almost like new. Because of this, African medlars are commonly stashed away for times of scarcity. In conjunction with tree planting and tree conservation, their food security talents are well worth putting on the stage.

Monkey Oranges

Monkey orange trees are certainly respected for their shade and good looks. However, the greatest admiration is engendered by the tasty fruits, which are widely enjoyed and have the amazing capacity to stay edible in tropical heat for months. At least one of these species has been called, "A great and precious resource in times of crop failure." The fruits can be buried several months, and (as long as care is taken to keep the shell whole) they come out of the ground juicy, golden, and perfect for eating. These are important resources for the future and seem likely to prove valuable tools for delivering a more secure life to those without access to money.

Star Apples

For food security projects this probably has limited potential. However, the trees grow rapidly and (after juvenile vulnerabilities) become almost trouble free, resisting among other things pests, diseases, and high winds. As long as they remain unexposed to freezing temperatures, African star apples

continue producing quantities of delicious fruit year after year while burdening labor almost not at all. That makes them at least a contributor to food, or economic, security.

Sugarplums

In some parts of some countries—notably Zimbabwe, Zambia, and Malawi—sugarplums basically underpin existence for part of the year. This is more a matter of choice than charity: people just like eating them so much. However, the trees generally occupy the drier and poorer areas, and seem at home on adverse sites where food production is generally poor and unpredictable. Because of that feature they have traditionally helped millions survive famine. The fruits have exceptionally high levels of vitamin C and definitely deserve consideration in efforts to help free Africa from famine.

Sweet Detar

Sweet detar seems a superb food-security tool. This tree legume is tolerant, adaptable, generally reliable, and relatively insensitive to site, soil, altitude, heat, or humidity. Because of this and because it continues producing fruits for decades on end, sweet detar could be placed in the forefront of many food-security planners' priorities. Silvicultural success could catapult it into a brawny resource that cuts malnutrition and contributes to rural development—all while it grows a great timber.

Tree Grapes

These trees are resilient, drought tolerant, and naturally adapted to harsh sites, including some in which humans sometimes have few food options. They resist the groundfires that are so prevalent and so ruinous in the savannas. The individual species are poorly known to science so no one can now say just what role they might play in food security projects, but on the basis of their resilience and productivity in the untamed wilderness, tree grapes seem likely to prove useful.

FOSTERING RURAL DEVELOPMENT

Although wild fruits have been accorded little horticultural recognition, some clearly promise to help reduce rural poverty and the dissatisfaction that leads to urban migration. This may come through cultivation or improved *in-situ* use in the wild, and it is an endeavor that promises to especially improve the lives of women. In many areas of Africa, gathering wild fruits for sale is considered a female prerogative. It is women who sell the fruits, thereby gaining a small income to supplement the welfare of their families. Any help for the resource will directly help such women and by extension their families. One particularly promising approach is the management and domestication of local fruit trees for the production of “exotic” juices.

Below is a summary of merits, *specifically in terms of rural development*, for each wild fruit highlighted in the remaining chapters of the book.

Aizen (Mukheit)

This little desert shrub seems at first to offer little direct economic benefit. But during the 1984-85 Sudan famine, its seed effectively became the staple of market society, replacing millet and sorghum (which morphed into luxury foods). In addition, the fruits dry down into a sweet delight, not unlike hard candy, that can probably be sold with little difficulty locally and perhaps at a distance. Furthermore, the dried seeds are ground into flour and used like sorghum, millet, or lentils. The processing and selling of fruits, seeds, or flour are possible routes to small-scale prosperity. People who live where aizen grows are among the earth’s poorest, but that doesn’t mean they are without buying, bargaining, or bartering power.

Chocolate Berries

Rugged, robust, resilient, these woody plants seem capable of contributing to rural development. Certainly a market for the fruits might be developed, but these utilitarian species also offer other potentially saleable products. They yield, for instance, a straight-grained timber resembling teak. They stay green far into the dry season and keep livestock alive (or even in good condition) when death seems the more likely fate. They are favorites for honey producers because bees visit them from afar. Understandably, rural people eagerly plant and tenderly nurture these trees. Thus, although they remain undomesticated, chocolate berries have rural-development potential.

Custard Apples

As noted, tropical America’s custard apples (especially cherimoya) are rising in horticultural importance in several parts of the world. Clearly, the African counterparts could now join this culinary wave. Crosses between

different species are also creating hybrids with their own attractive futures. Hybrids between the African species and their transatlantic relatives may well produce brightly colored, larger fruits with few (or perhaps no) seeds. Their genetic qualities, in other words, might bring commercial benefits to two continents at the very least.

Ebony

These persimmon relatives could in the future be widely grown both as village trees and as densely planted stands. Fruit pulp is just one useful product. The seeds of some ebonyes are edible. The leaves are used as animal feed. The bark in certain species yields a dark blue dye for coloring cloth as well as a gum used for glue. In the long run, however, the wood would be the greatest financial prize from these forests. Although little is known about their performance under cultivation, their long-term prospects as fruit-and-timber resources could be good. The sale of fruits could support annual maintenance costs and perhaps provide income during the long years in which they are laying down their gold-standard heartwood.

Gingerbread Plums

For purposes of rural development, these fruits seem at least worthy of exploration. They are already used in a variety of ways: some are eaten fresh, some are boiled with cereal, and some are made into colorful drinks, gruels, and syrups. With most of these botanically interrelated fruits the seed kernels are enjoyed like cashews or almonds. Several species are already “semi-cultivated”—farmers clearing land spare good trees and subsequently maintain them for the fruit. This salvage operation has been a first step toward developing a more formal rural resource, now ripe for plucking.

Gumvines

Little importance is nowadays attached to gumvines as potential income sources, but if they can be tamed and turned to use then tropical Africa will have a collection of interesting crops capable of contributing to economic progress. If particularly good specimens are located and produced in quantity, there is even the possibility of exports because the fruits tend to have shelf lives long enough for a sea voyage. Already, they are frequently sold in markets across West Africa. In Mali, Burkina Faso, and neighboring nations you commonly see boys selling them by the cluster along roadsides.

Icacina

This species’ potential in poverty reduction is uncertain, but possibly outstanding. Despite being untouched by agronomic science, the plant already contributes to the health and happiness of many. Any improvements,

no matter how modest, could thus have a satisfying impact on rural welfare. People truly enjoy the seeds, which provide a permanent, reliable, and very tasty food with at least modest profit potential to those who produce or gather it. And there are also the fruits and even the tuber in the bargain.

Imbe

Many African peoples already relish these fruits and even in its present unimproved state the species produce abundantly. Moreover, imbe trees integrate into the village scene neatly and form excellent partners in mixed-crop farming. Farmers are almost promised a profit because the general populace places high value on these fruits—indeed, demand is often great enough to go unfilled. The fruits themselves are attractive and of a good size for mass marketing. The trees thrive in adverse sites, including dry, damp, sandy, or rocky locations. They respond vigorously to good culture. Finally, they make excellent village-, farm- or dooryard trees, being tall enough to throw soothing shade over people, paths, and patios.

Medlars

African medlars are promising for commerce, regardless of whether wild or cultivated. All resemble one another in appearance and a propensity to bear masses of fruits. Specimens with as many as 1,800 fruits have been recorded and harvests approaching \$100 a tree are claimed. Marketable products include both fresh and dried fruit. Either way, they make food supplements with potentially high nutritional value. They can also be sold in the form of flavorings and beverages. And they provide edible seed kernels.

Monkey Oranges

These trees already provide a profit. Indeed, fruit sell at quite high prices and still demand is seldom met. There is even an extensive local and regional trade and, according to one observer, “[more] are urgently needed to make available fruits for export markets and for processing.” Indeed, a much greater commerce in monkey fruits seems eminently possible. A sustainable export trade is not beyond expectation. Zimbabwe has already trucked them to Botswana, and that could be just a beginning. Generally speaking, the three special *Strychnos* fruits are of marketable size and quite stunning to see. They typically store and ship far better than other tropical fruits. Indeed, they can be piled up and stored in the open because their hard, gourd-like shell resists not only pressure but fungi and fruit flies as well.

Star Apples

Today, these species’ broader potential is unexplored and their value in organized commercial plantings remains untried. They deserve better. An

important feature is that the fruit becomes available in the dry season, a time when all too often there is not enough to eat or sell. When superior strains become available they seem likely to find ready commercial outlets. However, at present not even the basics of the plant's production, maintenance, or use are well described.

Sugarplums

This is one of the few wild fruits with an organized distribution system. The districts in which *Uapaca kirkiana* grows send the fruits to distant markets. For example, parts of Zimbabwe where mohobohobo trees are abundant truck enormous quantities of the fruits into Harare, where most are sold by street vendors. Already these are quality fruits, but technical support is likely to lift them far above the forest fruits of today in terms of quality and quantity. Indeed, tomorrow's sugarplums could be exceptional resources for reducing rural poverty.

Sweet Detar

For all its utility, this tree remains wild, but it seems like a rural development star in waiting. Although normally consumed out of hand, the fruit is processed into such things as dried fruit "leather" and refreshing drinks. Presently, the species is unknown in intensive plantations or even in extensive village plantings. Rather, it occurs in outlying forests or in farm fields where scattered specimens remain from bygone days when the land was cleared. The trees furnish excellent timber. Often sold as "African mahogany," the heartwood has a fine and regular grain and is eagerly sought for carpentry, joinery, and other premium purposes.

Tree Grapes

Already these are of commercial importance. In certain sections of West Africa they are eagerly consumed and the trees are commonly cultivated in and around villages. At least one tree-grape species produces both prized fresh fruits and long-lasting "raisins." Wherever they occur tree grapes are avidly eaten; some already play a part in commerce. In West Africa, people commonly sell them in the city markets and along rural roadsides, and the grapelike fruits are "very suitable for juices." In addition, the bark yields edible gum, a reddish dye, and a fiber used for cordage and a lot more. The living trees provide poles and floats and fishing nets. Oil from the seed kernel has potential for soap and unguents; in Mali it reputedly strengthens the hair. Because of its shade and manifold bounty, tree grapes are typically protected when the land is cleared for farm fields. As a rural development tool it seems to offer much.

SUSTAINABLE LANDCARE

These days, environmental protection is of vital concern, the subject of solemn conferences and severe treaties. Yet for all the hand-wringing over land degradation, Africa's wild fruits are seldom, if ever, regarded as part of the solution.

This is unfortunate because promoting self-reliant fruits such as those described in these pages offer great prospects for keeping the continental landmass productive. Many of these wild species survive on marginal sites. Indeed, they represent one of the best tools for turning vast areas of what is now eroding, vulnerable wasteland to valuable use. They provide their food bounty without having to be cut down and without disturbing the land. And they give people a personal motivation to protect and preserve not only the trees but also the site and the associated ground cover.

Unlike domesticated plants, the ability of wild fruits' to survive independently of humans makes them especially promising as land-protecting, food-bearing inhabitants of places where human presence is thin or sporadic and almost always vulnerable. As of now, many such threshold locales become abandoned, less to rejuvenation than to wreck. Clearly, wild species are a best choice for extending presence in wild lands. And seeing they provide food seasonally, or even only when calamity strikes, they do a signal service to both the site and the citizenry.

The protection, establishment, and advancement of indigenous fruit-bearing trees can also help underpin sustainable farming practices. In fact, they might well provide shifting-cultivators food and income during the long wearying years while the land refurbishes itself. This "fallow/food-enhancement" system—which both protects the soil and produces something to eat or sell on the side—seems well worth Africa-wide attention.

At the very least, the wild fruits we describe are putative components in sustainable food production. They typically provide more than one edible product (a striking contrast with fruit trees grown in temperate zones) as well as non-edible benefits. For example, in addition to fruits, many are used by herbalists and other traditional healers. As a part of the natural landscape, they also contribute to both the environment and people's inner welfare. They therefore offer benefits both physiological and psychological.

Of course, wild fruits can never replace field crops, but they certainly can complement them in important ways. More than half of southern Africa's land is unsuitable for conventional cultivation. The marginal areas in which farming is attempted remain grossly underproductive due to recurrent drought and chronic soil infertility. In such regions the augmentation of the naturally productive vegetation already in existence can promote nutrition, food security, and rural development. In addition, the plants can be established in hedgerows and along contours to stabilize the slopes, thereby promoting environmental stability while also elevating income and health.

Below is a summary of the merits, *specifically in terms of sustainable landuse*, of each of the wild fruits highlighted in the remainder of the book.

Aizen (Mukheit)

This plant's endurance is remarkable. Shade-temperatures that reach as high as 45°C are far from rare in its habitat. Arid stony slopes, sand dunes, and cracking-clay plains are its bread and butter. This and the fact that livestock and wildlife leave it alone most of the year means people need not, as we have said, worry that their plants will be devastated by the desert or devoured by goats or gazelles. For this double security alone, aizen promises to be a practical way to protect erodible slopes, stabilize dunes, create windbreaks capable of keeping the ground unscoured, demarcate boundaries, and provide shelter for livestock and their owners. Further, aizen provides year-round shade where even slight relief from the sun is a great gift. And it also offers other utilitarian benefits in places where people need help in the struggle of life.

Chocolate Berries

Everyone likes having a chocolate berry tree around, and people already go out, gather the seeds, and deliberately plant their own. These 70 species include some specimens with exceptional promise in agroforestry and rural reforestation. Indeed, those might become standard components in the species mix employed to stabilize eroding slopes and abandoned wastelands across much of the continent. Among other advantages is their longevity. These trees are long-lived; moreover, they're never cut down irresponsibly. Even scraggly wild specimens are protected by societal rules and regulations. Almost everyone—not to mention the environment—benefits from living chocolate-berry trees.

Custard Apples

With their notable sugar content, these fruits appeal as foodstuffs, but the plants fall far short of any ideal for environmental protection. They are certainly capable of surviving without human help, and they add value to wooded wild areas. Though not often stand-alone trees, their shade is also desirable. Thus, people tend to preserve and protect their habitat. But beyond that they are not particularly hardy and seem to do little to save the soil or improve the ambiance in any other exceptional manner.

Ebony

For African agroforestry projects, local *Diospyros* species could be especially valuable. People know and love these trees. As long as superior planting materials are supplied, millions are likely to plant them

spontaneously and protect them from harm throughout a lifetime or two. Even now, volunteer plants are well cared-for. Indeed, African ebonies could become valuable not only for individual plantings but also for bordering streets and highways, for fencelines, for village squares, and for small-scale entrepreneurial endeavors of many kinds.

Gingerbread Plums

Producing vastly more of these tasty fruits under more organized conditions seems eminently feasible. Germinating the seeds is difficult, but most (perhaps all) *Parinari* species are easily reproduced via root suckers. These root cuttings also provide the key to propagating elite specimens. Through them, quality plantings could be quickly and easily established across much of Africa, clustered in villages perhaps, or scattered alongside roads in the valleys and tracks on the hillsides.

Gumvines

Adding vines as valuable as these might raise the economic worth of standing forests—thereby dampening the ardor to burn off the land or cut the trees for lumber. Incorporating gumvines into boundar rows, windbreaks, shelterbelts, and *ex-situ* conservation forest are also possibilities. Species that cling and climb could be a way to increase the utility of many tree plantings that are expected to provide long-term environmental benefits.

Icacina

Icacina forms vast thickets that are about as close to monoculture as can be found in nature. Their denseness protects the soil, which otherwise is often subject to erosion and degradation. This is a feature that might well be turned to environmental advantage.

Imbe

This is an unusual and eye-catching small tree. Its dense, spreading, or conical crown topping a short, often twisted trunk or cluster of trunks makes a striking sight. Its attractive form, together with the year-around foliage and heavily scented flowers, make imbe a landscaper's dream—so much so that it is nowadays planted more for beauty than for food. This certainly opens it up to use for esthetic uses and bigger plantings, but this is probably the extent of its landcare advantages.

Medlars

Across southern Africa, local lore claims that the beneficent *Vangueria infausta* bears fruits heavily just before a big drought. In agroforestry the trees could find a notable niche. Already several *Vangueria* species are used

as hedge plants to demarcate fields and farms. The trees' ultimate continental potential is probably more for back gardens, bare patches of hillside, village greens, or the verges of roads and tracks and rivers.

Monkey Oranges

The trees that yield monkey oranges make excellent additions to gardens, parks, streets, and fencelines—providing not only food but also shade, shelter, and erosion protection. Much more could be made of them in caring for the African land.

Star Apples

Regardless of food production, the various African star-apple species are promising for protecting and improving stressed sites. They could prove useful, for example, in land reclamation, erosion control, and, especially, in reducing wind-erosion. For their ornamental value alone these trees merit attention. People love having one standing beside the house. They might make useful reforestation species too. Fully grown, they top out at 30 m in height and 2 m in girth, and their hard, white wood is world famous for quality and high price.

Sugarplums

Farmers clearing land normally leave every sugarplum standing. These highly respected trees can usefully complement backyard gardens, agroforestry operations, and more. They seem ideal tools for protecting soil as well as for conserving habitat and native biodiversity.

Sweet Detar

Robust and resilient, this large tree is a candidate for reforestation purposes. Although this legume probably does not fix notable amounts of nitrogen, it survives in harsh, infertile sites and tolerates some drought and much heat. All in all, sweet detars seem likely to make good backyard, village, and street trees, providing welcome shade and environmental benefits, not to mention copious food.

Tree Grapes

Although these fruits look like grapes, they are borne on trees, not vines. Even where the fruits go unharvested, the trees are still revered. They coppice well and sprout with vigor, which makes them useful for hedges. While the environmental benefits have yet to be evidenced in practice, they could be so great that *Lannea* species seem promising for vast shelterbelts to settle the soil and make life more livable in their historical heartland across the Sahel.

WILD FRUIT ISSUES

We finish this introduction with passing mention of some strategic issues that seem especially relevant to the further development of Africa's wild fruit biodiversity.

INCREASING WILD FRUIT USAGE

Even where wild fruits grow in abundance, their significance is seldom fully appreciated. Locals consider them merely free wayside snacks for enjoyment alongside the roads, paths, and trails they take to school, to town, to the bus stop, or to the pastures. Outsiders, notably scientific investigators, have often been misled because people so fail to value wild fruits they go unmentioned in such things as socio-economic and nutritional surveys. Also, strangers from the city or a foreign country typically measure only the foods in the house and “on the table.” To them, the idea of a separate world of foods snatched from living nature could seem unimaginable. Sometimes, also, outsiders are victims of translation mistakes. In a number of African languages, for example, the local word generally translated as “food” refers only to cooked items, and therefore omits wild fruits.

There have been few concerted efforts to physically integrate wild fruits into the mainstream of dietary development. Despite being integral parts of traditional culture, these are one of the most neglected of all African resources. To advance the greater use of wild fruits is an exciting area with high possibilities for benefiting scores of economies and millions of people.

And the challenge may not be as great as might initially be assumed. Many of the following chapters attest that landowners already have a high regard for certain trees that produce wild fruits. Africa's traditional shifting agriculture usually aims less at destroying such trees than cutting them back while keeping them alive. This is seen across many savanna areas. Of course some plants die when cut, but many re-grow from the stems and stumps, and thus provide a tree fallow that covers and protects and restores fertility to the site for the next round of crop planting. For this purpose, “edible” trees are in many places singled out for special protection.

This is a valuable method of producing food, but increasing population pressure is seriously shortening fallow periods. Even stumps that re-sprout best are weakened and stressed beyond their limit if cut back too short or too often. A fast return to a fallowed site also reduces natural regeneration rates by retarding growth of plants too young to resist fire. Overgrazing is also a factor reducing natural regeneration rates. In addition, the wider use of animal traction or small tractors requires that stumps and roots be removed from cleared fields. And in forest zones, commercial logging opens land for shifting agriculture, meaning an expanding landscape where most species are stressed. Emphasizing wild fruits adds value to nurturing all such lands.

Even small improvements in awareness of bush fruits might well bring big benefits to localities in which they grow. Increments that perhaps seem insignificant could eventually be lifesavers to societies on a nutritional edge.

Exploring the greater use of the wild resource offers opportunities for innovations of the most far-reaching kind. Edible wild plants might, for example, be utilized for purposes such as groundcovers, shelterbelts, street trees, windbreaks, hedges, roadside screens, or erosion barriers. People (and especially children) could then, as in the past, find nourishment on every hand. It is not difficult to imagine the establishment of “edible parks,” “edible watersheds,” wild-food reserves, year-round fruit gardens, “edible fallows,” and street trees and hedges selected so as to provide a year-round cornucopia of “kid’s treats.” Such notions are especially important for towns and cities, as other parts of the tropical world have learned. Even in the center of Quito, Ecuador, for instance, bus stops usually have a native capulí cherry tree beside them. This is mainly to provide shade and beautification, but schoolchildren feed themselves as they wait for the ride home after a day in the classroom. In southern Mexico, many town squares are planted with mango trees that provide food and drink to kids as well as many adults (especially the poor). And in India, an African fruit tree, the tamarind, lines thousands of rural roads, paths, and highways, mainly for shade and shelter but partly to sustain the hungry.

DEVELOPING WILD FRUITS

Keeping wild fruits wild is certainly an important aspect of the future for Africa. But many of the native fruit species also seem to be good candidates for improvement, domestication, and commercial production. Awaiting the adventurous plant scientist and eager amateur are opportunities to create a new cultivated crop and possibly transform their own lives in the bargain.

The limitations of propagation can be overcome more easily today than ever before. And the entry of traditional products into long-distance trade is also easier than ever before. Thus in the decades ahead the world of African fruits could be made afresh.

For developing most of these species, the first requirement is selection—location and propagation of individual plants that yield superior fruits. Some features that make a superior fruit include large amounts of edible pulp, small numbers of small seeds, attractive colors, marketable size, appealing flavor, low stringiness, freestone features, resistance to pests and diseases, and long shelf life. Perhaps most important is yield potential, for this is what puts money in the grower’s pocket and incentive in the grower’s head.

Tropical fruit trees must be approached across a broad front because the majority of specimens are not worth propagating—neither are the majority of wild apples, oranges, peaches, kiwifruits, and the rest. With most tree fruits, mass propagation of single “elite” specimens can turn a commonplace

minor fruit into a major contributor. Oftentimes, only one plant in 10,000 (or many more) will bear such elite fruits. To find that one special plant, a person need not be a botanist, horticulturist, or other specialist. Indeed, the “loner” in a remote valley has a better opportunity of locating a winner in that genetic lottery than the scientist in the capital.⁶

With so much potential in wild fruits, many approaches to developing the resource are possible. In one, for instance, interested individuals could organize an “African wild-fruit development association.” Chapters could be established in different countries, or in the cyberworld. Their purpose: to save and share germplasm, to exchange results, to inventory various promising locations, to gather folklore, as well as to stimulate broader interest, to develop recipes, and, most of all, to get superior types into hands of villagers, landowners, marketers, exporters, and other potential users. This requires little or no government funding, and indeed might be more freewheeling, more dynamic, and more successful if it springs from grassroots operations organized and energized by enthusiasts. Schools could be encouraged to record yields, pollination methods, lifecycle stages, and so forth. This approach has already shown success in Botswana, where a small company organized a nationwide competition amongst school children to find plants with the biggest and sweetest fruit of selected species. Substantial prizes were given. The results were rewarding, producing fruits of exceptional quality that are now being promoted for the country’s benefit.⁷

Such generalized activities, while important and likely to bring success and satisfaction, can go only so far. Africa’s wild fruits offer such a wealth of benefits that formal research programs should also be set up all over the continent.⁸ In that way, horticulturists, plant pathologists, soil scientists, entomologists, foresters, and others can apply their training and experience to develop wild fruits. Examples of some specific technical needs are to:

- Reduce the often-long delay between propagation and first fruiting.
- Reduce the often-long delay between flowering and fruit maturation.
- Identify early-, middle-, and late-producing, superior genotypes for development into cultivars.
- Find how to propagate (both through seed and vegetative means), germinate, plant, and grow recalcitrant species.

⁶ It was an Australian housewife who discovered the ‘Granny Smith’ apple in the 1860s. The seedling popped up in her backyard after she had tossed out some old fruit. She recognized good taste and cooking qualities, and today it is one of the world’s major apples. Her name was indeed Smith and she was a grandmother.

⁷ Recent information on this initiative can be found at www.veldproducts.org.

⁸ The “Cinderella Tree” initiative of the World Agroforestry Centre in Nairobi (www.icraf.org) for domestication and commercialization of multipurpose tree species was a good example of this thinking, which seems to be taking hold among the broader research communities.

- Select desirable traits and specimens for propagation.
- Determine the limits—geographic, phenologic, edaphic, and climatic—where a species can be successful.
- Develop horticultural techniques—pruning, grafting, top-working, hybridizing, maintenance, orchard management, and more.
- Develop ethnobotanical, horticultural, extension, vocational, or other appropriate curricula for school levels from entry through post-graduate.
- Learn how to protect the plants from pests and pathogens.
- Undertake cultivar trials to prove efficacy of superior genotypes.
- Establish demonstration plots.
- Preserve the sources of wild fruits.

The involvement of professionals does not obviate the need for the grass-roots plant-lovers. Both offer much. Indeed, the collaboration between eager amateurs and devoted professionals has been a most successful one in the United States, where several societies of rare-fruit enthusiasts (of all age groups and walks of life) work together to introduce new fruits to the nation, with much enjoyment and personal satisfaction along the way. Exemplifying what can be done is the Florida mango industry, in which enthusiastic amateurs selected most of the cultivars. California's avocado and date industries began similarly with amateur initiatives, as did several Australian fruit resources, including passionfruit, custard apple, and macadamia.

NUTRITION

In the exploration of wild plants there is of course much need for laboratory scientists in disciplines such as nutrition and food technology. Despite the importance of nutritional composition data, many of the wild fruits have gone unrecorded. If made available, nutritional information alone might convince planners of a species' promise and potential. It is vital, therefore, to develop a nutritional database for the most important edible wild plants.⁹ For a relative pittance (at least in terms of today's research budgets), this could create nutritional and economic returns beyond measure. Indeed, a concerted program of information or education would likely transform the way rural people regard the small, concentrated-in-flavor fruits they find around them and often spurn. And along with the realization of the importance of wild fruits could also come care and concern and commitment to their greater protection and greater use. Helpful here could be the precedents of a dozen or more nations (from Scandinavia to Chile) that publicly disseminate depictions of nutrition pyramids or piecharts to induce consumption of local fruits and vegetables and a more balanced diet.

⁹ We wish here to recognize the pioneering work of A.S. Wehmeyer, who in a lifetime of dedicated scholarship recorded the basic nutritional constituents of over 300 of South Africa's edible species.

SUSTAINABLE FORESTRY

Africans' abiding interest in food trees could be made into a driving force for future forestry efforts. The problem is that foresters have traditionally dismissed such species. In their eyes these may be woody plants but they typically have "bad form" (that is, trunks not long and straight and properly rounded for the best production of timber). And they think of any food-producing tree as belonging to the alien sphere inhabited by horticulturists.

Yet many of Africa's wild fruits come from native forest trees. Of 1,000 indigenous trees growing in southern Africa, for example, more than 200 produce fruits eaten somewhere or another.¹⁰ Those tree-fruits may be eaten raw, dried, or mashed into paste; they may be eaten for health, hunger, or pleasure; they may be tasteless, astringent, or downright delicious. These comprise a vast forest food reserve, and such deep-rooted resources are urgently needed in these days when maintenance of trees is taking on greater and greater importance in sustaining a balanced environment.

One particularly innovative concept, "salvation forestry," might well soon employ wild fruit trees. In this system, local people produce products in the forests in ways that ensure them a stake in the profits. The goal is to help the villagers to become so dependent on natural forest bounty that they become the fiercest of all conservationists.¹¹ Perhaps there may also be ways to get credits for carbon sequestration or contributions to the conservation of biodiversity. Since only the fruits are harvested, these trees could also be seen as ideal for long-term credit schemes.

Such local support is crucial because many countries are so overcrowded that poor people are spilling out into the forests and savannas in never-ending numbers. In the past, authorities attempted to protect endangered systems behind the guise of exclusionary laws, but even the best-run nations lack the massive resources needed to enforce legal protections in remote areas. Moreover, many of the rural peoples feel driven toward the food or cash they can get from turning forest into farmland. There seems no practical way to thwart millions, especially when they are desperate to survive.

Salvation forestry, however, has a chance of succeeding. It is a "supply-side conservation" in which threatened areas now pay their way to survival. This approach is being adopted in several parts of the tropics. The organized use of wild tree-fruits could well improve the effectiveness of hundreds of efforts to conserve Africa's wooded habitats.

For these reasons, tree fruits should be incorporated into environmental programs, agroforestry, forestry, agricultural projects, and programs dealing

¹⁰ Palmer, E. and Pitman, N. 1972. *Trees of southern Africa, covering all known indigenous species in the Republic of South Africa, South-West Africa, Botswana, Lesotho & Swaziland*. A.A. Balkema, Cape Town.

¹¹ The Food and Agriculture Organization's (www.fao.org) initiative for Promotion and Development of Non-Wood Forest Products has been one of the leaders in this area.

with sustained food security for the peoples of Africa. Taken all in all, wild tree fruits are good for the environment, good for the people, and good for national stability in all nations, but most especially in those under-nourished and under-performing climes that fall below the Sahara.

SOCIAL DIFFICULTIES

Of course, in developing fruit activities, obstacles will intervene. Some could arise from social issues confronted by any tree planting effort in Africa, including questions of tenure and of the traditions of planting or owning trees. Other obstacles will arise from traditions concerning specific tree species. The very act of valuating what was essentially a free foodstuff will require careful evaluation of habits and community customs. In countries where national forest services have a mandate to protect naturally occurring trees, including those which bear fruit, clarification of ownership of wild fruit trees planted by individuals or communities may be necessary.¹² Should wild fruits ever become economically valuable on a level approaching that of mangos and citrus a new set of issues come into play. For example, grower's need access to the land on which their trees are planted, so as to protect and benefit from the investment of time and money over the decades the trees remain productive. Many such social challenges must be considered when pursuing development of wild fruits.

It is important also to realize that customary practices and even superstitions still play a strong role in the lives of many rural peoples. For example, in places some tree species may be designated for the use of specific groups. Similarly, the land-tenure system, in which land is communally owned (and also its resources, including trees for fruit), may militate against individual people planting trees. In some societies, such an act could arouse jealousy and suspicion and perhaps incur wrath by flouting inherited authority to "parcel out" land. A stand of trees, after all, implies permanency of tenure.¹³

So, research on wild fruits should take account of both the sociocultural systems in which the trees occur and the farming systems in which eventual cultivation of these trees might have to fit. This multiple-use feature is of special significance. One of our most experienced contributors—a botanist with a long lifetime's experience with African plants—wrote: "In general I feel that your search for food crops in Africa, in particular useful fruits, may be in vain. There are so many exotic fruit trees available that further new ones may be unlikely to repay the cost of development." But then he added

¹² It is interesting to note that the legal right to use and enjoy the advantages or profits of another's property, called "usufruct," arises from the Latin phrase for "use of fruits." It also bears the proviso that the property not be damaged or altered in any way.

¹³ For thoughts on these matters we want especially to thank B.N. Wolstenholme, who added, as if to reassure us, "These problems are real!"

as an afterthought: “As I think over the matter, I realize however that while there may be few plants worthy of cultivation *purely* for their *fruits* there probably are quite a considerable number worth growing on a *multipurpose* basis. Among the uses to be considered: fodder for reserve use in time of drought; sticks for hut building and so forth; wood for carving; fiber; medicines; honey and beeswax; bark; roots; and seeds for protein and cooking oil. All these are often more useful than are the fruits eaten for taste, minerals, and vitamins.”

In the view of this panel, it is worthwhile pursuing the full plethora of possibilities offered by the wild fruits of Africa—consumption and commerce, as well as whatever else can be made from the plant or its byproducts. For too long, the spark of modern ingenuity has ignored these ancient foods.

* * *

The potential of Africa’s wild fruits to improve its quality of life has been emphasized in the summary outlines above, but they are also constrained by various limitations, all of which are discussed in greater detail in the chapters that follow.

DESCRIPTIONS AND ASSESSMENTS OF
INDIVIDUAL SPECIES



1

AIZEN (MUKHEIT)

The aizen or mukheit (*Boscia senegalensis* (Pers.) Lam. ex Poiret) occurs across the very area that in recent decades has faced more hunger than any other in the world—the vast swath of Sahel and Sahara savannas stretching from Mauritania, Senegal, and Mali all the way to southeastern Egypt, Sudan, Ethiopia, Somalia, and Kenya.

This highly stressed and unforgiving region provides some of the most daunting conditions ever faced by higher plant life. Yet this is the aizen's territory. In extreme aridity it shrinks to a scrawny shrub less than 2 m tall, but in favorable environments it soars several times that height and becomes almost treelike with a rounded, spreading crown.

Having survived thousands of years of recurrent drought without horticultural help, this wild species holds the potential to make life more bearable under the desiccating conditions in which millions of Africa's most destitute are increasingly forced to exist. For this, there are at least three reasons. First, aizen is adaptable, resilient and, of course, capable of handling extreme drought and heat. Second, it yields an array of useful products. And third, it provides year-round shade in areas where even slight relief from the sun seems merciful.

Aizens are not fruit crops in the normal sense. It is the combination of foods and useful qualities that makes them important. The species produces enough different products to sustain human life almost by itself. In at least a dozen countries, at times people virtually live off aizen fruits, aizen seeds, aizen roots, and aizen leaves. In eastern Sudan, for example, men and women sometimes spend 8 hours a day seeking aizens, carrying the branches and fruits home to ease their hunger or sell along the roadsides to other hungry people. For them, these plants are crucial to existence, allaying hunger and earning cash. Also, the foliage keeps their animals alive during the dry months when little remains to sustain a herbivore. And certain peoples use various parts of the plant for cooking food, controlling pests and parasites, and clarifying water to render it safer for drinking.

Although not unpleasant on the palate, the fruits are most notable for being on hand when little else edible remains. The foliage's very unpalatability is key here: livestock and wildlife leave aizen alone for most of the year. Thus the human users have no worries that their trees will be



Zinder, Niger Republic. Aizen occupies some of the hottest, driest locations ever faced by plant life in the modern era. Yet it not only survives, it yields enough useful products to sustain human life almost by itself. In at least a dozen countries, people virtually live off aizen fruits, seeds, roots, and leaves. The bushes typically give a lot of fruits, which mostly ripen at once. The fruits shown here are unripe, and would normally be collected only after they turn yellow. But because of the food shortage, people are often unable to wait that long. (Eden Foundation)

destroyed by the desert or devoured by goats or gazelles. For this double security alone, aizen is promising for establishing famine-food reserves, for protecting erodible soil, for stabilizing dunes, for windbreaks, and for other utilitarian purposes in the harshest of harsh sites—ones where people need every last bit of help in the struggle to survive.

This plant's endurance is remarkable. It tolerates shade temperatures as high as 45°C, a level not rare in its habitat. It occupies most types of arid-land environment: stony slopes, sand dunes, and cracking-clay plains, just for starters. It often occurs in desiccated, barren, hard, and even fire-scorched sites. As to soils, they are usually poor, sandy, rocky, worn-out laterite, or clay. Commonly it sprouts directly out of termite mounds. And it survives in areas receiving as little as 100 mm annual rainfall, although it grows best where there is at least 250 mm. Contributing to the plant's built-in drought tolerance is its remarkable leaf structure: the cuticle is up to 20 microns thick, the stomata are sunk in deep cavities, and each stomate has thickened walls and a protective armoring of papillae.¹

¹ Killian, C. 1937. Contribution à l'étude écologique des végétaux du Sahara et du Soudan tropical. *Bull. Soc. Hist. Nat. Afrique du Nord* 28:12-18.

For all such reasons, this nondescript “ugly duckling” is in humanitarian terms one of the most admired of all trees. When in recent years researchers surveyed local food and forage species, aizen proved to be the most popular food source among all the indigenous trees in Niger.² During the 1984-1985 famine in Sudan it was by far the most widely used famine food.³ According to one analysis, 94 percent of people in northern Darfur who had access to aizen (mukheit) during the famine consumed it.⁴ In fact, during the famine a market developed in which it effectively replaced sorghum and millet (esh) as the staple and those normally basic grains became luxury foods.

Perhaps it is not so surprising that people like aizen fruits. At least six parts of it can be put to use, and most of those can be lifesavers. Further, aizen trees are used in at least four ways that relate indirectly to food production. All these are mentioned below.

Fruits The yellow cherry-sized berries (up to 1.5 cm in diameter) are borne in clusters. When newly ripe, their rather sweet pulp is translucent and jelly-like. However, in the desiccating air it quickly dries out, turning into something not unlike caramel before ending up a brittle, brown, and quite sugary solid. Despite its good taste, this toffee-like treat is difficult to separate from the seed.

Although the fruit is a seasonal food, its season differs from the norm and comes at the beginning of the rains, a time when farm crops are just being planted and anything to eat is usually difficult to find. This alone makes aizen a lifesaver.⁵ In the better-watered zones, where there are many edible plants to choose from, aizens serve mainly as supplementary, rather than staple, foods. But still, these fruits remain inestimably valuable backups for the devastating drought emergencies that arise almost routinely every decade or two.

Besides being eaten fresh, the ripe fruits are often boiled. Furthermore, sometimes juice is extracted, filtered, and boiled down into “aizen butter,” a semisolid commonly mixed with millet and curdled milk to make “cakes.”⁶

² Information from Timothy J. Johnson and Michele Rodrick.

³ Salih, O.M., Nour, A.M. and Harper, D.B. (1991) Chemical and nutritional composition of two famine food sources used in Sudan, mukheit (*Boscia senegalensis*) and maikah (*Dobera roxburghi*). *J. Sci. Food. Agric.* 57 367-377. Also, Omar Mohamed Salih Abdelmuti (1991) *Biochemical and Nutritional Evaluation of Famine Foods in the Sudan*, PhD thesis, University of Khartoum.

⁴ de Waal, Alex. 1989. *Famine That Kills: Darfur, Sudan, 1984-1985*. Clarendon Press, Oxford.

⁵ As contributor Paul Beckman wrote: “The fruits are usually ripe in the area around Eden’s field station near Tānout, Niger, for two months during July-August. This is in the rainy season but it is a critical period when food stocks from the previous harvest are at their lowest.”

⁶ Sometimes the juice is extracted by loading a pile of aizen fruits into the panniers carried by donkeys. The jolting does the job.

Detailed nutritional analyses seem unavailable, but the fruits are reportedly rich in calcium, phosphorus, iron, and B vitamins.⁷ They are also said to contain a little protein.

Seeds Each fruit usually has one or two greenish seeds, which look like peas and are used like peas. They are in fact the more important foodstuff. Throughout the Saharo-Sahelian zone they are such common items of diet they are sometimes described as desert dwellers' staples. They, too, are important famine-time foods. And roasted, they also substitute for coffee.

After extracting the juice from the fruit, people typically separate the seeds from the pithy residue, dry them in the sun, and put them aside for safekeeping. In times of scarcity, such as at the bitter end of the dry season, these dried seeds substitute for millet or lentils. They require lengthy preparation and must be eaten cooked. The traditional procedure involves soaking the seeds for a week (changing the water daily) to remove bitter components. Less commonly, they are boiled 3 hours (and rinsed at least twice with new water). In either case, they are subsequently dried and ground into flour. This aizen-seed flour commonly replaces sorghum, millet, or lentils in making porridge.

Nutritionally speaking, the seeds are satisfactory. Starch and soluble carbohydrate content compares favorably with local staples (sorghum and millet). The protein content is high relative to those cereals and the protein quality (chemical score 33) is similar to that of sorghum (chemical score 36). As to minerals, the seed has exceptional amounts of sulfur and zinc.⁸

Roots Young roots, scraped of bark, may be ground, sieved, mixed with cereals, and boiled into a thin gruel or thick porridge. They are very sweet. Some are dried in the sun and kept on hand for hungry times. Root tissues are also boiled slowly for several hours to make syrup.

Leaves The leaves, although just about the most leathery and least appealing foodstuffs on earth, are also consumed. Most are dropped into soups or boiled and mixed into cereal products such as gruel or couscous. The plant is particularly useful this way because it is an evergreen and provides food and nutrients when other plants are bare.

Flowers The flowers provide bee forage, often in areas where little else capable of sustaining honeybees is available.

⁷ Wickens, G.E. , J.R. Goodin, and D.V. Field, eds. 1984. *Plants for Arid Lands*. George Allen and Unwin, London.

⁸ Information from D.B. Harper. The protein quality mentioned was for seeds that had undergone a soaking treatment. The boiling process improved the quality of protein (to a chemical score of 49), but reduced the overall protein content. Assuming the bulk of the sulfur is present as sulfate, the seeds contain about 6 percent sulfate on a dry-matter basis.



Zinder, Niger Republic. A food security gem, this fruit has been a proven lifesaver during famines from ancient times right up to recent days. Within recent memory it has preserved many lives in the Sahel as well as during the subsequent famines in Sudan and Ethiopia. The fact that livestock and wildlife ignore aizen for most of the year removes one of the hazards of wild foods. And the trees resist destruction even by the desert. For this multi-layer security, alone, aizen is extremely promising for establishing famine-food reserves. (Eden Foundation)

Wood Aizen wood is cut for poles, notably those holding up houses. Although smoky and stinky, it is used as cooking fuel when nothing better is at hand (which in the harshest areas is all too often).

Forage Unpalatable as the fresh foliage is, aizen is nonetheless a vital feedstuff. There is a strange paradox in the fact it is good because it is unpalatable. In fact, its very repulsiveness is its strength: When all else has been eaten up, aizen keeps cattle, sheep, goats, camels, and donkeys (not to mention gazelles and other wild creatures) alive. It is what might be termed “famine forage.” Although the need for such a fallback-forage may be brief, it may be vital. Livestock cannot be dried and stored on the shelf like fruits; they must of course be fed year-round. A few scrawny aizen bushes providing sustenance for a few weeks or perhaps a few days may be all that stands between the animals and death.

Pest Repellent In some parts of the Sahel, aizen leaves are added to granaries to protect stored foods against pests. This long-standing traditional process seems to work. Given some study, it might prove to be yet another way this plant can contribute to food supplies and food security.

Water Clarification Aizen contains natural coagulants. In Sudan, Niger, and Nigeria, for example, bark, twigs, leaves, and roots are used to scavenge suspended and colloidal compounds from unclean water (such as that from ponds churned up by storms or from baobab-tree cisterns contaminated with soil). Normally the plant parts are sliced up and placed on the water surface. Compounds leach out and catch the clay and other particulates like magnets, causing them to clump and settle to the bottom. It is reported that truly turbid water can be safely drunk after just a day of such treatment. For even faster results, aizen branches are swirled in the water. Indeed, certain Tuareg groups in the Sahara region fill sacks with aizen leaves and dunk them into the muddy pools that comprise their only source for drinking. Following a rare desert downpour they may also place these giant tea bags across ditches so that the runoff clarifies itself as it oozes through.⁹

NEXT STEPS

Considering the desperate international efforts to feed people in the area where aizen grows, this plant deserves much greater support than it presently receives. Although it has not yet been subjected to horticultural attention, it is promising wherever in Africa desertification is a threat or a reality. Having a reliable backup on hand for the worst of hungry times would be a step toward stability for that part of the world that has absorbed billions of dollars of food aid during recent decades, and yet still lacks a reliable food base.

Despite all this promise, however, much fundamental research remains to be done before aizen projects can be launched with confidence. Some practical steps and basic fact-finding endeavors are the following.

Build Up Wild Stands One direct approach toward improving food security for Africa's most vulnerable regions is to rescue, revive, and redevelop the individual trees and existing stands of aizen. Farmers tend to respect areas carrying this species, and their bred-in-the-bone interest can be harnessed to solidify thousands of local stands.

This is a good endeavor to start an aizen program with: 1) it avoids the delay of waiting for the trees to grow and mature; 2) aizen's presence shows that at least the terrain, soil, and moisture are not in doubt; and 3) probably, the site will not be overgrazed. Hence restoration programs are more likely to be immediately successful than new plantings.

⁹ Although water clarification is an important feature, moringa (see companion report on African vegetables) does better. However, aizen thrives where moringa cannot survive.

Food Security Rescuing aizen stands provide excellent opportunities for relief programs among the destitute. Again, locals should see a lot of self-interest in the work, and will likely participate with enthusiasm, not to mention skill and care. According to a Sudanese famine-food specialist, aizen was the “number one” famine food during the horrific 1984 famine in the western Sudan. “It proved to be people’s lifesaver,” he reports, “and it saved more lives than all the food aid that was given.”¹⁰

Given an experience like that, aizen should be not only preserved and protected, it should be planted out in big blocks throughout the drought-threatened regions of the Sahel, Sudan, Somalia, and Ethiopia. Not only would these plantings protect the land, they would provide famine reserves for the future droughts to come. Global reforestation activities today largely focus on rainforest regions and temperate zones, but reforesting the drylands might bring the greater benefit, at least in humanitarian terms. Though aizen is today very far from any forester’s ideal, it could be a key for opening the reforestation activities across Africa’s hungry drylands. The trees may look terrible to a forester, but their benefits could nonetheless be sublime.

Although the seeds germinate readily, the seedlings have so far proved difficult to transplant from nursery to field. Thus, it is recommended that direct-seeding trials be established to find out how to establish healthy populations in situ.¹¹

Aizen is of course important to the natural environment, providing wildlife with a last-ditch forage supply. It is sometimes all that animals can find to eat; everything else being dead, dying, dormant, or too desiccated to digest. Expanded plantings will therefore bring benefits beyond purely humanitarian ones.

Gather Germplasm No scientific authority has reported on the genetic diversity in *Boscia senegalensis*. At present, the variability is dispersed and known only to local individuals. This traditional knowledge could point to immensely valuable variants relating to fruit size, sweetness, and at least a dozen other features. The key is to assess this decentralized wisdom and to locate the best individual plants. Contests and cash prizes would likely winkle out surprising genetic variants. Seeds from these could be collected and made available especially for use in these self-same regions threatened by disastrous drought, including the Horn of Africa and the Sahara’s sharp southern edge. This is a big undertaking but their own knowledge—coupled with science—could make one of the greatest contributions to these same peoples, among the most vulnerable in the world.

¹⁰ Information from O.M. Salih Abdelmuti.

¹¹ Direct seeding is already being advanced by the Eden Foundation (eden-foundation.org), a Norway-based charity operating out of Zinder, Niger.

Horticultural Development At this point aizen's ultimate contribution as a resource is anyone's guess. It is hard to assess the potential of any food crop when there exists neither agricultural trials nor any estimate of yield. One certainty, however, is that the much abused specimens now populating the dry zones around the Sahara are poor indicators of the species' potential. Indeed, considering that the species has not been domesticated, there should exist opportunities for improving everything from yields to palatability. Once superior types are identified and mass propagation worked out those improvements can occur with a rush.

Although details are uncertain, there are claims that root and shoot cuttings have been used to propagate aizen. This could be a vital lead because with them superior plants can be replicated. Also grafting should be explored, because it would allow elite aizen types to be grafted onto the wild trees now so prevalent and widespread. That in turn would ensure rapid quality-fruit production. Also, it would provide lasting benefits because of the rootstock's obvious adaptability to the site.

Analyze Current Usage Aizen offers much potential for anthropological studies, especially in the hunger-prone regions. There have been studies already, of course, but those were sweeping assessments of all the so-called famine plants. Now is the time to focus specifically on this particular plant. It is clearly a leader, and the specifics awaiting documentation are likely to be surprising.

Nutrition and Food Science A major immediate need is for toxicological tests. Toxicity in the fruits seems unlikely considering that they are such a common food. But the seeds are certainly bitter and may prove unsafe. Given the fact that poorer families rely on the flour from dried aizen seeds, researchers should investigate and determine what (if any) toxic compounds are present. Helpful here, also, would be public health surveys of possible harmful effects on the people who eat aizen fruits in quantity. Analyses should also be made of the various processes used to remove bitterness. This would clarify whether or not such lengthy preparations (or even more lengthy ones) are needed to make the seeds edible.

Similar toxicological tests should be performed on leaves. This will settle (or confirm) doubts about their use for feeding both people and animals.

Pest Control The aforesaid fact that aizen leaves are used to protect grain against pests deserves at least preliminary investigation. This is exactly how neem is used in rural India. Over the past few decades researchers have followed up that lead and their work has led to the use of neem in countries as far away as the United States, where the seed-extracts have environmental approval and are now considered a wonderful new organic pesticide.

FAMINE FOOD

In famine times, people in rural Sudan rely on aizen. Typically, they collect the fruits, sun-dry them, separate the pea-sized seeds, and remove the hard outer seed coat. Seeds are then subjected to “sweetening” to remove bitter and possibly toxic components. The traditional procedure involves soaking for a week, changing the water every day. Sometimes “kambo,” a local potash prepared from plant ash, is added to aid the debittering. Less commonly, sweetening is conducted by boiling for 3 hours, with the water changed hourly. After such treatment, the sun-dried “sweet” seeds are stored until required, at which time they are boiled until soft, changing the water once during the process. The resulting food is usually eaten with oil and salt. Alternatively, seeds are ground to a flour which is consumed in the form of kisra, a flat thin bread popular in Sudan or asida, a local form of porridge. The taste of the final product can be improved by blending with millet or sorghum flour. (D.B. Harper, Eden Foundation)

Anti-Desertification Trials As already noted, aizen’s helps people survive in some of the most desolate, dry, and infinitely difficult regions.¹² Preserving aizen along the Sahara margins could be a first practical step in

¹² For instance, when crops failed in the western Sudan (Kordofan) way back in 1900, aizen fruits were fed to the people and apparently this is what kept them alive in that era before rock stars and airlifts could rush in support from the world outside.

AIZEN BY ANY OTHER NAME

This plant goes by innumerable common names. Aizen (sometimes spelled ayzen) is a Berber word and is the one most commonly used in the literature dealing with West Africa. Other names include mandiarha (Berber); mokheit, mukheit, umkheit (all Arabic), bere (Bambara); ngigili (Fulani). Other common names for the fruit include dilo (Hausa); bokkhelli and kursan (Arabic); gigile (Fulani); tadahant, tadent, tadomet (Tamachek); harrenya (Sonrai); nabedega (More); and nkiandam and diendoum (Wolof).

The genus is named for a French biologist, Louis Bosc (1759-1828). During the French Revolution he was rendered destitute and imprisoned for the obvious crime of possessing a father who'd been King Louis XIV's doctor. In 1796, however, he was reinstated and sent to the United States as his country's consul. There (particularly in North Carolina), he did most of his botany, eventually naming some 600 North American species. Later, when the Swedish botanist Carl Peter Thunberg—today recognized as the "Father of South African Botany"—discovered a new genus of plants at the Cape of Good Hope, he named it *Boscia* in tribute.

reversing the destitution caused by desertification. And the power of this plant is not just stopping expansion of desert conditions; aizen could be a prime offensive weapon for active reclamation of lands that now seem lost.

In this regard, trials with planting seeds and/or cuttings into sand dunes should be carried out. Aizen is commonly the last vegetation left before the desert takes over, so there is hope that it could be the first vegetation in the process of taking the land back from the desert's grasp.

AIZEN RELATIVES

The genus *Boscia* includes almost a dozen species bearing edible fruits of reasonable size in Africa. Various of these species are to be found across the continent. Most of them populate open savanna, but can also form a thick understory in woodlands and dry forests. Possibly all have merits as future foods, but now is the time to focus on the few showing immediate promise. Research to clarify the genetic differences, as well as test plantings to identify different ecological requirements, are particularly suggested. Perhaps cross-pollinations between species will yield useful hybrid products, such as seedless fruits or extra-vigorous trees that grow fast and yield above-average fruit harvests.

Below we highlight two of the better-known aizen relatives.

Boscia angustifolia A. Rich This species, too, is found in the huge belt stretching from Senegal to northern Nigeria, but it occupies an area just to the southward of aizen. It also extends at least as far south as Malawi. In many places it is more common than aizen, and the two are often confused. Although its roots are inedible, people often dig them up in the mistaken belief that they are aizen roots.

Although quite edible, the fruits are bitter. The seeds are cooked and then eaten. Even the bark is supposedly edible. Powdered and mixed with millet flour, it is added to soups or cereals.

The plant is browsed by herbivores, although somewhat reluctantly. Nevertheless, it is a *very* important browse plant for livestock, notably for goats, sometimes sheep. Trees are heavily lopped, especially at the end of the dry season, as a way to keep the herds from starving.

Boscia albitrunca (Burch.) Gilg & Gilg-Ben. (**Shepherd's Tree**) Perhaps Africa's second-best known *Boscia* species, the shepherd's tree or witgat is widespread in drier sections of southern Africa. It is found, for example, throughout Namibia and South Africa, as well as in parts of Angola, Zambia, Zimbabwe, and Mozambique. It mainly occurs in savannas and bushveld. Dubbed a "tree of life," it provides nourishing fodder for game and livestock and water for people. The San, for example, seek out its old hollow trunks for the water they hold. Many African groups regard this tree so highly they forbid anyone destroying it. In times of drought, herdsman cut off the branches or bend them within reach of grazing stock; hence the name "shepherd's tree."

The smooth-skinned, cherry-sized fruits are orange-yellow when ripe. They are rather acrid in taste and have slimy flesh, but are nevertheless widely and eagerly eaten. Although having a short shelf life, they are easily preserved in the form of a tasty jam or syrup. Soaked in water, they produce a sweet drink. Some are also crushed in fresh milk to make a pleasant treat.

Surprisingly, the roots contain sugar...a lot of sugar. In Botswana, they are widely used to make sweet drinks. The bark is scraped off, the inner tissues are pounded to separate the coarsest fibers, and the resulting cassava-like pith dried in the sun. When needed, this white solid is pounded to a powder and boiled with water until it resembles syrup; on cooling and diluting it is ready to drink. The young roots are also roasted, ground, and used as a coffee or chicory substitute.

This attractive plant produces an abundance of small, sweet-smelling flowers. The flower buds may be pickled in vinegar and used like capers. For this reason it is also known as caper bush.¹³

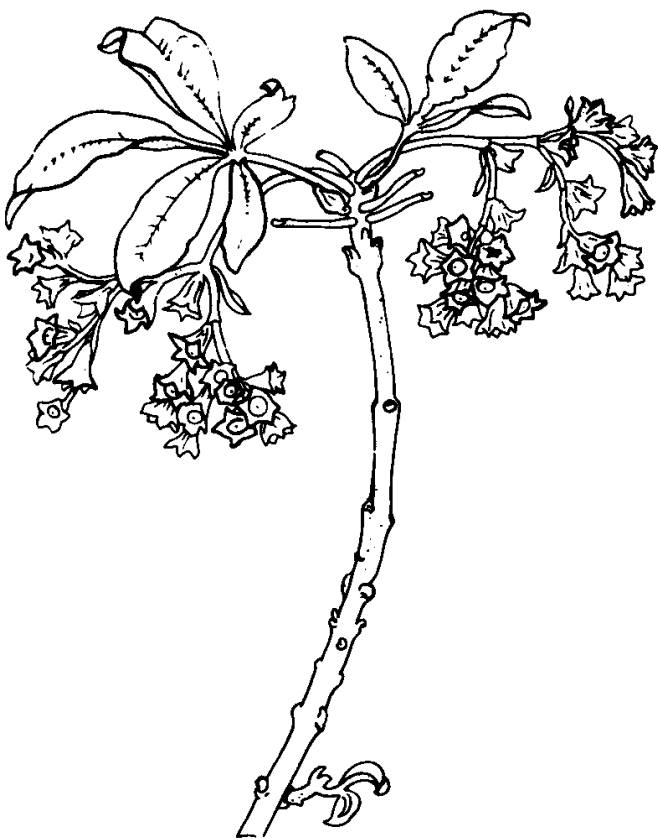
¹³ Both it and the capers plant belong to the same family, Capparaceae.

South African research (carried out by the CSIR's Division of Food Science and Technology) has shown that the root kills fungi well enough to be used to preserve food. Local people have long known this; the use of root slices to keep butter and other foods from molding is of long tradition.

This small tree is important to the lives of millions of domestic and wild animals, especially in drier areas. Cattle, goats, birds, monkeys, antelopes, and even elephants devour the fruits and leaves, which are said to be exceptionally high in protein and vitamin A.

The shepherd's tree might prove useful for supplementing the aizen in the Sudano-Sahelian zone.





Vitex zeyheri

2

CHOCOLATE BERRIES

Of the nearly 70 *Vitex* species found scattered across tropical Africa, at least some are of local commercial and nutritional importance. These small and rugged trees are quintessential wild foods. In season, they become bespangled by an abundance of blackish fruits, which passersby eagerly gather up. Part of the harvest is eaten there and then, but most goes to market for sale. The reason? Although newcomers may loathe the pungent scent and brown stain on the lips, almost everyone loves the “chocolate” flavor.

Unknown beyond Africa, these particular *Vitex* species, from the mint family (Labiatae), are essentially unknown to science too. But they are so useful that without them life would be even harder in many places between Senegal and South Africa. You see, villagers rely on these trees for much more than just fruits. They boil and eat the young leaves like spinach.¹ They depend on the foliage to keep their livestock from starving during the long and trying months when the grass is gone. They use the twigs as chewsticks to clean their teeth. And they visit the trees to obtain medicines.²

Beyond all that, these supremely utilitarian species produce a straight-grained timber resembling teak. It is used for the walls and roofs of houses as well as for furniture, boats, crates, bowls, stools, shelves, and (at least in Uganda) chairs, drums, and knife handles. It also makes good firewood and is said to be good for rubbing together to start a fire by friction.

For all these reasons, these rugged, robust, and resilient woody plants seem excellent candidates for further development and more organized use. They are obviously not solely horticultural resources: their greatest value, eventually, may be not to fruit growers, but to livestock owners and to foresters. For this last, they are especially promising because people eagerly plant and tenderly nurture any quality seedlings supplied. Everyone likes

¹ The resulting food is called dinkin in Hausa.

² This may not be without merit. In 2001, the *British Medical Journal* (BMJ 322:134-7) reported on the effects of extracts from the fruit of the “chaste tree.” In the study, 170 women took this preparation over three menstrual cycles. More than half showed less irritability, anger, headache, and breast engorgement—classic manifestations of premenstrual syndrome. The study’s authors speculate that the tree has hormonal properties and also acts directly on the brain. Its scientific name: *Vitex agnus-castus*.



Central African Republic. A chocolate berry (species unidentified) locally known as mbili. (Roy Danforth and Paul Noren)

having a chocolate berry tree³ around. Some already go out, gather the seeds, and deliberately plant their own. For such reasons, these species likely have exceptional promise in agroforestry and rural reforestation, and they might perhaps become standard components in the mix of species employed to stabilize eroding slopes and abandoned wastelands across much of the continent. Among other advantages is their longevity. These trees are never cut down irresponsibly. Even the wild ones are protected by societal rules.

Those traditional rules have a good social purpose. Almost everyone—not to mention the environment—benefits from the living trees. But certain people benefit more. An example is livestock owners, for whom the trees' ability to stay green far into the dry season has a vital appeal. When grasses shrivel away to nothing these trees, whose roots tap into moisture reserves far below the grass's reach, stay green. That is a feature particularly appreciated by anyone facing loss of livelihood when the fodder runs out.

In addition, the living trees are renowned among honey hunters. The flowers attract bees from long distances. Indeed, beekeepers deliberately seek out the trees and hang their hives among the branches. Furthermore, a hollowed-out chocolate-berry trunk makes a most favored beehive.

³ There is no collective common name for these fruits. "Chocolate berry" has in the past referred only to *Vitex payos*, but for purposes of this chapter we have co-opted the name to refer collectively to the various African *Vitex* species with promise as fruit trees. It is not a perfect match, given that botanically speaking the fruits are not berries but drupes.

Little is presently known of the nutritional contributions, but the fruits seem likely to be excellent foods. In Sierra Leone they are claimed to cure a condition associated with sores at the corners of the mouth and eyes. That particular condition is most likely a nutritional deficiency caused by lack of vitamins A and B.

Despite the baffling dearth of technical data, these are almost certainly promising resources. Having more chocolate-berry trees would likely benefit Africa's many economies, people, livestock, wildlife, and general environment. Anyone developing sustainable agriculture or raising rural incomes or reducing environmental degradation should consider planting, protecting, and promoting these species.

Clearly, appropriate authorities should engage themselves in the process of moving *Vitex* species into greater production. Specific opportunities to advance these small rugged trees are legion. There are, for example, tasks here for sociologists, anthropologists, village leaders, NGOs of various kinds, government researchers, students, professionals, schoolteachers, and more. Building projects around any of these species might involve:

- Making better use of the local wild plants;
- Documenting traditional usages;
- Selection of elite specimens;
- Horticultural development;
- Plant physiology and botanical studies;
- Food technology;
- Nutrition research and feeding trials;
- Marketing and economic development;
- Publicity and promotion;
- New plantings;
- Financial support for humanitarian or environmental benefit; and
- Coordinating cooperation and education through websites or newsletters.

Although all 70 *Vitex* species might be worth investigating, we highlight below 7 seemingly representative examples.

Black Plum Tallest, most common, and best known of Africa's chocolate berries, this tree (*Vitex doniana* Sweet)⁴ produces purple-black fruits that are sweet and mealy. Most of the time they are eaten merely as snacks, but sometimes—notably during the rainy season—they turn into family staples, not to mention profit centers. During that time in Mali—to mention just one country—thousands of women and children go out and collect the fruits to sell in the marketplace. When ripe, the fruits fall from the tree and (because

⁴ Synonyms are *Vitex cuneata* and *Vitex cienkowskii*.



Mature *Vitex doniana* tree near Jinka town, South Omo, in southern Ethiopia. (© Erick C. M. Fernandes, ecf3@cornell.edu)

neither the impact nor the soil dampness does any damage) they are usually picked from the ground rather than from the tree.

Black plum grows wild throughout tropical Africa: from Senegal to Angola, including the Congo basin, Sudan, Uganda, and Zambia. It is a much-branched, rounded tree ranging in height from 10 to 25 m. In nature it occurs mostly in coastal savannas, savanna woodlands, and secondary deciduous forests. Though the species is not truly domesticated, throughout West Africa it is found growing in villages. Some of the trees there were deliberately planted, but most were retained when the land was cleared.

Olive-shaped and black when ripe, the fruit has prune-flavored pulp. It can be eaten fresh like plums or dried like prunes. It is also suitable for processing into jams and jellies. A kind of black molasses as well as various

sweetmeats are made as well.⁵ The roasted fruit gives a coffee-like beverage.

The fruit, however, is just a beginning of this tree's utility. Indeed, black plum is so useful it has been described as "practically a department store on a trunk." Beyond the sweet-tasting fruits, the young leafy shoots are also popular. They are boiled up and eaten like spinach. The flowers attract so many bees that beekeepers fight over who gets to hang their hives among the branches. The foliage provides fodder for goats, sheep, and cattle. And the tree provides medicines. A bark decoction, for example, is applied to skin diseases and aching teeth, and the leaves are used to treat diarrhea.

To date, little has been done to regenerate this species artificially. However, in preliminary investigations Nigerian researchers have found the black plum propagates easily.⁶ It can be planted by direct seeding (preferably after piercing the hard seedcoat so water can pass through). It can be raised in a nursery and transplanted as seedlings, bare-root or potted. And it regenerates naturally by coppice and root suckers, so that vegetative propagation should be readily achievable. This important step, the critical one allowing superior types to be replicated, is probably the key to this species' future as a fruit crop.

Vitex grandiflora Turcz. Much like the black plum, this West African species is common in deciduous and secondary forests from Gabon in the east to Guinea in the west. It is a shrub or sometimes a tree (to 13 m high) with spreading branches. The yellow fruit, about the size and shape of an olive, turns jet black when ripe. Although the pulp is thin, it is made into sweetmeats like those made from the black plum. In Lagos, and probably elsewhere, an alcoholic beverage is made from the fruit. Aficionados liken it to Caribbean rum.

Termite resistant and durable, the wood is valued for making houses, drums, and utensils. It finishes well and has at times been exported to Europe as a top-grade cabinet wood.

Vitex simplicifolia Oliv. A small tree reaching not much more than 5 m, this West African species⁷ is common in savanna forests of Ghana, Mali, Togo, and Cameroon, and is to be found as far to the east as Sudan and Egypt. The flowers are greenish and violet. As in related species, the fruit is olive sized, purple-black, and cupped in a calyx like an acorn. The thin pulp clings to the stone, which contains 3 to 4 seeds. The leaves yield an essential oil of such sweet and penetrating fragrance that it is recommended for commercial development.⁸

⁵ In Hausa, these sweets are known as alewa.

⁶ Propagation by budding is successful. Information from J.C. Okafor.

⁷ This species is also known as *Vitex diversifolia*.

⁸ Information from J.C. Okafor.

Vitex payos (Lour.) Merr. These fruits, the “real” chocolate berries, are very popular in parts of southern and eastern Africa, from roughly Mozambique to Tanzania. Zimbabwean villagers are said to collect them in quantity every winter.⁹ Each fruit is about 2 cm long, with pointed tips and a chocolate brown or black skin. The juicy pulp surrounds a single hard stone. However, it is definitely an acquired taste. Westerners are typically offended by the flavor, the powdery texture, the oily mouthfeel, and the strong smell. But even then not all is lost: Since 1990, Zimbabwean entrepreneurs have been making jam from the fruit and selling it in the city markets.

The low-growing tree is attractive enough to have promise purely as an ornamental. In full flower it becomes bespangled with myriad flowers, which, set off against the gray of the wood, attract both attention and praise.

This is another *Vitex* that has received some horticultural exploration.¹⁰ Its woody seed has proven reluctant to germinate, but one method for overcoming this natural resistance is leaving seeds out in the open for a year then nick the end where there are two holes. Trees grow slowly during the first three years in the nursery, but then growth speeds up.¹¹

Vitex madiensis Oliv. This similar but smaller tree (5-10 m high) occurs from Senegal to Uganda and from Uganda to South Africa. Nowhere, however, is it common. Indeed, everywhere it is rather rare. Most specimens are found in open woodlands. In season, black, egg-shaped fruits dangle from the branches on long stalks. Their smooth and transparent skins enclose a black pulp that is exceptionally popular among all those who know it. The fruits are commonly harvested and sold by women in local and regional market, as are the leaves and roots, which are used in medicine.

Because of the social and economic importance of *Vitex madiensis*, it is considered a top species for local agroforestry. Recent horticultural research to understand the species and identify, select, and reproduce elite types for local growers is showing good results, especially documenting reliable vegetative propagation techniques such as rooting and air-layering.¹² Similar “domestication” research on other *Vitex* species, indeed on “lost” African fruits in general, could quickly advance them from obscurity, and could be accomplished with little expense by horticultural workers across Africa.

⁹ “Around Bulawayo you get *Vitex isotjensis*, *Vitex mombassae* and *Vitex payos*,” writes our contributor Ray Perry. “The last is the best. It is sold in the markets and is among the most popular indigenous fruits.”

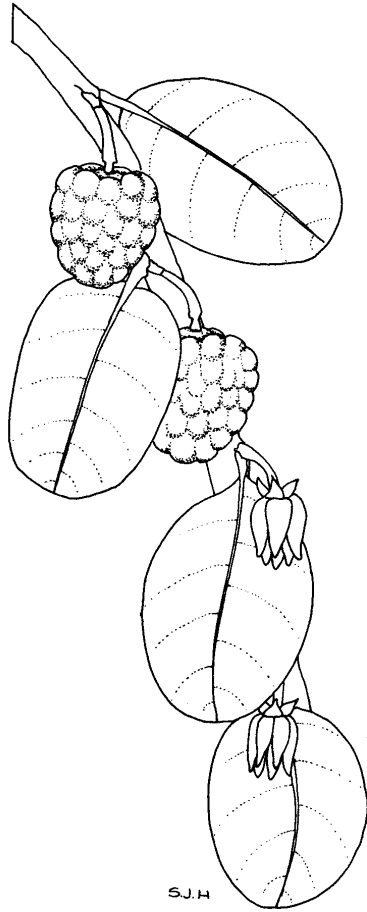
¹⁰ Information from Ray Perry, who adds that care must be taken because the seedlings are easily over-watered.

¹¹ Information from Ray Perry.

¹² Mapongmetsem, P.M. 2006. Domestication of *Vitex madiensis* in the Adamawa Highlands of Cameroon: phenology and propagation. *Akdeniz Üniversitesi Ziraat Fakültesi Dergisi* 19(2):269-278.

Vitex mombassae Vatke In East and southern Africa, the ripe fruits of this species are picked by the wayside, eaten in homes, and even sold in markets. They are borne in profusion and are eagerly sought. It has been said that Pedi women willingly donate a day's work for permission to gather *mphu* from a farmer's property. The fruits are eaten fresh but are also boiled up into a sweet, black concoction used at least in part for strengthening and flavoring tobacco.

Vitex pooara Corbishley Another southern African species (or perhaps the same as *V. mombassae*), this tree is typically 4-5 m. tall with small, violet-hued flowers. The fruits are 2 cm long, very dark purple or black when ripe, and the calyx may enclose half the fruit. In South Africa's Waterberg region the fruits become so plentiful in season they constitute an important part of the Pedi diet. One drawback is that the juice may stain the mouth; after eating these chocolate berries everyone has black lips.



S.J.H.

3

CUSTARD APPLES

The food markets of tropical America routinely exhibit a number of large green premium fruits whose soft and delicious pulp is likened to fruit-salad from a tree. Various known as “sops” or “custard apples,” these attractive greenish globes include soursop (guanabana), sweetsop, custard apple, sugar apple, cherimoya, and bullock’s heart. In recent decades these delicacies have been planted ever more widely and certain ones have turned into popular commercial products in locations far beyond their ancestral home, including Europe, the United States, and Australia.

What is not well known is that this famous fruit family (Annonaceae) has African members as well. These, however, are little studied and are not well understood even within their natural habitats. Now they deserve the same kind of attention as their botanical brethren across the Atlantic. One, the African custard apple, has been called “the best indigenous fruit in most parts of tropical Africa.” Another, the junglesop, produces probably the biggest fruits in the whole family—as long as a person’s forearm and as thick as a person’s thigh. A third—perhaps the strangest of all—“hangs like a bunch of sausages,” each fruit a bright scarlet link. At least two more produce small tasty fruits that make people’s mouths water at just the remembrance from a long-ago childhood. And this group includes a tangy fruit borne on a plant so strange that it barely rises above ground level.

This is a good time to investigate these unusual fruits. Their American relatives, especially the highland cherimoya, are rising in horticultural importance throughout many parts of the world. And crosses between different species are creating hybrids that appear to have their own attractive futures. Clearly, the African counterparts should now join in this march of culinary progress.

Scientifically speaking, Africa’s annonas are so neglected that their genetic variability still awaits discovery and description. Fruits of above-average in size and excellent taste exist in abundance. Gathering those should be a priority. Types with few or no seeds are known, and should also be sought. Certain plants also show other useful genetic traits. Some, for instance, grow upright while many others sprawl.

In addition, hybrids between the African species and their American relatives may well produce brightly colored, larger fruits with few (or

perhaps no) seeds. Those are genetic qualities that could bring breakthroughs to both sides of the Atlantic.

However, much remains to be learned before anyone can cultivate the African species with confidence. At present, for example, many of the seeds are reluctant to germinate.¹ And some of these species—jungle-sop is an example—take as long as 10 years to produce their first flowers. Vegetative propagation is apparently untried, but experiments along this line seem likely to overcome the delay as well as several other practical difficulties.

All in all, then, these inter-related species comprise a great group for Africa-wide collaborations and for both professional and amateur contributions. As with other pre-domesticated species, urgent needs are:

- Making better use of the existing wild resource;
- Documenting traditional and modern usages;
- Collecting different species and types for comparative testing;
- Genetic selection; and
- Horticultural development.

Philanthropists could help a lot. Funding any of these steps would immensely speed up the process of bringing these crops to modern life. Progress and satisfaction will not even be notably expensive.

Notable interesting delights among local custard apples are described below.

AFRICAN CUSTARD APPLE

Best known among the indigenous annonas, African custard apple (*Annona senegalensis*)² produces fruits that smell like pineapple and taste like apricot. Found from Senegal to South Africa, the tree is a surprisingly common companion to thousands of villages. People everywhere go out of their way to preserve a few trees around their houses or in the fields where the crops grow. But for all that, this species has never been awarded serious agronomic attention.

If now given horticultural help, the African custard apple will likely become planted quite intensively and its fruits will become better foodstuffs, far more widely eaten and far more widely sold in local and city markets than they are today. As a result, the crop would contribute substantially to Africa's future nutrition, not to mention its overall rural economy.

¹ "Despite many attempts," write our contributors Roy Danforth and Paul Noren, "we have been unable to germinate *Annona senegalensis* seeds except about two plants out of thousands of seeds."

² This plant's botanic name is in dispute. The full formal name is *Annona senegalensis* Auct. Another name often cited, but apparently in error, is *Annona senegalensis* Pers. Some taxonomists denote the plant as *Annona chrysophylla* Boj.



The African custard apple tree is a surprisingly common companion to thousands of villages from Senegal to South Africa. Resembling its more famous American cousins, the fruits smell like pineapple and taste like apricot. (Paul Latham)

In its present unselected state, this local custard apple is smaller than its American counterpart. Also, its pulp is packed with many pale brown seeds. Despite that, however, ripe ones are very attractive with bright colors and tasty flesh. In appearance, these fruits are lumpy skinned, roughly spherical, yellow to orange in color, and fleshily soft to the touch. They are best picked before achieving full ripeness and stored in a warm, dark place to ripen slowly out of reach of the sun.

The tree bearing these fruits branches so prodigiously it is usually hardly more than a shrub. Under exceptionally favorable conditions it may reach 8 m, but more often is only 3 m tall. It has large leaves and is deciduous. Although distributed throughout tropical Africa (Senegal, Congo, Sudan, Kenya, Zambia, Malawi, Zimbabwe, and Mozambique, for example), it clearly possesses at least modest cold tolerance. It occurs, for instance, in subtropical parts of South Africa, reaching its southern natural limit on Natal's north coast.

Ecologically, the plant appears best suited to warm-but-not-hot conditions, as well as to fairly moist environments (probably those where annual rainfall exceeds 750 mm). In nature it tends to occur in mixed woodlands and open savannas. It also seems to favor sandy sites; indeed, in the wild, it is commonly found on deep sands. However, it also readily colonizes rocky outcrops.

In addition to its own promise, the species may also benefit its better-known American relatives in at least two ways. For one, smaller seeds could

perhaps be induced in the popular cherimoya or soursop through creating hybrids from them using the African custard apple as a pollinator (it produces pollen prodigiously). The African custard apple may also make an excellent rootstock for its relatives. The fact that it likes deep sandy soils suggests that its roots plunge deep and downward, a feature of special significance in conferring drought resistance.

The plant has seldom been tested outside Africa, but there is a reference to it growing in Brazil. According to this report, it has become well established especially around Minas Gerais, Bahia, and Espirito Santo.³

Beyond its fruits, African custard apple could have other important local uses. Various parts of the tree are renowned for providing medicines. In Swaziland, for instance, the bark is used to treat open sores.⁴ And there may be merit in using the leaves against lice and other skin pests because other members of this genus are known for their lethal effects on insects.

JUNGLESOP

The junglesop (*Anonidium mannii* (Oliv.) Engl. & Diels)⁵ is a medium sized tropical African tree bearing the fruits that are almost as long as a person's forearm and as thick as a leg. Typically these giants weigh between 4 and 6 kg; they are often as big as jackfruit (the world's biggest fruit). Despite being more than half a meter long, most of those seen today are not fully rounded out because of inadequate pollination.

Although a rarity, the plant is very popular where it occurs. In the Central African Republic, for instance, people reportedly pay up to two days salary for a single junglesop. And special trips are organized to collect the fruits during the season.

This fruit's tough and leathery brown skin has a surface patterned with raised diamond-shapes. About four or five days after picking, the fruit softens and can be easily broken open to expose the soft, yellow-orange flesh inside. In some varieties this is deliciously sweet and very good to the taste; in others, it can be not only sour but downright awful. Just how mature the fruit was when picked can affect the sweetness, but genetics also plays a part, and locals know individual trees that are always sweet and others that are always sour.

As in most annonaceous fruits, the flavor is rich—but in this case it is sometimes so rich that a person cannot eat more than a few bites at a time. But apparently not everyone is so inhibited: People in northern Congo, for

³ Cruz, G. L. 1979. *Dicionario das Plantas Uteis do Brasil*. Editora Civilizacao Brasileira S.A., Rio de Janeiro. The plant is locally known as araticum da areia. The fruit is described with a rougher surface and much bigger than in Africa; it may be an elite germline but could also be a hybrid or even a variation of some other *Annona* species.

⁴ Information from Harry van den Burg.

⁵ Previously known as *Annona mannii*. Information in this section came especially from Roy Danforth and Paul Noren.



Bangui, Central African Republic. In this area, custard apple trees are a common accompaniment to rural houses. They are beloved for the deep shade they provide as well as for the quality fruits that are tasty and salable in the market. (Roy Danforth and Paul Noren)

instance, say that five hungry men can completely fill their stomachs with a good-sized junglesop!

Although (or perhaps because) this is a common tree in some of the Central African rainforest, people have so far failed to develop it as a crop. Attempt after attempt has come to nothing. Part of the difficulty lies in fungal diseases that attack the plants. Today, these problems can probably be

overcome by careful selection of growing site and perhaps other techniques such as grafting onto resistant rootstocks or the judicious use of fungicides.

Although essentially unknown outside Central Africa, individual trees now can be found in southern Florida, Hawaii, Malaysia, and northern Queensland (Australia). All are young, but each is growing well. This indicates possibilities for a better international understanding of the species, its management, and its fruit.

GROUND SOP

This plant (*Annona stenophylla* Engl. & Diels) is a dwarf of the family. Indeed, it is so small it bears its fruits literally “on the ground.” Nonetheless, those low-borne fruits rank high in people’s esteem. They are said to be better eating than even the African custard apple. A southern Africa native, it is found in northern Botswana, northern Namibia, Zimbabwe, and Mozambique. Despite the plant’s diminutive size, the fruits are large. They are yellow or reddish orbs crammed with pumpkin-colored flesh. They are said to be tasty, and people eat them raw, cooked, or preserved. In the diets of those living in the semi-arid northern areas of Botswana and Namibia, ground sop becomes almost a staple during the season.

OTHER SPECIES

Other African Annonaceae yield edible fruit delights as well. Nothing much can be said about them because as of now they are among the most obscure resources in the world. Essentially nothing has been contributed to the scientific literature describing their qualities and promise. Despite that neglect, however, these seem to have qualities that make them worth exploration and perhaps exploitation. They include the following species.

Baboon’s Breakfast This plant (*Hexalobus monopetalus* (A.Rich.) Engl. & Diels)⁶ is a shrub or small deciduous tree (2-8 m tall) found throughout tropical Africa—as far north as Senegal and Sudan and as far south as Gauteng in South Africa. Its small, oblong fruits are scarlet when ripe and sometimes are patterned with green-veins. Inside is a juicy white pulp that is eaten fresh or in the form of jam (said to be delicious). Fresh, they have a pleasantly acid taste. The seeds are sometimes separated, dried, and employed as a spicy condiment. The cluster of oval scarlet to orange fruitlets, each about 5 cm long, are borne in a single flower. According to one report they taste like the red, sweet ‘Satsuma’ plum, and are much sought by local people, not to mention myriad animals. In nature, the plant grows in open woodlands in dry regions as well as reasonably well-watered ones. It therefore seems quite adaptable.

⁶ It is known as shakama plum (from the Shangaan name in South Africa) and, in Zambia, as mkandachembele (N); Bambara names include sama-bolokoni (elephant’s little toe).



Junglesop produces probably one of the world's biggest fruits—as long as a person's forearm and as thick as a person's thigh. Like America's custard apples, especially cherimoya, this one is sweet and soft. Clearly, this and the other African custard apples should now join this culinary wave that is lifting other custard apples in horticultural importance in several parts of the world. (Roy Danforth and Paul Noren)

Elsewhere in tropical Africa are found the botanically related *Hexalobus senegalensis* A. DC (a savanna species) and *Hexalobus crispifloris* A. DC (a forest species). Both also offer good fruits, and people like having the trees around. The latter species is abundant in Cameroon cocoa plantations, “undoubtedly the result of effective conservation, enrichment planting or other type of human intervention,” notes an FAO report.⁷

⁷ van Dijk, J.F.W. 1999. An assessment of non-wood forest product resources for the

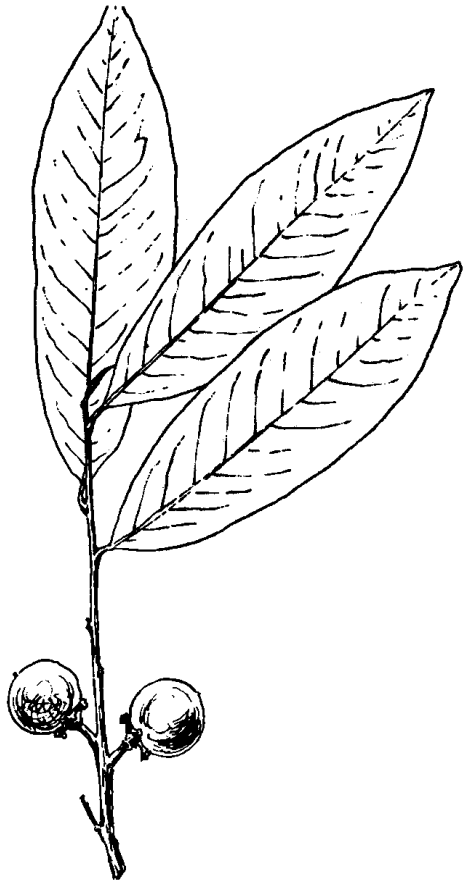
Dwaba-Berry The dwaba-berry (*Monanthonotaxis caffra* [Sond.] Verdc.) is a climber, shrub, or small tree (up to 3 m) that occurs in evergreen forests and nondescript scrub in eastern South Africa, Lesotho, Swaziland, and Mozambique. Its small, flask-shaped fruits come in clusters. Yellow at first, they ripen to a very bright red. Most are eaten fresh and have a slightly acidulous flavor. Among the wild fruits of northern KwaZulu (South Africa), these are a favorite of the summer. In Swaziland, fibers stripped from the bark are made into baskets or even woven into a cloth (traditionally used for burial shrouds).

Monkey Fingers The so-called Monkey fingers (*Friesodielsia obovata* [Benth.] Verdc.)⁸ is the fascinating fruit that “hangs like a bunch of sausages” from a single flower of a small tree. The individual fruitlet fingers are bright scarlet, fleshy, and tart. They are eaten fresh or stewed or cooked as a tasty jelly. Some are fermented into wine. A fruit of such strange shape and such bright color seems likely to create great interest in the modern upscale marketplace, whatever it tastes like.

development of sustainable commercial extraction. In T.C.H. Sunderland, L.E. Clark, and P. Vantomme, eds., *Current Research Issues and Prospects for Conservation and Development*. Food and Agriculture Organization of the United Nations, Rome.

⁸ A synonym is *Popowia obovata* (Benth.) Engl. & Diels.





Diospyros mespiliformis

4

EBONY

Ebony trees (*Diospyros* species, Ebenaceae) are renowned worldwide. Their black, rock-hard wood is perhaps the smoothest, shiniest, and most beautiful of all. It is almost a precious material, sometimes sold by the gram like gold. But *Diospyros*, the generic name for these plants, actually means “fruit of the gods,” and outside the tropics ebony species are renowned for the persimmon. Originally from China, persimmon (*Diospyros kaki*) has for centuries ranked among the most prized fruits in certain areas, notably Japan and parts of Europe. Now it is gaining a more extensive following, with commercial production rising in the United States, Europe, Israel, and elsewhere. Thanks to genetic selection, airfreight, and advanced materials, an international trade in this fragile fruit is now beginning, with Israeli persimmons flying first-class all the way to Europe and the United States.

Almost unappreciated at present is the fact that most species in this genus are tropical, and that the species of Africa, Southeast Asia, and the Americas also bear fruits. Typically, those fruits are yellow, red, or purplish in color, about the size of golf balls, sweet and tasty, exceptionally abundant, and widely enjoyed. Examples include the black sapote (*Diospyros ebenaster*) of Mexico and the velvet apple (*Diospyros discolor*) of the Far East.

Although hardly anything is known about Africa’s ebonies as crops, their long-term prospects could be good. These counterparts of the persimmon seem adaptable species; occurring from dry to humid zones all across the continent, from Senegal to Sudan and from Sudan to South Africa. This suggests that various ones could in the future be grown more widely too, and not only as scattered village trees but also as densely planted stands.

For agroforestry projects, African *Diospyros* species could be especially valuable. They are trees people know and love. As long as planting materials of superior types are supplied, millions are likely to plant them spontaneously and protect them from harm. Even now, volunteer plants are well cared for.¹ Indeed, these African ebonies could become valuable not only for individual plantings but also for bordering streets and highways, for fencelines, for village plots, and for small-scale entrepreneurial endeavors (care should be taken when introducing ebonies to new areas, however, as

¹ This is true of *D. mespiliformis* in Namibia, for instance. Information from P. du Plessis.



Jackal berry tree, Kruger National Park, South Africa. The best known and most developed ebony-fruit species, the jackal berry (*Diospyros mespiliformis*) is typical of the group. Its black, rock-hard heartwood is used for carvings, but locally it is more renowned for its fruits, a popular favorite. (Willem van der Merwe)

some species may be invasive of open ground.). In certain areas ebony forests might be established as food reserves, which would likely be an excellent way to obtain local cooperation for planting and protecting both trees and land. In the long run, however, the very valuable wood could be the greater financial prize.

Despite their domicile in the wild, African persimmons are particularly enjoyed. For marketing on a large scale, they are suitably sized, attractive to look at, and appealingly sweet and succulent. They are, however, very soft and delicate. And this fragility is at present the biggest—perhaps only—thing limiting their advancement into big time food resources.²

These fruits are versatile. Most are eaten fresh. Many are eaten dried. Some are pulped and incorporated into sauces. A few are reduced to concentrate, sometimes sold in frozen form. Others are incorporated into

² “They are virtually impossible to transport fresh,” wrote one of our contributors, “but they dry very well.”

porridges, toffees (called ma'di in Hausa), fermented drinks, and even a distilled liquor, "ebony brandy."

They also help save lives. People keep the dried fruits as a reserve for use following the end of the farming season, a period when food often runs out. But even then ebony is much more than a famine food. Africans often consider this local version of dried apricot much better than the real thing.

As far as nutrition is concerned, little is known with certainty. The fruit pulp consists largely of water and carbohydrates, with small quantities of minerals for good measure. Details of the vitamin content are so far unreported, but the pulp can be expected to be a source of vitamin C, with perhaps 25-50 mg per 100 grams. Interestingly, like apples, commercial persimmons have more vitamin C in their skin than in their flesh. That skin can have more than four times the already substantial amount it encloses. In addition, the skin's bright red color likely reflects the presence of lycopene, a nutritionally important carotenoid found in tomatoes.

Fruit pulp is not the only useful resource these trees confer. Others are:

Seeds Seeds are said to be edible, but this seems to depend on species, and does not apply, for instance, to *Diospyros mesipiliformis*.³

Foliage The leaves are used as animal feed.

Bark In some species a bark infusion yields a dark blue dye for coloring cloth. Also, the injured bark exudes a gum, useful as glue.

Wood The world famous fine-grained black or dark-brown heartwood is used in cabinetwork and carving. Because of its termite resistance, it has long been employed for posts in house construction. More valuable personal uses include tool handles, pestles and mortars, and small dugout canoes. Most valuable of all is ebony's use in sculpture and crafts, for which it sells by the gram. In the past, some was burned for firewood and charcoal, a phenomenon now almost unthinkable.

PROSPECTS

These plants are quite versatile and adaptable. The limitations on ebony-fruit enterprises lie mostly with the softness of the fruit. Just which zones within Africa are best for ebony-fruit enterprises is today a guess. Possibilities are:

³ According to contributor Harry van den Burg, the roasted seeds of *Diospyros whyteana* make a surprisingly good substitute for coffee.



African ebony fruits under development as an orchard crop in Israel. These persimmon counterparts could in future be widely grown both as scattered village trees and also as densely planted stands. Although hardly anything is known about Africa's ebonies under cultivation, their long-term prospects as fruit-and-timber resources could be good. The sale of fruits would support the annual maintenance costs and perhaps provide income during the long years in which they are laying down their heartwood, which is so prized by artists it can be sold to the world in small select pieces. (Yosef Mizrahi)

Humid Areas Excellent prospects. Because most African ebonies hale from the humid lowlands, hot and steamy sites they would seem to offer excellent prospects, perhaps even in sizeable plantations. Also possible is the concept of "salvation farming," in which threatened native forests would be endowed with economic value by organized harvests of sustainable forest products, including ebony fruits. The importance of this lies in the fact that forests producing food and income have a better chance of being spared the match, machete, or chainsaw.

Dry Areas Modest prospects. Clearly, Africa's most desiccated zone will never be prime ebony fruit country, but the Israeli experience indicates that good production might be achieved in certain dry areas, especially if a little irrigation can be found. Forestry and agroforestry projects throughout the savanna region should consider incorporating at least a few of these trees into their testing programs.

Upland Areas Doubtful prospects. The potential for Africa's ebony fruits for Africa's highlands is untested. It will depend on species, latitude, and altitude, as well as site orientation and consequent exposure to cold. At the very high zones of Ethiopia, for instance, potential is likely to be zero. But at lesser elevations across the continental uplands, it could well be excellent.

NEXT STEPS

Now is the time to reconsider these species. Given horticultural selection, ebony fruits may prove just as appealing to tropical Africa as the persimmon is to the temperate world. Foresters, pomologists, and interested plantmen and plantwomen throughout Africa could probably develop the native persimmons into important crops without massive expenditures or major governmental interventions. But to achieve any sweeping success will take teamwork among persons with differing skills.

For one thing, plant-nursery workers and others skilled in propagating plants are urgently needed. Vegetative propagation has not yet been reported, but is probably not difficult to accomplish. In the wild, the trees regenerate by coppice and root suckers as well as by seed. Older seed has a built-in dormancy, but that is easily overcome with hot water treatment. Although seedlings grow slowly at first, they later elongate rapidly. Apparently, they can be transplanted into forest clearings, but, due to their slow early growth, need a lot of weeding.

Foresters could also contribute. Ebony is not only ranked among the world's finest woods, it is also already often associated with Africa and Africans. So far, however, there have been few, if any, attempts to produce it in plantations. Largely, this is owing to the trees' perceived slow growth and the expectation of a financially devastating delay between planting and harvesting. But all this may change if annual crops of valuable fruits can be harvested during the years the trees are maturing to timber size. With some testing—as well as with some cleverness or luck in selecting compatible sites and planting materials—these plants could well prove faster maturing than is now anticipated. Indeed, evidence suggests that this might be true even now. *Diospyros lycioides*, for instance, is an ebony bush bearing heavy crops of pleasant fruit that grows fast.⁴

The skills of food scientists are also needed. Harvesting and handling these fragile fruits is an especially uncertain topic. In general, the trees flower in the rainy season and ripen their fruits in the dry season. In humid lowland forests fruits ripen about 6-8 months after flower fertilization, but in hot, dry woodlands they ripen much faster. Although the ripe fruits are usually collected from the ground, they may be picked from the tree.

⁴ In Swaziland the rate under good conditions is half a meter a year or more. Information from Harry van den Burg.

Anthropologists and others interested in traditional cultures could do much to help. The different species, different traditions, and different experiences with these fruits in various parts of Africa are uncollated. Someone should pull together a corpus of continent-wide knowledge. Important insights into the propagation, horticulture, harvesting, handling, and processing of the different species will be gleaned from such work.

Non-specialists can help as well. One necessary step is to gather germplasm in the different and varied regions where the ebony fruits grow, a task perhaps best done by those residing in the remote rural regions. Another interesting approach is to convene contests for the biggest, sweetest ebony fruits. People who are observant and adventurous are likely to respond eagerly. Thus, there are likely to be many budding winners, whose germplasm could be of benefit to all Africa.

Although individuals throughout Africa need to contribute their time and talents to the selection, propagation, and other studies of the ebony fruits, the development of these crops could also be a good topic for voluntary and economic-development assistance from Japan. Its experts and expertise on the horticultural development of Japanese persimmon might well provide a key to quickly achieving the potential inherent in Africa's own counterparts.

However, horticultural improvements will not occur overnight and much scientific groundwork remains to be done. All in all, there's much to learn about means for maximizing these plants fruit production. Examples follow.

Fruit Quality One prime task is improving fruit quality, especially the strength of the skin. This is vital for making African persimmons suitable for mass markets. Superior types already exist, but they are scattered throughout the continent and their whereabouts is unrecorded. They need to be located and vegetatively propagated. Disseminating planting materials (such as scion wood) of these will give the crop a chance in exploratory production and perhaps even commercial-scale ventures. Overall fruit-quality features to consider include hardness, shape, size, color, general appearance, skin thickness, skin strength, pulp-to-seed ratio, and tannin levels.

Fruit size is a straightforward target for selection. Today's African ebony fruits are much smaller than a persimmon, but larger-fruited forms undoubtedly exist. These should be plucked from hiding. Fruit-size might also be increased by horticultural or genetic manipulation or by improved management of the trees.

Tannins need to be considered, too. It may seem likely that the immature African persimmons, like those in the rest of the world, will pucker the mouth. But those of the main African species are commonly tasty even unripe. Nonetheless, any chance trees with especially low-tannin fruits should be seized upon.

Genetic Manipulation Hybridization between African species might produce larger (maybe even seedless) fruits. Also, hybridization with the common persimmon might perhaps lead to the betterment of both.

Management Yields at present are low, but this is undoubtedly through lack of horticultural help. Attention should be given to the plants' needs for water, fertilizer, and pest and disease control. Grafting onto rootstock of the same or different species also needs testing, particularly because it might produce dwarf plants that would be easier to manage as food producers.

Handling Chilling requirements for maximum storage, shelf life under ambient conditions, and overall quality control all need determining.

Nutrition The nutritional composition and tannin contents of the various species and major genotypes should be assessed.

Processing Processing is important with these fruits, which are often too soft and squishy to transport, especially in hot weather. Opportunities exist for manufacturing dried and preserved products as well as beverages and prepared foods, including porridges and toffees flavored with ebony fruit.

Marketing Much can be done to better market fruits to consumers in African cities; many will be as new to ebony fruits as Europeans or Asians.

Which of the numerous ebony-fruit species to advance is as yet uncertain. Below some possibilities are highlighted.

JACKAL BERRY TREE

The best known and most developed ebony-fruit species in Africa, the jackal berry tree (*Diospyros mespiliformis* Hochst ex A. DC) is also typical.⁵ An evergreen or semi-evergreen, it reaches 15-20 m tall in drier zones and up to 45 m in humid forests. Mature specimens have dense, wide-spreading, rounded crowns with trunks that are sometimes buttressed or fluted. However, in some regions the plant occurs only as a large, multi-stemmed shrub. It is common in the gallery forests alongside rivers in southern Africa. According to at least one observer, these forests constituted one of the major habitats in which humans evolved. This fruit, therefore, is likely to be one of our oldest foods of all.

Male and female flowers appear on different trees: males in clusters; females solitary. The fruits are more or less round, up to 3 cm in diameter, greenish and hairy when young, yellow or purplish and smooth when ripe.

⁵ Vernacular names are abundant, including mu-koro (Kikuyu) and gughan (Arabic), eenyandi (Oshiwambo), and ngombe.

The pulp of these small fruits is *very* sweet. This is one that is quite tasty even when not completely ripe—it seems remarkably tannin-free for a persimmon. The 4-6 dark brown seeds are oblong, flattish, minutely warty, and hairy.

As for known environmental requirements, they can be summarized as:

Rainfall The tree is generally found in areas receiving from 500-1,270 mm in four out of five years, but grows also in areas with around 300 mm (Chad and Namibia, for instance).

Altitude It grows naturally up to 1,250 m (in Tanzania, for instance).

Temperature In areas with mean annual minimum temperature of 16°C. Seems to grow best in areas with mean annual maximum temperature of 27°C.

Soil The species appears to favor heavy soils, but is not unhappy in sands, loams, volcanic soils, or rocky sands with clay or alluvium.

OTHERS

Yet more ebonies bearing heavy crops of pleasant fruits include the following from southern Africa (often called “blue bushes” in the region):

Diospyros lycioides Desf. This small shrub of central and southern Africa bears reddish or yellow fruit the size of small plums. The pulp is translucent and faintly sweet.⁶ This is the species that grows fast. In Zimbabwe it produces fruit after 4 years, while still in the nursery.⁷ Moreover, its wood is high in quality. Twigs from this species are commonly used as a toothbrush and have been found to contain effective antibacterial compounds.⁸

Diospyros kirkii Hiern In spring this small tree of the tropical lowveld of southern Africa bears sweet mealy fruit (2.5-4 cm in diameter). The fruits are good enough eating and the trees are resilient and productive enough that one writer, after surveying hundreds of wild food plants, considered this species as “perhaps being worth domesticating.”

⁶ “This is a nice fruit,” wrote our contributor Harry van den Burg. “It has three subspecies [here] in Swaziland, and lots of genetic variability that is worth exploring.”

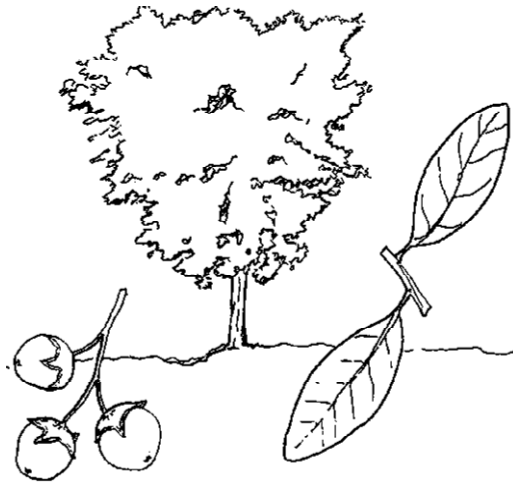
⁷ Information from Ray Perry.

⁸ Cai L., G.X. Wei, P. van der Bijl, and C.D. Wu. 2000. Namibian chewing stick, *Diospyros lycioides*, contains antibacterial compounds against oral pathogens. *J. Agric Food Chem.* 48(3):909-914.

Diospyros batocana Hiern Not all African persimmons are small—this one is apple sized. Those yellowish-orange fruits have a very acid pulp that is said to be refreshing on a hot day.

Diospyros chamaethamnus Dinter ex Mildbr. The inhabitants of Namibia and Botswana (especially San and Okavangos) regard this as one of their most important foods. They say “a man could live on these fruits alone for three months, provided that water was available.” The gelatinous flesh is commonly pulped in water and drunk as a sweet, milky beverage.

Diospyros pallens Thunb. Southern Africa. According to one account, local fans can eat at one sitting as much as a kilo or two of these red fruits, which when fully ripe taste like raspberries.





Parinari capensis subsp. *capensis*

5

GINGERBREAD PLUMS

Within the vast stretch of territory between Senegal and Madagascar there exist a number of interrelated wild fruits (*Parinari* or kindred genera) with very agreeable strawberry-like flavors. Usually red or yellow in color, these plum-sized delicacies lack the sourness typical of wild fruits (and of plums for that matter). These so-called gingerbread plums can have a texture firm enough to crunch like a crisp apple.¹ Those who love the crunchy sugariness, especially children, consume them in large quantity.

These seem like fruits with a future. They do not bruise easily. Their colorful skins and bright yellow flesh appeal to the eye. Their sweetness appeals to the taste buds. All in all, millions of Africans like them a lot. Indeed, during the harvest season certain peoples rely on gingerbread plums almost as a dietary staple.

These fruits are used in a variety of ways. Many are eaten fresh or are boiled with cereal. Pounded with water, they create a colorful red counterpart to lemonades or orange crushes. And often this refreshing liquid is thickened with flour (from maize or cassava) and boiled into a widely enjoyed and tangy tasting gruel. Fragrant syrups are often prepared as well, and gingerbread plum is also the basis for some drinks that prove much stronger than any fruit squash.

With most of these botanically interrelated fruits, the kernels inside the seeds are eaten too. These somewhat oily “gingerbread nuts” are usually roasted and enjoyed like cashews or almonds. Some are consumed as snacks, others mixed into cooked dishes, and a few are pressed to yield cooking oil.

Beyond food, these trees provide a fairly hard wood that polishes to a bright luster and ends up in prized furniture, not to mention building materials, firewood, and charcoal.

No one has ever attempted to develop the various gingerbread plums into modern and reliable resources, not even to gather together representative

¹ Traditionally, the name gingerbread plum has been applied to a couple of these species (especially *Parinari excelsa* and *Neocarya macrophylla*, see below). We recommend extending that usage as a collective name for all the various *Parinari* and related species with edible fruits. This is not without hesitation: these African delights are far from being soft and watery, and botanically they are only very distant cousins of plums.



Fruits of the “mobola” gingerbread plum are reddish-yellow mottled with gray. They are sweet, delicious, and popular, especially in Malawi, where they are regarded as one of its best wild foods. Trees yield exceptional quantities of fruits, with most eaten out of hand. (PhytoTrade Africa)

specimens for comparative study, grafting, or hybridization. For all that, though, several are already managed in a way that could be called “semi-cultivated.” In other words, farmers spare the trees whenever they clear land and subsequently support the rescued specimens to a greater or lesser extent.

Producing vastly more of these tasty fruits under more organized conditions seems eminently feasible. Seeds are difficult to germinate, but most (perhaps all) *Parinari* species are easily reproduced via root suckers. Whenever exposed or wounded, the roots erupt in a profusion of sprouts, which can be cut off, rooted in sand (preferably under intermittent mist), and used to directly establish new plantings. Root cuttings also provide a key to propagating elite specimens. Through them, superior types could be quickly and easily established across much of Africa: clustered in villages perhaps, or scattered alongside roads in the valleys and tracks in the hillsides.

The following species seem particularly worthy of investigation, intense selection, and efforts at domestication.

MOBOLA

The best known of these fruits, mobola (*Parinari curatellifolia*)² is found in woodlands and tree savannas throughout tropical and southern Africa. It occurs extensively, for example, in Zambia, Zimbabwe, and the lowveld of South Africa. The trees yield exceptional quantities of reddish-yellow fruits, mottled with gray. They are sweet, delicious, and popular. Malawi regards them as one of its best wild foods. Most are eaten out of hand, but some are concentrated into a syrup that is poured on cereal products (the way maple syrup is in North America). Beer is also brewed, and the unripe fruits are converted into a sweet, very pleasant, non-intoxicating beverage (called luzwazhi in Zambia).

In various places the seed kernels are also eaten. These so-called mobola nuts are rich in oil and are considered excellent almond substitutes. They are eaten raw or are added to vegetables, fish, or soups during cooking.

Although the tree grows and matures slowly it is so highly prized that it could have a future as a plantation crop.³ The combination of a tasty fruit and an easily stored nut provides a double attraction for domestication. Although analyses have yet to be done, it seems probable that the nut has considerable nutritional value.

The tree—sometimes known as the “hissing tree” because of the final sibilant groan it makes when chopped down—is almost evergreen and can be as tall as 20 m. This briefly deciduous species has an erect stem, a dense spreading crown, and branches that droop all around. At certain times of the year, but particularly in hot weather, it can emit an unpleasant odor.

The wood is light brown, hard, and borer-proof. While not durable if exposed to weather, it is used for simple building purposes such as poles for huts and sheds. It is also made into mortars for pounding grain. Unfortunately, it contains silica crystals that blunt saws and other cutting tools. Despite being considered a prize source charcoal, mobola is seldom felled for fuel.

These beautiful trees are conspicuous across the landscape of southern Africa and it is easy to understand why one of them was chosen to bear a final tribute to David Livingstone. After his death (on 4 May 1873) his helpers carved a commemorative inscription on the trunk of a fine mobola marking the spot at Chitambo's village in central Zambia where the famous explorer died.

² *Parinari curatellifolia* Planchon ex Benth. (including *P. c. mobola* (Oliv.) R. Grah.), sometimes called mobola plum.

³ One contributor wrote saying, “In my opinion this is the southern African fruit with the greatest potential for domestication. Currently, however, efforts are directed at marula, which I think is inferior in taste and has less yielding capacity.”

SAND APPLE

The sand apple (*Parinari capensis* Harv.) is one of earth's strangest plants: a shrub that grows underground.⁴ In a sense, it can be considered a tree without a trunk: branches pop up directly from the roots. These "root branches" are very short, extending less than a meter above ground.

Found widely scattered over the southern half of Africa,⁵ its weird shrunken tree bears hard, brown fruits about the size of small plums. Even when ripe they are somewhat dry, smelly, and astringent, but to those who know how to handle them they are delicious. The key is to bury them in the sand (hence the name), a process that, during the course of a few days, removes the astringency, hardness, and odor.

Despite its bizarre growth form (or perhaps because of it), the sand apple is highly tolerant of harshness and often grows where other crops prove unreliable. It is, for instance, common on the sandy palm veld of coastal northern Natal, where the watertable fluctuates wildly from one to two meters below the soil surface. Despite that ability to deal with drought, the plant is also found on the edges of marshes and beside seasonally waterlogged depressions.

People in various locations—in the northern Kalahari and Zambia's Barotseland, for instance—eat both the sweet outer flesh and the raw kernel. They also ferment the fruit into alcoholic drinks.

Of the nutritional value nothing is presently known, but it must be quite substantial. Sand apples reportedly can sustain a person, keeping them in reasonable health for about 3 months without any other kind of food. The fruits can also be dried and formed into a soft "cake" that keeps so well it can be safely saved emergency use. David Livingstone often carried dried sand apples, and on one of his travels relied on them as his only food for more than 60 km of hard walking.

ROUGH-SKINNED PLUM

Another of these interrelated species, the rough-skinned plum (*Parinari excelsa* Sabine) is also commonly called gingerbread plum.⁶ It is found throughout both East and West Africa, and is well known, for instance, in both Tanzania and Gambia. It comes in two forms: One, a large tree (as much as 50 m tall) of the moist forest; the other, a smaller tree of open (often riverine) woodlands.

⁴ This strange form of plant has been called "geoxylic suffrutex," a term southern African botanists use for a "tree" with no trunk between root and branch. The colonies are presumably clonal; the mainly underground stems are rhizomatous.

⁵ The plant is best known in Swaziland, South Africa, Namibia, and Botswana. However, it also extends northwards as far as Congo and Tanzania. Two subspecies, *capensis* Harv. and *incohata* F. White, have been designated.

⁶ Also known as kura (Fula), mampato (Mandinka), bulee (Jola), and other names.

The fruits are red or tan in color and are not unlike small plums, but with rough, pitted, and sometimes-silvery skins flecked with brownish to purplish patches. Each contains yellowish flesh enclosing a hard pit.

On ripening, the fruits quickly fall. In wet weather they quickly perish on the ground, but in dry weather they remain in good condition for a week or so. Used as both a snack and a staple, the ripe flesh has a flavor some liken to caramel, others to avocado. The different descriptions perhaps reflect genetic variability, because yet others have written that the fruits are “astringent to sweet, depending on the individual tree.” It is also written that they are much sought by small boys (so they can’t be all bad).

Like the mobola, the rough-skinned plum is at times an important emergency food. It is also employed more mundanely in everyday items such as beverages. For this, the pulp is soaked in water and the resulting sweet liquid filtered off and drunk directly. Sometimes the diluted juice is first concentrated by boiling and at other times it is fermented into intoxicating liquor.

An important timber, this species’ wood is hard and durable and in some areas is sought for cabinetry, joinery, construction, and furniture. It also makes excellent firewood.

In essence, little has been done to regenerate this species artificially. Perhaps that’s because of recalcitrant seeds. Research carried out in Tanzania showed that only a few of the seeds are viable. Actually the researchers, who were at the Lushoto Silviculture Nursery, had a hard time finding any seeds...people and animals gobble the fruits up too quickly for mere scientists. Regeneration by wounding the roots and planting the resulting suckers was judged the more promising propagation method.

GINGERBREAD PLUM

A purely West African species (formerly *Parinari macrophylla* Sabine; now *Neocarya macrophylla* (Sabine) Prance) is another member of this interesting group.⁷ Its mealy fruits are especially loved in Sierra Leone, but are esteemed from Senegal to northern Nigeria, where they can be seen in the local markets. The flesh is soft and yellowish when fresh, with a peculiar flavor sometimes likened to avocado.

As with the other species, the plant is semi-cultivated, and its abundant fruits are normally harvested from the ground. They are used both for casual snacks as well as in formal dining.

The seeds are also important foods. The kernels are made into a spicy sauce, and they also provide the so-called neou oil, which is renowned in Sierra Leone as pomade. The kernels are said comprise 62 percent oil—a

⁷ This fruit is also called gawusa (Hausa), buwell (Jola), and tamba (Mandinka), as well as, it is said by some, rotten plum.

very large amount.⁸ Nutritionally speaking, the oil is of fairly good nutritional quality, with considerable amounts of unsaturated fatty acids.⁹

This species is esteemed for many additional products. The rind from fresh fruits is used to impart a pleasant scent to ointments. The living tree provides villagers with dye, glue, fodder, firewood, soap, structural materials, and even termite repellents (in the Gambia). And the leaves are used medicinally for such things as toothache and mouthwash.

OTHERS

Related species with edible fruits can be found throughout Africa. Whether any are worthy of development as food crops cannot presently be judged, at least from a distance. Examples include:

- *Parinari benna* Scott-Elliot (*Bafodeya benna* (Scott-Elliot) Prance ex F. White). Tree similar to the rough-skinned plum. Guinea.
- *Parinari campestre* Aubl.. Fruits of a pleasant flavor. Guinea.
- *Parinari congensis* Didr. A rainforest tree. Equatorial Africa.
- *Parinari emimensis* Baker. Vandevenona. A tree of central Madagascar.
- *Parinari goetzeniana* Engl. An evergreen rainforest tree growing to a height of 25-50 m. East Africa.

⁸ Dalziel, J.M. 1937. *The Useful Plants of West Tropical Africa*. The Crown Agents for the Colonies, London.

⁹ Hilditch, T.P. and P.N. Williams. 1964. *The Chemical Constitution of Natural Fats*. Chapman and Hall, London. According to an early analysis, it contains 8 percent palmitic, 4 percent stearic, 44 percent oleic, 16 percent linoleic, 1 percent linolenic, and 4 percent licanic acid.



S.J.H.
Parinari curatellifolia



6

GUMVINES

The latex-filled stems of the genus *Landolphia*¹ once produced all the rubber for Senegal and Sudan and some of the rubber for other African nations. Part of the harvest was even exported to Europe, where it was esteemed. Commercial interest in these plants collapsed only when, in the early 1900s, Brazil's rubber tree (*Hevea brasiliensis*) began dominating world production.

The problem was not the quality of the rubber. The African plants were superseded because, being vines or climbing shrubs, they are hard to handle in horticulture. Further, they had never been brought into organized cultivation, and harvesting latex from scattered wild plants cannot compete with organized plantation production, even in the rubber tree itself.

During World War II, when the Allied Powers were cut off from Southeast Asia's huge rubber production, interest in Africa's so-called gumvines picked up once more. However, the wartime crisis passed before much product could be supplied. The subsequent perfection of synthetic elastomers then seemed to forever seal the fate of Africa's own native rubber supply. People gave up on these crops, which have since remained mere curiosities of minor local historical interest.

Now, however, international interest should pick up once more. Some *Landolphia* species bear masses of fruits that are very pleasant to the taste buds. A few of these "gumvine fruits" or "rubber fruits" are yellow and furry and look somewhat like apricots; most, however, are more like an orange with smooth tough skins that are reddish, yellow, or orange in color.

These fruits are frequently seen for sale in markets across West Africa. In Mali, Burkina Faso, and neighboring nations it is also common to see young boys selling clusters of them along the roadways. The juice from these fruits is regarded as extremely healthful, probably with good reason. In addition to a normal nutritional content for fruits, some have vitamin C levels approaching oranges. At least one species, *Landolphia hirsuta*, provides

¹ *Landolphia* taxonomy is tangled, with much overlap among scientific and common names. Further, some botanists transfer all *Landolphia* species to the genus *Saba*, some refer a number of them, including *L. capensis* and *L. kirkii*, to *Acylobothrys*. However, most of the literature is still to be found under *Landolphia*.



Landolphia lanceolata photographed beside a highway in western Congo (D.R. Congo). Boys peddling clusters of gumvine fruits are a common sight across West and Central Africa. The fruits are sweet, juicy, and can provide good provitamin A. Of all Central Africa's fruits these are the ones most commonly offered in markets and along the roadsides. This popular food remains a wild resource, but it holds much promise to help rural peoples produce highly salable products in some of the world's most horticulturally challenged regions. (Paul Latham)

good levels of provitamin A, and all gumvines share the same tell-tale yellowish carotenoid color. People often use them to season rice, maize, and other cereals; to prepare refreshing, lemonade-like drinks; to make a type of beer; and to flavor foods such as fish. In The Gambia, and perhaps elsewhere, gumvine is used this way as a condiment in place of limejuice.

At least 17 *Landolphia* species—perhaps a hundred or more—occur in tropical savannas and forests, notably in West and Central Africa. They are common forest lianas and sprawly shrubs noted for their jasmine-scented flowers as much as for their plentiful fruits or latex-filled stems.

Currently, little importance is attached to the plants as potential income sources. But if they can be tamed and turned to use, tropical Africa will have a collection of new, interesting, and appealing crops that could contribute much to nutrition and perhaps much to economic well-being as well. If particularly good specimens can be located and produced in quantity, there is even the possibility of exports, because these fruits tend to have shelf lives long enough for ocean travel.

All in all, rubber fruits offer good projects for plant lovers and progressive farmers throughout the African tropics. In addition, scholars in France, Belgium, Germany, and Britain could help the cause by scouring the

colonial archives and botanical records for horticultural information recorded during both World War II and the earlier rubber-producing era. This could be most useful because the musty old documents are difficult for outsiders to access today, and the results of all the earlier work are essentially lost to worldview.

Even armed with such information, organizing rubber-fruit production will not be easy. Viney plants are horticultural horrors. They require supports, and their climbing or spreading growth habit makes them hard to manage. Nonetheless, the world's biggest fruit crop (grapes) comes from a vine, as do some fast-developing newcomers (kiwifruit and passionfruit, for example). Adapting management techniques from those (or from vanilla, for that matter) may provide the keys for domesticating rubber fruits.

In this regard, then, pruning, training, and general horticultural improvement should be explored. In addition to using trellises and pergolas, the concept of training these vines on trees should be evaluated. If successful, rubber fruits could raise the economic value of standing forests—thereby dampening the ardor to burn those forests down for land or cut them up for lumber. Perhaps rubber fruits could also help shifting-cultivators by providing food and income while they wait out the weary years for the land to restore itself. In fact, fruits in many other parts of this report might be used for such “fallow enhancement”—both protecting the soil and producing at least a small something to eat or sell on the side.

Other agroforestry interventions should be tested as well. Incorporating gumvines into boundary tree rows, windbreaks, shelterbelts, and *ex-situ* conservation forests are possibilities.² Plants such as these that cling onto something could be a way to increase the utility of many long-term environmental tree-plantings. On the other hand, caution is needed because these vines are vigorous and get to be very heavy if left unmanaged. Indeed, these vines would seem to be ideal wherever dense, interwoven “nets of living vegetation” could prove useful. In village settings they might also be trained along fences, up walls, or perhaps over roofs.

Paralleling such endeavors should also be farmer-participation programs. This is needed because at present farmers offer more insights than science. Their experience together with researchers' training make a uniquely powerful intellectual cocktail for progress. Wild stands are especially appropriate places for local participation. And any efforts to advance gumvine fruits should include *in-situ* conservation to preserve those stands.

Despite all the promise and possibilities, organizing commercial production presents grave horticultural challenges. In the wild, gumvines do not fruit every year, nor do the plants form their fruits all at the same time.

² The process of weaving vines among the trees is already practiced in Africa. An orchardist in Djenné, Mali, for example, plants a thorny climber (*Acacia pennata*) among neem trees to create a barrier to both wind and animals. Malians also plant thorny *Capparis* vines among their trees to equally good effect. Information from D. Osborn.

Also, it is reported that some species take as long as 12 months to mature each crop of fruits.

However, such difficulties probably reflect merely our primitive state of knowledge. Although little effort has been made to propagate the vines, this seems not to be problematic. Freshly collected seed normally germinates well.³ Selected plants can also be propagated via cuttings. Production can be exceptional: Vines yielding 200 fruits have been recorded, and even better specimens undoubtedly await discovery. Indeed, throughout Africa gumvines are renowned for the often-enormous burden of fruits hanging around them on all sides.

Genetic selection and domestication are important for turning gumvines into fruit crops. Finding quality types and developing horticultural methods that speed up production are two keys to success.

Following are gumvines possessing potential as future fruit crops.

RUBBER VINE

The so-called rubber vine (*Landolphia florida* Benth.)⁴ is perhaps the most common gumvine. Its fruits are eaten in many parts of Africa. They are round or slightly pear-shaped and are about the size of grapefruits. Their thick and leathery rind is yellow to orange in color, dusted with a whitish “bloom” at maturity. The inside is full of soft, reddish pulp within which are embedded a few seeds.

The succulent, smooth, and either sour or agreeably subacid pulp pulls away easily from the rind. Normally, the seeds are picked out and the remainder blended with water and sugar. The resulting beverage is consumed either fresh or fermented, and is said to be most pleasant.

The species occurs in lowland rainforests and flourishes on a variety of sites and soils. It is a liana, climbing up the sides of trees as high as 20 m. Its stems are stiff enough to make useful walking sticks, and sometimes they are intertwined between fenceposts to construct corrals capable of holding cattle overnight. Fruits remain on the tree when ripe and can be “stored” there on the vine till needed.

SABA

The saba (*Landolphia senegalensis* (A. DC.) Kotschy & Peyr.)⁵ is an “upwardly mobile” plant of tropical West Africa and the western Sudan.

³ A success rate of over 90 percent has been reported, but apparently the seeds must be clean and fresh; dirty seeds lose viability in just weeks.

⁴ Synonyms are *Landolphia comorensis*, *Landolphia comorensis* variety *florida*, *Saba florida*, *Saba comorensis*, and *Vahea senegalensis*. Common names include rubber vine, aboli, saba du Sénégal (French), and anoma (Ghana).

⁵ A synonym is *Saba senegalensis* (A. DC.) Pichon.

Typically, this woody vine clammers up the fringes of the forest. It is a high climber when trees are available to support its ambition to get to the top, but in more open and dry lands it remains a lowly shrub.

Saba fruits are orange on the outside and pale yellow inside. They have a thick, rough rind. Most are about the size of a medium to small orange. In taste, they are acidic, almost like a strange form of citrus, which they nearly match in vitamin C content. In parts of Africa, they are important to the rural economy, and many are trucked or carried in baskets to sell in the cities.

These colorful treats are, for example, widely consumed in Senegal and the Gambia. They are full of big seeds that are coated with an aromatic sweet and sour flesh. Most are eaten as casual snacks, but some are employed even as a staple—especially during the rainy season. They are also blended with water and sugar and made into fruity beverages. One of our contributors calls them, “fantastic for exotic juice.”

The vines themselves have uses too. They make beautiful ornamentals. And they do more: homeowners even use the almost unbreakable vines to tie down their roofs. In addition, the latex-filled sap is used to mend bicycle tires, football bladders, and so forth. And the long lianas are made into “ropes,” with which to scale trees (for tapping palm-wine, for instance, or collecting nuts).

WILD APRICOT

One of the plants English speakers in tropical and southern Africa refer to as “wild apricot” is actually a native rubber fruit (*Landolphia capensis* Oliver). This sprawling shrub, for example, rambles over rocky ground in South Africa (notably Gauteng). In season, groups are commonly organized to go out and gather the large, yellowish-red fruits on the hillsides and plains. Their tasty flesh can be sucked directly, but the parts immediately around the seeds are very sour. The fruits are also fried or made into preserves, jellies, vinegar, or “brandy.”

Like its relatives, this plant’s stems ooze latex when cut.

WILD PEACH

This strong climber (*Landolphia kirkii*) abounds on rocky, wooded hillsides in eastern and southern Africa (Somalia to South Africa), especially in the high-rainfall parts. In the past it was East Africa’s most important rubber plant. The extracted latex is of good quality: high in rubber, low in resin. It was once known worldwide under the name “Zanzibar rubber” and was a major export of German East Africa (today’s Tanzania).

As a result of past commercial significance, the species was sometimes cultivated. Colonial records contain information on planting, managing, and tapping for latex. Today, the plant is rarely if ever cultivated—and perhaps there is no need as it is plentiful in the forests, where it readily reseeds itself.

EATING ETA



After cracking open an eta fruit one sees the seeds and pulp clinging together in a tight ball, quite loose from the outer shell. People eat this in different ways. Some use a finger, knife, or other utensil to separate the seeds so they can be eaten individually. Others tip back their heads and shake the whole mass into their mouths. Most of us do it that way, swallowing the seeds after swishing the fruit around for just a couple of seconds. Speed is needed because the aromatic sweetness soon turns sour and intensifies until almost unbearable.

We found one eta fruit, however, that never turned sour. Eating it was a whole new experience. Also, the flesh was separated from the seeds, an exceptionally desirable trait. Seeds from this particular fruit were planted at our experimental fruit farm in Congo, but we don't yet know if they too will bear sweet and cling-free fruits.

The point is, a lot of variation is to be found and it might provide many unexpected ways for advancing this crop. (Roy Danforth and Paul Noren)

Fruits of this gumvine are round, speckled, and sized like mandarin oranges. They are popular with those in the know, but their tartness can put off the uninitiated.

GUINEA GUMVINE

Despite its common name, guinea gumvine (*Landolphia heudelotii* A. DC.) occurs throughout most of tropical Africa from Senegal to Tanzania

and as far south as the Congo area or even Angola. It is a characteristic feature of the vegetation on the interior plateaus throughout this vast area. Mainly a savanna and understory shrub, it is often found in open forests and on laterite and sandy soils near rivers.

This climbing vine or spreading shrub once was the main rubber supplier to Senegal, Guinea, and the French Sudan (modern Mali). Some of its rubber reached Europe. A century ago, farmers were encouraged to cultivate the plant in gardens and farms, particularly after the wild vines were so decimated that the rubber supply began dropping. Propagation was both by seeds and cuttings.

The sap is even today used locally to fix bicycle tubes. However, the fruits are now much more important than the rubber. Small (3 cm in diameter), round, and yellow to orange in color, they sell well in markets. The pulp surrounding the seeds is filled with a juice that is regarded as very healthful and is sometimes prescribed as an aid to digestion. Rich in organic acids, this pulp is used as a snack, as a breakfast food, and as a source of refreshing drinks. Beer is also made, and the juice is commonly used to season rice with its sprightly sourness. In some countries—The Gambia, for instance—it is especially important during the “hungry time” each year.

The plant grows under trees and is promising for agroforestry. Farmers are likely to grow it eagerly, whether they really want fruits or not. To them, it is a self-replenishing annual fodder reserve. Goats like the desiccated leaves, and the plants thereby help a farmer’s “cash on the hoof” survive the dry season.

ETA

The eta (*Landolphia owariensis* Beauv.) is found in tropical Central and West Africa.⁶ It grows as a vine in forest; as a shrub in savanna. At the turn of last century it was a major source of rubber produced in Sierra Leone, Ghana, Nigeria, and perhaps other nations as well. Today people make rubber bands out of the cured latex, but this is increasingly rare.

The fruits, however, are widely eaten. They are the size of oranges and have a reddish-brown, woody shell and an agreeable pulp. This pulp is eaten directly. It is also used to season foods and to make tangy fruit drinks and even wine. Typically, the flavor is both sweet and sour at the same time.

Eta is an unusual fruit, but people really like it. Normally, the pulp is merely dumped in water and left to soak a few minutes. Being highly acidic, it makes a lot of beverage. Sugar is added to taste, and the final product conveys a delightful aroma.

The tough and leathery skin is usually opened with a whack of the fist or heel of the hand. (It can be cut open, but latex in the thick outer shell soon gums up the knife.)

⁶ It is also known as abo and Congo rubber.

Seeds and cuttings are the usual means of propagation.⁷ For the first couple of years the plants are slow growing and remain short and stubby bushes, but they then begin elongating and take on the appearance of vines. At that time they are removed from the nursery and planted in the field. If given a chance, this gumvine grows straight up the trunks of trees, making its way to the top of the forest canopy.

The twigs, like other gumvines, are also used as chewsticks.

OTHER GUMVINES

Below are mentioned several other species worthy of evaluation, which should be based on a fruits' qualities rather than taxonomy.

Landolphia petersiana Dyer This little-known eastern African gumvine bears apricot-colored, pear-shaped fruit that some experts consider to have more potential than wild peach (p. 275). It is sweeter, tastier, and more attractive than its better-known cousin, and therefore, they say, more saleable. Its flavor has been likened to guava, but so far no one has done much to explore the plant's crop potential. The fruit is found in essentially the same range as wild peach—from Natal in South Africa through Mozambique and Tanzania, north as far as Somalia. It, too, is associated with tropical forest and bush. The plant is a sprawling shrub or woody liana, with tendrils. Its sweetly scented white flowers are cluster in panicles at the end of the branches. The fruit is more or less round, with numerous seeds embedded in the soft pulp. It is eaten when both ripe and nearly ripe. The ripe fruit is eaten skin and all, but the semi-ripe fruit must be first peeled.

Landolphia ugandensis Stapf This large vine, the source of nandi rubber, is found at elevation (1,200-1,500 m) in Uganda. The rubber is obtained by shaving off slices of the bark and smearing salt water onto the cut surfaces, which then ooze latex.

Landolphia buchananii Stapf Generally associated with forested environments in eastern Africa (Mozambique, Tanzania, and eastern Zimbabwe are reported), this vine bears yellow fruits as big as oranges.

Landolphia parvifolia K.Schum. A plant found mainly on the shores of lakes in Malawi as well as in nearby Zambia, this gumvine bears edible greenish-purple fruits the size of plums or peaches.

Landolphia calabarica (Stapf) E.A.Bruce This gumvine of Ghana has edible fruits up to 10 cm wide and 12.5 cm long. Rubber was once derived from the stems and roots.

⁷ Information from R. Danforth.

Landolphia dulcis var. *barteri* (Stapf) Pichon This pointy fruit, which looks not unlike a cocoa pod, is found in fallowed forest in West Africa.⁸ The roots are renowned for their supposed effectiveness as an aphrodisiac. Recorded in Senegal, common in ravine and gallery forests of moist climate ecozones. Also recorded as a sweetener in Sierra Leone.

Landolphia hirsuta Beauvois is harvested from wild forests in Côte d'Ivoire. A rare nutritional analysis showed that merely three fruits (about 100 g edible portion) provide for almost 2/3 the daily vitamin A requirements of a 7-9 year old child.⁹



Landolphia capensis

⁸ Information from S.C. Achinewhu. The plant is known in Nigeria as mbelekwulekwu.

⁹ Herzog F., Z. Farah and R. Amadò. 1994. Composition and consumption of gathered wild fruits in the V-Baoulé, Côte d'Ivoire. *Ecology of Food and Nutrition* 32:181-169.



Dried fruit and seeds

7

ICACINA

Icacina (*Icacina oliviformis*)¹ is a small, drought-resistant shrub forming dense stands in the West African and Central African savannas. It is remarkable for yielding three fundamentally different types of food: a snack, a staple, and a famine food. In a sense, icacina (pronounced ik-a-SEE-na) is a living grocery store during normal times and an emergency relief-food supplier during hungry times.

Although the plant is essentially unknown to agronomists, horticulturists, or even the technical literature, several million people rely at various times upon its three different products: fruits, seeds, and tuberous roots. The fruits, for instance, are widely enjoyed during the annual harvesting season. Bright red and plum-like, they are sweet and usually consumed fresh. Plants can grow so densely and yield so exuberantly that a family can sometimes collect several hundred kilos of fruits a day even from untended wild stands.

The seeds from the center of the fruits are also edible. They, too, are often plentiful. Dried, they turn rock hard, but then can be stored with negligible loss. In a test in a mouse-infested storeroom, for example, seeds remained untouched during several weeks. This is an important attribute because icacina grows where people lose a lot of food to rodents and insects. However, the seeds contain bitter substances and cannot be eaten directly. They are soaked several days, boiled in new water, dried, dehusked, and ground. The result—a floury solid with a rich, nutty flavor—takes a lot of work to make but it is greatly appreciated, especially where diets are bland staples such as cassava.

The third edible product is a fleshy, tuberous root. Known widely as “false yam,” it resembles turnip or beet but can grow to giant size, sometimes weighing more than 60 kg. The usable portion is about 80 percent starch and a crucial resource during famines. People leave them underground until absolutely needed. The tubers are then sliced and soaked in clean water for several days to soften the flesh and leach out bitter compounds. They are then dried in the sun, pulverized, and sieved. What results is a white, grayish, or creamy-yellow flour. Drying the damp flour in a pot over a fire produces clear, hard “rocks” of what is probably almost pure starch.

¹ *Icacina senegalensis* is also still widely used as the botanic name.

The giant tuber is such a great source of emergency moisture and food energy to the plant that it can survive at least four years without rain. Thus, as long as *icacina* is around food is always available for people too. This rugged shrub is the traditional emergency reserve for use in the absolute worst of times when even pearl millet succumbs.

In better times, however, *icacina* can save lives too. Its fruits ripen as the dry season comes to an end, the very moment when the stores of other foods often run out. In the northern parts of the Central African Republic, for instance, hordes of people each year mount expeditions to collect the fruits and keep themselves fed during the few most-threatening weeks when little else is on hand in the villages.²

Despite its vital value to the hungry, *icacina* has never been fully domesticated or even investigated horticulturally. Nonetheless, it could be produced in far greater amounts. Indeed, it has a future as both a subsistence and commercial crop. The species is easy to grow and is already sometimes cultivated in gardens (at least in Senegal). It is also easy to harvest because the bush seldom exceeds 80 cm in height and bears its fruits near the outside, where they can be reached without difficulty. Even mechanical harvesting seems feasible.

In part, this crop has suffered because of its common name. The words “false yam” confer a sense of illegitimacy. Among the better educated, many consider it a rogue plant...or even a dastardly weed. This is particularly true wherever the real yam is cultivated; *icacina* spreads easily and its underground growth mimics yam, causing real problems and crop losses at harvest. But no one should write off *icacina* hastily. Indeed, in certain areas it might prove to be a better source of commercial starch than the yam itself. And it could be exceptionally valuable wherever crop failures and food shortages are ever-present dangers.

In part, this resource has also suffered because it is a shrub. Although an especially hardy life form, shrubs are generally neglected in development activities. Too big for agriculture; too small for forestry, they fall between the disciplinary cracks. *icacina* is a prime example of how the world misses out on valuable woody resources merely because they have branches where they should have trunks.

Efforts should be made to explore this species’ possibly substantial agricultural potential. Even in the wild, it grows in a natural monoculture; pure stands with over 400 plants per hectare have been recorded. In the exploration of this possibility lie fascinating challenges to researchers, entrepreneurs, and other pioneer movers and shakers. *icacina* perhaps doesn’t deserve massive international efforts, but a few motivated “crop champions” could likely transform this plant and bring to more Africans a new resource and a new level of food security.

² Information from Michael Fay, the individual who has done more than perhaps anyone to draw international attention to this plant and its promise.



The bright red fruit of icacina contains a sweet, sought-after pulp. The seed, after processing, yields a tasty and nutritious flour, as does the tuber. Though always popular, icacina can take on crucial importance during times of famine. This extremely drought-tolerant shrub is easy to grow and is already sometimes cultivated. (Marco Schmidt)

This could be an outstanding life-support species for the Sahel and for the equally drought-fraught areas of Ethiopia, Somalia, and southern Africa.

Upland Areas Potential here is unknown, but perhaps worth finding out.

Beyond Africa

Prospects here are probably low. Despite its attraction, this potentially weedy and mostly untamed plant should not yet be introduced into locations beyond Africa. Even exploratory trials are not justified at present.

PROSPECTS

Success with icacina is uncertain, but could be outstanding. Although untouched by agronomic science, the plant is already widespread and depended on by millions. Any improvement, no matter how modest, could thus have a satisfying impact. To consider icacina as just a weed or fallback crop for the worst of times is quite wrong. People truly enjoy the fruits as well as the seeds, which represent a permanent, reliable, and very tasty food.

Within Africa

Humid Areas

Prospects here are high. The plant grows both in the forest (at least along edges) and savanna areas.

Dry Areas Prospects here are even higher.

USES

As has been noted, the fruits are eaten fresh. They are a particular favorite of children.

The seeds, in addition to roasting, are sometimes dried and pounded into flour, which can be stored for use especially during times of food scarcity.

The tubers, too, are used in the form of flour. Despite the need for processing first, and sometimes a slightly bitter flavor, icacina flour is commonly used to make pastes or porridges. Composed mainly of starch, the flour nonetheless can contain up to about 10 percent protein, a remarkable amount for a root crop—five times that in cassava flour and twice that in potato, for example. It can be stored until needed.

NUTRITION

Owing to a lack of data, there is not much to report here.

Fruits Regarding the fruit's nutritional quality, no basic information is yet available. They are eaten fresh, but are often sun dried as well.

Seeds In one analysis, flour extracted from the seeds was about 13 percent moisture, 72 percent carbohydrate, and 8 percent protein, with little fat (about 0.1 percent) or ash (about 0.5 percent).³ As noted, before they can be eaten they must be soaked to remove somewhat bitter compounds (see Next Steps). Seeds are normally boiled and eaten directly, but can also be redried for further storage or pounded into powder like cassava or sorghum.

Roots The tubers contain about 10-15 percent starch. The starch granules are irregular in shape and size, some spherical and some elliptical, with diameters varying from 12 to 50 microns. Roots, too, can contain toxins unless properly processed.

AGRONOMY

Information on best cultivation practices has yet to be developed. No particular pests or diseases are reported, but this is perhaps only because the plant is so little studied.

The tubers are harvested only when required. Owing to their size and the fact that they can penetrate far below the surface, they are difficult to dig out.⁴ In Senegal yields have been reported to average 2-3 tons per hectare; elsewhere in West Africa yields are reported to reach 20 tons per hectare. For a wild and untended plant, these are remarkable amounts.

³ Kay, D.E. 1973. *TPI Crop and Product Digest No. 2, Root Crops*. Overseas Development Administration, London:

⁴ For this reason the plant has been nicknamed "break hoe" (abub ntope) by the Ashanti of northern Ghana.

LIMITATIONS

Most fruits have only small amounts of pulp.

Both tubers and seeds contain bitter compounds that must be washed out.

Roots are difficult to lift from the soil and their preparation is arduous.

The plant can be troublesome in savanna lands and along roadsides. Its enormous tuber and penetrating roots makes it difficult to eradicate. It is renowned for destroying not only shovels and plows, but people's patience.⁵

NEXT STEPS

Although this life-saving plant deserves much greater recognition, exploratory investigations are mainly what are needed for the moment. Actions likely to provide an across-the-board picture of icacina's practical potentials include those given below.⁶

Extension Support Helping current icacina users is one thing that doesn't need to be approached on an exploratory basis. Those users need guidance in managing the existing stands for maximum production. However, extension services could also develop ways to increase the size and density and productivity of the wild stands. This would help provide the ultimate in food security, not only filling bellies down the decades but also helping save the populace when disastrous droughts arise.

Genetic Selection Knowing any crop's capabilities is fundamental to its future development. But at present no one knows those capabilities for icacina. Thus, there is a need to build a background of reliable knowledge by collecting both knowledge and germplasm, and comparing different features such as fruit size and flavor, seed size and palatability, resistance to pests and diseases, rate of growth, and other important horticultural attributes. From that base of knowledge should arise highly productive and resilient shrubs with shapes (open bottoms, for example) that are best for purposes of weed control, ease of harvest, and general management.

Documenting Traditional Knowledge Because this plant is so new to science but so old to Africans, it is vital to document the methods and practices traditionally employed for handling and using it. That will avoid having to reinvent ancient wheels of knowledge. Even though scientists may not know much about this plant, rural peoples know a lot.

⁵ To remove icacina in Casamance (Senegal), people cut the upper part of the plant and burn the remaining portion at the beginning of the rainy season. But sometimes a portion survives and produces a new shoot anyway. Information from Venceslas Goudiaby.

⁶ In all research activities it should be borne in mind that this plant might become troublesome. The enormous tuber—30-45 cm long and 30 cm or more in diameter with long penetrating roots—requires much labor to eradicate.

Publicity and Promotion This crop has unwarrantedly been dismissed as just a “famine food.” It does serve that purpose, but much of the early literature is filled with misleading inferences that are still repeated to the crop’s detriment. Needed now are actions to break through the “inferior food” image and give the plant the prestige it deserves. Means to this end might include simple activities such as putting out an icacina cookbook, holding contests for best recipes, or serving icacina at prestigious functions.

Plant Physiology and Botanical Studies For proper progress we need to better understand the plant’s physiology and phenology. Such things as pollination and seed set, tuber growth, seed viability, pruning, and possible daylength requirements deserve rapid “agricultural assessment.” Checks of icacina’s environmental limits—climate, soils, altitude, moisture requirements, and the rest—should also be included as part of this general endeavor to build a clearer picture of the plant and its normal needs.

Toxicological Studies Although widely eaten, there exist some safety concerns about the seeds and tubers, at least of some species.⁷ How hazardous, for instance, are the bitter chemicals that are **not** washed out of the seeds and/or the tubers? Are any residues left in the flour? How good does the preparation need to be for safety? Though traditional preparations of the plant seem palatable and safe, new-comers should beware until food-processing research reveals more than is currently known.

Horticultural Development Although the plant is sometimes cultivated, it is only on a very small, household scale. Agronomists should begin experimental trials to determine the main features limiting growth and productivity. These might include trials to see what maximum production levels can be when the plants are fertilized and well cared for in good, deep, loose soils. How does management differ for fruit/seed vs. tuber production? This could include trials on horticultural manipulations such as pruning flowers to remove them as an energy sink and thereby improve production of underground parts. And there should be a check of seed germination, which is a possible difficulty through the seeds having a short longevity.

Moreover, better methods of handling the tubers are also needed. Investigations should be undertaken to assess the promise and pitfalls of

⁷ Extracts from some species have been shown to induce sleepiness and reduce pain in rodent studies (Asuzu, I.U. and I.I. Abubaker. 1996. The emetic, antihepatotoxic, and antinephrotoxic effects of an extract from *Icacina trichantha*. *Journal of Herbs, Spices & Medicinal Plants* 3(4):9-20) but also to contain hydrocyanic acid, phytic acid and oxalic acid—the same bitter principals as cassava, a global staple (Antai, S.P. and G. Nkwelang. 1999. Reduction of some toxicants in *Icacina mannii* by fermentation with *Saccharomyces cerevisiae*. *Plant Foods for Human Nutrition* 53(2):103-111).

mechanized harvesting. Although the giant size of the old roots makes them hard to harvest, those pulled up on an annual basis would be smaller and much easier to lift from the soil. Cassava is also a shrub, so this possibility is not as far-fetched as it may seem.

Nutritional Studies Nutritionists in West and Central Africa should check into local food uses of icacina and evaluate any impacts on nutrition and/or malnutrition. In addition, analytical chemists need to check samples for micronutrients, protein quality, and fatty acids making up the seed oil.

Famine Food Trials Icacina helps those most at risk in drought times. It deserves organized testing in dry zones in various parts of Africa to see how it survives within and beyond its current range. A perennial that produces large quantities of three different foods could be a valuable food-security crop for the most difficult regions and most threatening times. The Horn of Africa—especially Ethiopia’s chronically drought-stricken Ogaden province—comes to mind as a good place to start confined trials.

Food Technology Better methods of extracting starch from the tuber should be developed. Current processes can be extremely wasteful, with sometimes only 10 percent of the raw tuber’s starch being recovered. The root is not unlike cassava; various methods developed for handling cassava and its products could provide invaluable leads. Success might instantly turn this wild resource into a cash crop for regions with few salable materials.

Forestry Perhaps this woody plant could also make a useful firewood crop, with the fruits and roots coming as a bonus. Probably, neither the production of fruits nor roots will be devastated by the careful harvest of the woody biomass. It’s well known that it’s very difficult to eradicate the icacina tree because the plant is constantly refreshed from its deep tuber.

SPECIES INFORMATION

Botanical Name *Icacina oliviformis* (Poiret) Raynal

Family Icacinaceae

Synonyms *Icacina senegalensis* A. Juss.

Common Names⁸

English: icacina, false yam

⁸ A full list of local names is in Fay, J.M. 1987. *Icacina oliviformis* (Icacinaceae): a close look at an underexploited crop. I. Overview and ethnobotany. *Econ. Bot.* 41(4):512-522

French: bankanas

Senegal: furabã, kurabã (Diolas), mǎnkanaso (Mandingue), bãnkanas, ndangam (Wolof)

Gambia: manankaso

Ghana: takwara, abub ntope (northern Ashanti)

Hausa: tankwara

Sudan: Pané

West Africa: basouna

Description

Icacina is a shrubby perennial showing considerable variation in form. At or before the beginning of the rainy season it throws out erect leafy shoots from a large underground fleshy tuber. Its aerial stems can reach almost 1 m in height. The five-petaled flowers are inconspicuous, usually white or cream, and pedunculate on an ascending panicle.

The fruit is a bright-red ovoid berry, approximately 2.5-3 cm in length and 2-2.5 cm in width. It is covered with very short hairs and contains a thin layer of white pulp, approximately 0.2 cm thick, surrounding a single spherical or ovoid seed.

The tubers show considerable variation in size, ranging up to 100 cm in length, with a diameter of about 30 cm. They are typically 50 cm wide and weigh 10 kg or more. They have a thin, grayish skin. The flesh is white and is usually speckled with yellow spots (corresponding to bundles of free xylem). It contains bitter (and perhaps toxic) principles.

Distribution

Indigenous to West and Central Africa, *icacina* is found in the savanna areas of Senegal, Gambia, Guinea, northern Ghana, Benin, Nigeria, Central African Republic, Congo (both), Chad, and parts of Sudan. Even in those areas where it is abundant collections have been scanty, and it likely occurs in many more areas than are now described. Nonetheless, there appear to be three locales of especial abundance: Senegal and Guinea-Bissau, Ghana, and Central African Republic.⁹

Related Species

Although the taxonomy of these plants is not too firm, there seem to be six *Icacina* species. All are African. Three more with edible parts are:

⁹ One cannot discount the possible role of people in this unusual distribution pattern. Information from M. Fay.

Icacina mannii Often called *mumu*, this species is found from Congo to Senegal. Its fruits, seeds and tubers are all edible, at least after proper preparation. The pink pulp of the fruit is eaten at least in Congo, Senegal, and Guinea. The seeds are steeped for a week in water, which is changed each morning to remove bitter elements. They are then left in the sun two days to dry. Finally, they are reduced to flour by pounding. The resulting meal can be mixed with that of millet or beans to make a thick paste (known as enap in Senegal). The tuber is cut up and leached in running water to remove toxic elements and facilitate maceration. The pieces are afterwards dried, pounded, and strained to remove fibers. The starchy flour is then either eaten without further processing or, more often, is blended with the flour from the seeds. It is also softened into an edible paste by the addition of boiling water.

Icacina claesensi Called kukbukumbu in Congo.

Icacina guessfeldtii The fruit is reportedly eaten in Congo.





Garcinia livingstonei

8

IMBE

Asia's mangosteen is commonly called the world's most delicious fruit. However, the plant producing it (*Garcinia mangostana*) happens to be only one of 400 *Garcinia* species found in Asia and Africa. Some of the lesser-known examples also have delicious soft fruits, while others produce chewy nuts described as "falling somewhere between fruits and chewing gum."

Africa's best-known mangosteen relative is the imbe,¹ a tree whose soft and colorful fruits brighten up markets from Senegal to South Africa. Its botanical name, *Garcinia livingstonei* T. Anderson, derives from Dr. David Livingstone. In the East African area through which the legendary explorer wandered during the 1860s, imbe is known as "the King of Fruits." The pulp of these small, orange-colored delights is juicy, pleasant, and sweet-to-acid on the tastebuds. Even those specimens that are unusually sour are considered agreeable and refreshing on a hot afternoon.

Imbes come from a shrub or small tree with a dense spreading or conical crown topping a short, often twisted trunk or cluster of trunks. The effect is a tree that seems to grow strangely off-kilter. Its unsymmetrical shape and stiff, dark leaves create a striking appearance. This unusual and eye-catching form, together with the year-around foliage and heavily scented flowers, make it a landscaper's dream. As a result, this tree is today planted more for beauty than for food. It has, for example, long decorated Mozambique's capital. Many Maputo streets are lined with imbe trees, providing shade to all and fruits to some (mostly kids waiting for the bus to school). Imbes also beautify the landscape around the famous Victoria Falls.²

But in the opinion of many who know this species, the imbe is a candidate for domestication and for much more intensive use in Africa's lowland tropics and hotter subtropics. A host of specific reasons support this opinion: Many African peoples already relish the fruits. Even in its present

¹ Commonly also called wild plum, wild mangosteen, pama, gupenja, and mwausungulu.

² "I've just come back from the Zambezi Valley below Victoria Falls Gorge," wrote Ray Perry, one of our contributors. "The *Garcinia* were in full blossom (September). What a wonderful smell. The trees were alive with insects and birds. Bees obviously love the flowers. There was also a small moth around the trees. There are many 10 m tall specimens, but the species seems to only grow along the river courses."



This eye-catching imbe tree with a dense crown makes a striking sight. This, together with the year-around foliage and heavily scented flowers, make it a landscaper's dream. As a result, this tree is today planted mostly for its good looks. However, the plant happens to be related to Asia's mangosteen, generally considered the "world's most delicious fruit." Imbe's colorful fruits brighten up markets from Senegal to South Africa but they have yet to be produced in anything like substantial commerce. (Steve Flowers)

unimproved state, the species produces abundantly. The trees integrate well into the village scene and make excellent partners in mixed-crop farming. Farmers are almost promised a profit because the general populace places a high value on these fruits—indeed, demand is so great it often cannot be filled. The fruits themselves are already attractive and of a good size for mass marketing. The trees are adaptable and thrive in adverse sites, including dry, damp, sandy, or rocky locations. Although not overly particular as to soil, the trees respond vigorously to good culture. Finally, they make excellent village-, farm- or dooryard companions, being tall enough to throw soothing shade over people, paths, and patios.

Unfortunately, however, little is currently known about how to grow this plant as a food crop. Despite common occurrence and widespread popularity, its production under cultivated conditions remains basically undocumented. Given this paucity of experience, imbe's commercial future must therefore be considered uncertain. Nonetheless, further horticultural exploration should be undertaken with vigor, as this seems likely to unleash a new, nutritional, and notable indigenous resource.

Even without their fruits, these highly ornamental trees are good to have around. Seen in profile, they frequently divide near the ground into three or four upright, outward-curving trunks that carry short, stiff, lateral branches.

They can reach 10 m in height, but are normally much less. The new shoots grow in whorls (verticils) of three and emerge at an acute angle from the stem, giving the tree its characteristic asymmetry and crooked form.

Imbe trees are normally described as being dioecious (male and female flowers occurring on separate trees). Both sexes flower prolifically, and the quantities of pollen and nectar they produce attract large numbers of insects, which in turn attract large numbers of birds, making imbe trees a boon to the environment. As the season progresses the trees become loaded with ripe fruit and take on an even more exceptional appearance. Each fruit looks like a small plum: yellow-orange-red in color and round or ovoid in shape but it has a point at the bottom. The skin—thin, smooth, glossy, and leathery tough—separates easily from the flesh. The pulp itself is yellow and watery, with a pleasing flavor—sweet, and not unlike a perfect peach. In the center are one or two seeds which, unlike its relatives, are not reported as eaten.

On the downside, these seeds are about the size of small dates and are quite large in proportion to the overall fruit, making the pulp correspondingly thin. Also, the pulp clings to those stones in the center. In addition, unripe pulp can contain latex, which tends to stick to the consumer.

The fresh fruits are eaten raw or are commonly cooked with porridge and other cereal products. Once the seeds are removed, the flesh can be sundried and stored like a pitted prune. The fruit is also crushed like grapes to create a drink. Indeed, fermented beverages are sometimes prepared. One of these is a purplish, claret-like wine; another is a liqueur made by soaking the fruits in alcohol and thickening the extract with syrup.

NEXT STEPS

Africans, like people everywhere, value certain trees more than others, and superior trees are already well known in various locations. These offer opportunities for rapid horticultural advancement. Among the first things to be done, therefore, is to locate, identify, and compare these special types.

This process of genetic selection offers to considerably improve characters such as sweetness, appearance, rind toughness, pulp thickness, latex content, fruit size, seed size, and maybe freestone quality. It should be possible to increase the thickness of the pulp by seedling selection; likely they already exist. The culinary preferences of the local inhabitants also may have been subjected to selection, so superior types that reflect flavor and other local preferences may well be available. Precocity, prolificacy, tree size, and regularity of bearing are additional important horticultural attributes that likely have been selected for.

The key to turning imbe into a viable fruit crop lies in the vegetative cloning of select specimens. Both male and female specimens can be vegetatively propagated by air layering or grafting. Budding is probably feasible as well.



The small, orange-colored imbe provides a pulp that is juicy, pleasant, and sweet-to-acid on the tastebuds. East Africans have dubbed it “King of Fruits.” Even those specimens that are unusually sour prove notably appealing on a hot and sweaty afternoon. (© TopTropicals.com)

There is also, however, the possibility that imbe is one of those rare plants that can clone itself through its own seeds (a process known in botany as apomixis). In various places several generations of trees grown from seed have yielded plants exactly like their parents...with no apparent variation among all the progeny. Also, it is said that female flowers that have been bagged (to keep all pollen out) can produce normal fruits and set viable seed.³ This pollenless fruit production obviously has important implications for selection—some trees will produce apomictic seeds, which grow true-to-type, while other trees produce sexual seed, which express various gene blends. The apomixis would greatly aid selection and virtually guarantee clonal purity. In addition, male plants would not be needed in any planting

³ Imbe’s famed Asian cousin, the edible, cultivated mangosteen (*Garcinia mangostana* L.), is an obligate agamosperm (creating unfertilized, clonal embryos), which arose in cultivation and does not occur in the wild. Reproduction is entirely asexual. Fruits grow parthenocarpically on female trees, and seeds maintain trueness-to-type. Richards states that imbe is a probable facultative agamosperm. In other words, it is likely imbe reproduces both by apomixis (like mangosteen) *and/or* by normal sexual reproduction between male and female trees. Richards, A.J. 1990. Studies in *Garcinia*, Dioecious Tropical Forest Trees: Agamospermy. *Bot. J. Linn. Soc.* 103(3):233-250 (this is the first of three seminal articles detailing the long-mystifying origin of the Asian mangosteen).

(indeed, as in certain other species, males might be mere nuisances). Best of all, good types could be replicated via the simplest and cheapest method: planting seeds. Obviously, further research to clarify these aspects—which could rapidly open this crop to major new production with little fuss or fumbling—is urgently needed.

Virtually no research on the horticultural requirements has been done to date. In a sense, everything about cultivating imbe needs investigation. In particular, conventional vegetative propagation needs to be researched. Even if apomixis proves to be real, reliable, and practical, grafting onto selected rootstocks might still be beneficial. Other unknowns that need answering include: Is pollination sometimes necessary or beneficial? What are the optimal sex ratios in cultivated pollinating populations? How densely should the trees be planted? Should they be pruned? If so, when? And how?

It is known that the seeds germinate readily if they are fresh and are kept moist and warm. Also, the seedlings are said to transplant easily. The problem is that they subsequently grow too slowly for most people.⁴ This slowness will likely be overcome by vegetative propagation, which is known to slash the time-to-first-flowering in many crops.⁵

Little is known about handling imbe fruits. The rather tender skin would seem to limit the possibility of shipping imbes long distances, but so many other fragile fruits are routinely transported across the oceans these days so it may be less of a limitation. In addition, the imbe deserves to be more widely cultivated as a backyard fruit, where the question of shipment is moot. This topic is clearly connected with the strength of the skin. Not all the fruits are thin skinned. Some have a thick hide, a genetic quality that could be most valuable and vastly change imbe's prospects.

Special areas for fascinating research into the greater use of this resource include the following.

Environmental Improvement The plant is surprisingly drought resistant and may find use in efforts to combat early stages of desertification. Yet another interesting environmental benefit deals with imbe's potential as a hedge. Although normally a tree, it can be planted close together and clipped to form a low and solid hedge. Given the dense and evergreen foliage, imbe hedges might find many uses. They might, for instance, be planted around fields and gardens. Imbe hedges planted on the contour across the hillslopes

⁴ "We've successfully grown *Garcinia livingstonei* and have many in the nursery but they don't sell because they're so slow growing. We keep on planting them though out of responsibility to future society. One day they'll be large and everyone will be wanting them. Fresh seeds germinate very easily in moist mulch but are not viable once they've dried out." Ray Perry.

⁵ Even without vegetative propagation it could have a future. Imbe certainly grows faster than the true mangosteen, which begins rapid growth only after 5 to 7 years and fruits heavily only after 6 to 12 years and has nonetheless become a major crop in Asia.

may provide excellent edible erosion control. Similar close-spaced plantings could mark compound boundaries, pathways, property lines, and so forth. In such cases fruits could be a secondary product or at least a contribution to the diets of wandering children or animals.

Food Technology There is much potential for processing into fruit-based products such as juices and pulps. This needs exploration. The rind is rich in pectin, potentially making imbe an excellent ingredient for preserves, jams, and jellies.

Health Research Perhaps there are medicinal benefits to be gained from the imbe. Extracts of leaves and flowers apparently have antibiotic properties. The sap is said to be bactericidal.

Subbing for the King Imbe might also prove especially useful in extending mangosteen production to Africa. The two are so closely related that imbe is likely to provide a rootstock onto which its cousin can be grafted. This combination may have considerable commercial significance for extending the mangosteen's range beyond Asia and perhaps beyond the humid tropics. This would put mangosteen on the lips of millions who can now only dream of what the "world's most delicious fruit" must taste like.

Environmental Requirements

As to where imbe cultivation should be attempted, no one can be certain. Natural stands may or may not be a guide in this regard. However, based on those natural stands one might consider:

Temperature Despite an ability to survive light frost, this plant must be regarded as heat loving and likely to perform best in tropical lowlands and the hot subtropics. In cooler subtropical climates where, for example, the navel orange achieves best quality, the imbe grows too slowly to be commercially viable. In the lowveld as far south as KwaZulu-Natal, it typically occurs where mean annual temperature is 20-22.5°C and frost never occurs. This is the most southerly distribution of what is essentially a tropical tree.⁶ In Botswana, imbe is fairly common around the huge inland delta known as the Okavango. Here, and to a lesser extent in Namibia's Caprivi Strip, light ground frosts occur during the coldest winter months, but winter days are warm and the summers extremely hot. Mature imbes are reported to withstand 7°C below freezing without serious injury.

⁶ The immediate, low-lying coastal strip to approximately Durban is probably the southerly limit in terms of heat unit accumulation for satisfactory growth.

Soil Trees are found on sandy or dry rocky sites as well as in coastal areas. Soils vary from deep sands to heavy alluvial soils along riverbanks.

Moisture Although many grow beside rivers, on floodplains, or other locations with high watertables, others grow in fairly arid locales. It tolerates dry seasons as long as 5 months with ease and withstands fire as well. Like many arid and fire-resistant trees, these robust plants have a bulbous base underground. At the same time, the species grows satisfactorily in most soils

BITTER KOLA

Probably all the 400 *Garcinia* species have edible fruits. Among other African species worth research attention is *Garcinia kola*. Known in commerce as bitter kola,⁷ this is a species of tropical West Africa, perhaps most famous in Sierra Leone. The pulp of the fruit is good, having a sweet/sour taste, but it is hardly known even where the tree is widely grown. Seeds are currently the important product, and are seen in markets from Senegal to southern Nigeria, Cameroon, and deep into the interior. They are chewed like cola nuts (the source of ingredients in drinks such as Coca-Cola® and Pepsi-Cola®). They are bitter, astringent, aromatic, and taste somewhat like coffee beans, followed by a slight sweetness.

A contributor in Ghana, Albert Adai Enti, urged this species' inclusion: "The seed of *Garcinia kola* is little known," he explained, "only because the amount sold in the markets is insignificant and many people do not notice it. In addition, the wood is a popular chewstick, which is used mostly to clean the teeth. It is sold everywhere and used by almost everybody. So people hardly allow the tree to fruiting age before they cut it. The result is that only a few trees, fortunately hiding in remote areas, are able to fruit but cannot produce enough to meet commercial demand.

"So although the seed is a good chewable food, it has never been popular. At present, *Cola nitida*, the true kola, is the most popular chewed seed, which is also meeting commercial demand for export. But if *Garcinia kola* can be established in plantations and protected, the fruits will certainly be produced and used in the same way as *Cola nitida*. It is a rainforest tree species and the seed germinates well. It may be slow growing but will grow by all means if left undisturbed. I am sure it could be an economic fruit tree once established and controlled."

Adding to this species' potential is the fact that Africans use the small branches every day as disposable toothbrushes. The twigs have recently been shown to contain antiseptics, and thus seem likely able to maintain healthy teeth and gums. The seeds are also added to palm wine to make it "stronger" in its effects.

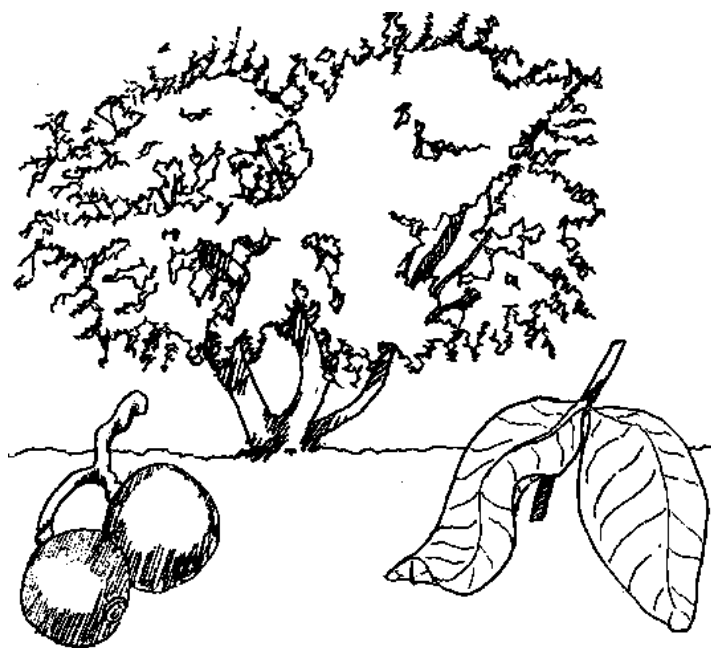
⁷ It is also called false kola, kola male, or kola bitter.

This plant is a highly valued ingredient in African traditional medicine. Throughout West Africa it has been employed in folk medicine as rejuvenating agent and general antidote. Confirmatory discoveries have recently been made by researchers working in prestigious medical research facilities in the United States and elsewhere. In this work, bitter kola seeds have been shown to contain a complex mixture of biflavonoids, benzophenones, and xanthenes. The biflavonoids have demonstrated many pharmacological effects, among them antiviral, anti-inflammatory, antidiabetic, bronchodilator, and antihepatotoxic properties. The benzophenones showed antimicrobial activity in other studies. Some proprietary dietary supplements containing *Garcinia kola* extractives already exist in African and Western markets.

Among the myriad African *Garcinia* species, a sampling of the “best known” includes:

- Garcinia afzelii*** West tropical Africa, fruits chewed like cola.
- Garcinia buchananii*** Tropical Africa.
- Garcinia buchneri*** Southern tropical Africa.
- Garcinia cernua*** Voahandrintsahona. Madagascar.
- Garcinia conrauana*** Southern tropical Africa.
- Garcinia gerrardii*** Umbini. Large shrub of Natal and adjacent territory. The fruits are orange, ovoid, and big (up to 2.5 cm long).
- Garcinia huillensis*** Yellow plum-like fruits; juicy yellow flesh.
- Garcinia kingaensis*** Excellent fruits, but very acid.
- Garcinia ovalifolia*** Tropical Africa.
- Garcinia polyantha*** Tropical Africa.
- Garcinia wentzeliana*** Mogola. This woody climber of tropical Africa, bears sweet, juicy, agreeable fruits that look like grapes.





MEDLARS

In eastern, central, and southern Africa, at least eight species of *Vangueria* are commonly found growing with vigor in dry, eroded, infertile, leached, or otherwise challenging sites. These trees closely resemble one another in both appearance and a propensity to bear lots of fruits. Specimens with as many as 1,800 fruits have been recorded and, given a street value of 4 cents each (U.S. currency, as recorded from Botswana), that amounts to a harvest worth more than \$70 a tree.

With their unusual but appealing flavor and aroma, these fruits are described as being akin to dried apple. Although of apricot size, the fresh fruits resemble the European medlar (*Mespilus germanica*) in color and appearance. In many parts of Africa they are eaten and enjoyed like medlars...raw, roasted, and dried. A renowned and potent gin (known in Afrikaans as mampoer) is distilled from their fermented pulp. Indeed, they are so all-round popular that farmers from South Africa to Sudan and Senegal carefully preserve the trees when clearing land to make fields.

Despite the widespread enthusiasm, little was done to explore the economic potential or horticultural development of these species until quite recently. They were thought to grow slowly and yield too little to be worth the bother. Now a few brave pioneers are discovering that at least one member of this African fruit genus is relatively fast growing and has good potential for domestication.

For the moment, though, a horticultural industry based on African medlars is a long way off. Wild stands are likely to remain the predominant source of fruits for some time to come. This is unfortunate because the fruits of most of those trees are more seed than flesh. It is misleading to judge the ultimate promise by present appearances. The current types are unselected, and some are wasted and withered because they come from trees that are stressed from the difficult sites they grow on.

As these trees are made increasingly user-friendly they could contribute much to rural Africa. Although seeds fill most of the space inside most of the fruits, the pulp-to-seed ratio is very variable. Where the trees are reasonably well watered and benefit from good soils (which is far from frequent nowadays), the fruits are larger and can have a huge proportion of flesh. Fruits of the best-known medlar (*Vangueria infausta*) have been



The mealy fig-like flesh of the African medlar is sweet and refreshing and tastes somewhat like apple. It is an important and popular food. In fresh form it lasts barely a week, but in dried form it can keep for almost a year. Although still undomesticated, the fruit has much potential for horticultural development. (Rihana Botha, www.ecoport.org)

measured having 60 percent flesh, sometimes 80 percent in Botswana. This is a clear indication that careful selection of site and seed can alone transform this crop.

The trees' immediate potential is probably not production in orchards but in back gardens, spare patches of hillside, village greens, or verges of roads, tracks, and rivers. In agroforestry they could find a notable niche. Already several species are used as hedge plants to demarcate fields and farms.

Even when ripe, their fruits refuse to fall, and must necessarily be picked. Although the fruits may stay aloft on the branches for up to a couple of years, by then they are usually useless. However, for maybe six months they remain edible, which can provide a handy food-store in times of need.

The fruits are promising in commerce. Marketable products include whole or dried fruit. Unprocessed or processed, they are potentially useful as nutritional supplements (in, for instance, the widely popular sour-tasting fermented porridge). They are also sold as a flavoring agent and for producing alcoholic beverages.

A special feature is the easy desiccation. The fruits can be sundried, stored, and then eaten months later. After soaking in cold water for 12 hours or in warm water for less, the reconstituted fruit tastes almost like new. Because of this, they are commonly stored in dried form and used in times of scarcity, such as during the winter months. Typically, they are then boiled in

water and the resulting liquid is then used to flavor other foods, notably mealies (maize porridge).

Undoubtedly, though, they contribute more than just flavor. One African medlar's vitamin C content, for instance, is said to be 3.7 mg per 100 g.¹ However, other species are said to contain no vitamin C, and analytical chemists could perform a signal service by analyzing representative samples of African medlars fruits to determine their full nutritional qualities.

Like so many of the other plants highlighted in this book, the African medlars provide more than one food. In this case, the kernels of the seeds are also eaten. And there are non-food uses, too. The wood, roots, and leaves have medicinal uses.² Perhaps because of this, there is considerable positive superstition associated with these trees. Across southern Africa, for instance, local lore has it that a beneficent *Vangueria infausta* bears fruits heavily just before a big drought.³ And in Swaziland, stakes or pegs from the wood are used to ward off lightning.

Individuals interested in helping different parts of Africa should investigate the local *Vangueria* species and genotypes, not to mention the many and varied local methods of handling and preparing the different fruits. Taken overall, these plants offer great projects for students, anthropologists, botanists, plants persons of varying levels of experience, and Africanists of perhaps every type. Pooling the Africa-wide knowledge and the best insights of science will likely catalyze even greater levels of activity and thereby arouse not only greater appreciation for this indigenous resource but also open the doors to a new and vibrant horticultural industry.

Documenting traditional usages together with exploratory nutrition research and feeding trials should be the first steps. As these plants are already well known to millions, information on local traditional usages will enable a fair assessment of the plant's true value. The nutrition research and feeding trials will complement the information on local uses. Not until the real importance becomes known should other major research and development thrusts be undertaken. If the preliminary findings are good it should be easy to carry out awareness campaigns leading to and resulting in marketing and economic development.⁴

There are reports of a surprising number of medicinal uses, which, given the state of healthcare in Africa, might open another pathway to progress for these resources.⁵

¹ Watt and Breyer-Brandwijk, 1962. *Medicinal and Poisonous Plants of Southern and Eastern Africa*. Livingstone, Edinburgh and London.

² Roots are used, for instance, as antimalarials and to treat pneumonia. Crushed, soaked leaves are said to bring down swellings and to be good for treating styes in the eyes.

³ Whereas trees cannot possibly foretell the future, one of our contributors noted the coincidence that the trees in his neighborhood did exactly that 1981, a year that was followed by a terrible eight-year dry spell.

⁴ Ideas from Nat and Patricia Quansah, Madagascar.

⁵ See, for example, Venter, F. and J. Venter. 1996. *Making the Most of Indigenous Trees*,

Promising species include the following:

***Vangueria infausta* Burch.**⁶

This shrub or small tree occurs in abundance in woodlands, scrub, valleys, stony kopjies, or sandy dunes throughout much of South Africa (Transkei and Gauteng, for instance), Swaziland, Botswana, Namibia, Zimbabwe, Mozambique, and Malawi. It reaches 6 m tall, with a fluted cylindrical trunk and a spreading, somewhat rounded crown.

When ripe, the fruits are spherical, shiny, and yellow or light- to reddish-brown. They come crowned with the remains of the calyx. The leathery skin easily peels away to expose the pulp and seeds (usually three) inside. The fruits themselves look somewhat like dried pears, and their sweet-acid flavor is much liked. Mixed with a little sugar and water, the pulp produces a good substitute for applesauce; many farm families use it in puddings.

This is a species for which domestication projects are underway. One is that of Veld Products Research in Gaborone, Botswana. Its researchers turned for help to Botswana's children; co-opting the kids' expertise to find which trees produced the best fruits and providing prizes for the best seeds. The kids proved to really know the plants. Some seedlings from their favorite trees produced fruit at the almost incredibly early age of 8 months; at 2 years of age (and only 1.3 m tall) they bore as many as 400 fruits.⁷

In this and other programs, encouraging responses to grafting have also been observed. In some cases grafted trees have been found to grow up to twice as fast as the ungrafted seedlings and to yield as many as 1,500 fruits. Some of those fruits were as big as 15 cm in diameter, an almost unimaginable size to those who've seen only the wild fruits.

The researchers domesticating *Vangueria infausta* in Botswana have run into potential problems, however. First, they've found that drought or erratic rainfall causes fruits to abort, a problem easily overcome by supplemental irrigation (if it is available—and if it is not commandeered for something like mangoes). Second, a mite causes galls on the leaves and if the trees are grown at high density it can spread easily and quickly and affect overall

Briza Publishers, Pretoria.

⁶ A synonym is *Vangueria tomentosa*. Lacking any other common English name, these fruits are called wild medlar, or African medlar. Local names for this species and its fruit include mmilo (Pedi, Sotho, Tswana), umviyo and umvilo (Zulu), mispel, mobilo, and matugongo, umntulu (siSwati), mmilo (sePedi), and umviyo (isiZulu).

⁷ In Malawi, similar spectacular growth and production have been obtained. Maghembe, J.A., 1995. Achievements in the establishment of indigenous fruit trees of the miombo woodlands of southern Africa. Pp. 39-49 in Maghembe, J.A., Y. Ntupanyama, and P.W. Chirwa, eds., *Improvement of Indigenous Fruit Trees of the Miombo Woodlands of Southern Africa. Proceedings of a Conference, January 23-27, 1994*, Mangochi, Malawi. International Centre for Research in Agroforestry, Nairobi.

production. Third, the tree's leaves are attacked by fungus, although there seems to be little effect on the production of fruit.

In this research, it has been found that the seedlings need the help of beneficial fungi. Most of the specimens examined in the field have formed symbioses with these helpful microbes (arbuscular mycorrhizae), which aid in the plant's establishment, survival, growth, and productivity. They are now working on ways to ensure that the seedlings in the nursery have this beneficial infection on their roots.⁸

Food technologists in South Africa have also run into problems. "We have found," writes our contributor Cori Ham, "that there is so little juice in the fruit that it is very difficult to work with when making nectar and fruit rolls. The nectar has a brown color and cinnamon-like taste and our consumer panel rejected it on the basis of its unpleasing color and thick consistency. It had however very high sugar levels and the potential for blending it with other fruits should be investigated."

***Vangueria madagascariensis* J Gmelin⁹**

This species is native to Mozambique, Madagascar, and the Indian Ocean islands of Mauritius and Réunion. Its somewhat apple-like fruits are borne in clusters of two to five. They are nearly round and sized like golf balls (3.5 cm diameter), with smooth tough skin and whitish flesh, turning brown when fully ripe. The flavor has been likened to "a blend of apple and tamarind." The fruits sell well in the produce markets of Uganda, Kenya, Madagascar, and elsewhere. They are eaten raw, stewed, or roasted.

Even on Madagascar itself, little has been done to develop this much-enjoyed fruit. Artificial regeneration has not been tried, and there are no orchards. The crop is, however, semi-cultivated on farms. People clearing land for farming always leave these trees as future sources of fruits. The tree is variously associated with magic and witchcraft and cattle fertility and so it is not cut down nor is its wood burned.

Germination is said to be difficult, owing to the hard seedcoat. However, it cannot be too difficult, because the plant is grown to a small extent in Bangladesh, the Philippines, Puerto Rico, the Virgin Islands, Martinique, and Trinidad and Tobago.

Improved methods of propagation and horticulture could help boost the income of fruit growers, especially if the marketing of fruits can be better organized. And beyond that, this forest-dwelling species holds promise for helping Madagascar's beleaguered and fast-disappearing rainforests. The tree will grow in dry regions but bears best where there is plenty of year-

⁸ This is of course a means for benefiting not just this species but most or all of the others in this book as well.

⁹ Synonyms are *Vangueria edulis*, *Vangueria acutiloba*, and *Vangueria venosa*. Common names include voa-vanga and Spanish tamarind.

round precipitation. It has good potential for contributing to “supply-side” conservation. Organized harvesting of such forest fruits would help give local people a stake in keeping the forests standing. Some use might be found for the seeds, which, apparently, have received no attention. At present, however, the species is not regenerating adequately.

***Vangueria apiculata* K. Schum.**

This eastern African species, often called shikomoli, is common to all parts of Uganda and is found as far south as eastern Zimbabwe. It, too, occurs in scrubland and forests and is typically a shrub or tree to 12 m or more. Its fruit is fleshy and 2-3 cm wide. It is produced in abundance and is commonly eaten. The pulp around the seed is thin but sweet. The root is employed to treat roundworm.

***Vangueriopsis lanciflora* (Hiern) Robyns¹⁰**

This fruit of a closely related genus is reported to be the tastiest African medlar of them all.¹¹ It comes from a species found notably in Zimbabwe. It grows as a bush up to 3 m high in the southern part of the country and a tree up to 12 m tall in northern part. The fruits look like oblong, yellow plums. They are similar to the main African medlar (*Vangueria infausta*), but can be both smaller and slightly larger. The pulp is crumbly, but the skin is tough and the pulp is easily squeezed right out into the mouth. Only one or two seeds occur in these fruits.

This species is in need of genetic selection. Whereas most of the fruits are exceptionally flavorful, some are reported to be tasteless. Undoubtedly, this is due to genetic differences between the trees. Vegetative propagation of superior types might quickly make this into a winner. The plant is grown from branches “stuck in the ground.” These apparently take root readily, so the cloning of great-tasting types should be easy.

***Lagynias lasiantha* (Sond.) Bullock¹²**

Another fruit-bearing tree from a closely related genus, this species is said to produce fruits “as good, if not better than *Vangueria*.”¹³ Native to tropical East and southern Africa, the fruits of this shrub are undoubtedly pleasant to eat and should be more widely enjoyed.

¹⁰ Often called Zimbabwe wild medlar, mutufu, umyiyo, mufilu (Bembe), msoli (Nyanja), musole (Tonga).

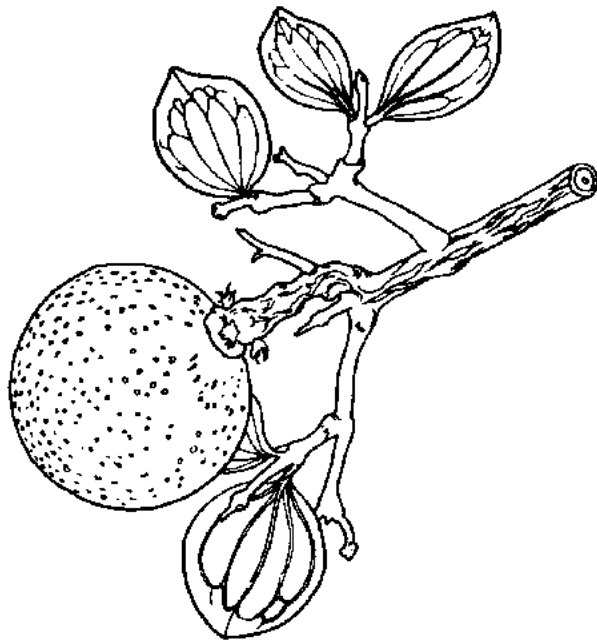
¹¹ When we asked about dropping certain species from our first draft one contributor wrote back: “Please keep *V. lanciflora*—it is yummy!!”

¹² Known in South Africa as the umtulu tree.

¹³ Information from A. B. Cunningham.



Vangueria esculenta



Strychnos cocculoides

MONKEY ORANGES

Although perhaps more than 20 *Strychnos* species produce edible fruits in various parts of Africa, three stand out. *Strychnos cocculoides*, *S. spinosa*, and *S. pungens* produce large, pleasantly flavored fruits that are easy to handle and often in short supply. Farmers appreciate the trees so much that when clearing land they spare them the ax—even if plowing or planting field crops will be awkward. These three special monkey orange trees are widely enjoyed and have the amazing capacity to stay edible in tropical heat for months after maturity. This is important for food security: monkey orange has been called, “A great and precious resource in times of crop failure.”

Of all Africa’s native fruits, these are perhaps the most “conventional.” They are similar in size and shape to apple, pear, and orange trees. Given horticultural attention, they probably can be raised with equal facility. There have other advantages, too. They bear fruit in abundance. They make excellent additions to gardens, parks, streets, and fence lines, by providing not only food but also shade, shelter, and erosion protection.

Above all, though, these fruits provide a profit. Indeed, they sell at very high prices and still the full demand is seldom met. A much greater commerce in monkey fruits is eminently possible. Even an export trade is not beyond question. Zimbabwe has already exported some of the fruits to Botswana, and that could be just the beginning.

High prices, high productivity, great shelf life, unmet demand...these are the makings of success in any fruit. However, few people have attempted to produce monkey oranges in organized cultivation. For all intents and purposes, they remain unknown to horticulture, and remain undomesticated.

Clearly, these three special monkey orange trees warrant intensive research and development. And that has begun...at least in a modest way. In southern Africa, selection and cultivation of monkey oranges is underway, in hopes these plants may eventually be grown intensively. Beyond the possibility of orchards, however, is the promise of improving production from the wild resource and expanding monkey orange trade within and among African nations. These fruits may find a home beyond Africa as well.

One species grown in Israel is already showing enough promise for optimism about its future as a crop.¹

In these three special *Strychnos* species, fruits tend to be yellow, orange, or brown in color and about the size of grapefruits. They are marketable size and quite stunning to the eye. They typically store and ship far better than most fruits. Indeed, they can be piled in the open for storage because their hard, gourd-like shell resists not only fungi but also fruit flies. Some are even buried several months, and (as long as the shell has no cracks) they come out of the ground juicy and golden ready for dessert.²

The yellow or brownish pulp inside the fruit surrounds a number of scattered but conspicuous seeds. To eat a fresh monkey orange you simply suck the juicy flesh from around those seeds.

A particular problem with some *Strychnos* species is that, although the ripe pulp is safe to eat in moderation, eating too much at one time can be purgative. In addition, care must be taken not to chew the seeds of most (but not all) the species. Those smooth and shiny seeds, as well as the bark and roots, contain strychnine and may produce vomiting or headaches. Their slippery nature makes them easy to swallow accidentally, but they pass through the body safely without causing harm. **However, in extreme cases, after chewing irresponsibly the bitterest seeds, even death may occur.** These facts are widely known where these trees occur, and at least in *Strychnos pungens* not even the seeds seem to contain toxins.

Although high prices, high productivity, and great shelf life make for success in any fruit, capitalizing on that promise in an organized way requires that much more be done. The priorities for domestication given in other chapters are also relevant with monkey oranges. The goal should be high and consistent yields of large, good quality fruits. And that requires technical advances such as selection, vegetative propagation, and proper management of the plants. This seems certainly achievable; however, monkey oranges have some special research needs, including:

- Selection of trees with minimal levels of harmful alkaloids (strychnine, bruisine) in the seeds and skins.
- Artificial defoliation to synchronize the fruit formation and allow orchardists to harvest the entire crop at once.
- Hybridization between species to explore the possibility of wholly new and perhaps exceptional fruits, al la nectarine or plumcot. This is a speculative notion, but *Strychnos pungens* is known to hybridize with *S. innocua*, so the possibility of shared genes and perhaps of seedless fruits is far from impossible.

¹ Information from Y. Mizrahi.

² An exception appears to be *Strychnos spinosa*, which cannot be stored for long, especially under tropical heat and humidity, perhaps because of higher fat levels.



Strychnos cocculoides, Congo D.R. Fruits of this and the other three special monkey orange species are of marketable size and quite stunning to see. Not only are they large, flavorful, and easy to handle, they are often desperately difficult to find due to overwhelming demand. (Paul Latham)

Contributor P. du Plessis summed up the overall situation: “*Strychnos* fruits are very popular and seldom available in surplus quantities because of an extensive local and regional trade,” he wrote on a draft. “New plantings are urgently needed to make available fruits for export markets and for processing. This should be done in Africa with Africans.”

These three promising species are highlighted below.

Corky-Bark Monkey Orange (*Strychnos cocculoides* Baker)³

This compact tree 2-8 m tall (occasionally reaching 10 m) of the Kalahari and its surrounding savannas and dry woodlands is found on sandy soils and rocky slopes in Botswana, northern Namibia, and parts of Zimbabwe and South Africa.⁴ It bears round fruits 6-10 cm in diameter, with hard, woody, brittle shells. When immature they look like avocados. They fall from the tree before they ripen. As they mature the thick shell turns orange, at which

³ The tree derives its name from the characteristic corky bark, deeply ridged longitudinally. It is also known as suurklapper (Afrikaans). Much additional information on this species is available in Mwamba, C.K. 2006. Monkey Orange (*Strychnos cocculoides*). Fruits for the Future 8. International Centre for Underutilised Crops, Southampton, UK; see icuc-iwmi.org.

⁴ Notably the bushveld of Gauteng (western Transvaal).



Green monkey orange, Luphisis village, South Africa. The trees that yield monkey oranges make excellent additions to gardens, parks, streets, and fencelines—providing not only food but also shade, shelter, and erosion protection. However, fruits from these unselected trees can be disappointing as food. (Claus Lipis)

point it can be broken open and the yellow or brownish pulp scooped out. The pulp is very refreshing, and its taste has been variously described as “a combination of citrus and pineapple” or “a mixture of citrus and banana.” It is much beloved. Kung people walk for days to find trees that are bearing, and fruits are widely sold in traditional markets throughout the area. They are sold, for example, in Bulawayo, Zimbabwe from September to October.

In nature, the species regenerates by seed, coppice, and root suckers. The seed has a hard coat and resists easy germination. Undoubtedly, scarification techniques can be found to promote quick and uniform sprouting.⁵

⁵ Indeed, one of our contributors in Zimbabwe wrote: “I have had no trouble germinating

In a pioneering program in Botswana, a small organization devoted to the development of wild African plant resources has made remarkable progress with improving this plant's overall productivity. Researchers at Veld Products Research applied horticultural techniques to six superior phenotypes they obtained from the wild. Even before receiving horticultural attention those select 6 averaged between 300 to 400 fruits per tree, each fruit averaging 10 cm in diameter and a third of a kilo in weight. Those may seem like exceptional trees, but given some fertilizer and appropriate watering the fruit size rose to 15 cm diameter, the maximum production to 700 fruits per tree, and the weight to over half a kilo per fruit. Street value of each fruit (before improvement) was 40 cents in U.S. currency, so a single tree producing 700 fruits could bring in gross income of well over \$200.

In these trials, propagation by seed has been successful; in the nursery 80 percent germination within 3 weeks has been recorded on seeds sown in summer. (Those sown in winter took more than 9 weeks.) The plants also responded well to inorganic fertilizers.⁶ In field plantings at Gabane, Botswana seedlings treated with superphosphate and blood- and bone-meal (Nitrosol[®]) fertilizers doubled their heights (to an average of 76 cm) within 13 months, while those untreated remained below 20 cm for 3 years.

Encouraging responses to grafting were also obtained. In some cases the grafted trees grew twice as fast as the ungrafted ones. They also tended to yield fruits within 3 years of transplanting. The ungrafted seedlings, on the other hand, took 4 to 5 years to bear any fruit.⁷

Green Monkey Orange (*Strychnos spinosa* Lam.)⁸

This small thorny shrub or small tree (6-10 m) is very similar to corky-bark monkey orange. It is, however, found more broadly throughout the drier parts of Africa: from Senegal to southern Ethiopia, and from there to the eastern seaboard of South Africa. It is a variable species, its genetic divergence being so great that three subspecies have been recognized. It is widely spread across dry tropical to subtropical savannas, open woodland, river fringes, and mountain slopes up to about 2,000 m. Although home in hot, dry tropical or subtropical savannas, it tolerates light frost.

The spherical fruits—sometimes as large as a quince (15 cm in diameter)—are bright green when immature, but turn yellow when they fall, and then brown or black. They have been called “one of the best native

seed from old, open fruit (presumably opened by baboons), which was thoroughly dried.”

⁶ Not all responded; some, for reasons unknown, stayed short and refused to flower.

⁷ In Zambia, however, there are reports of trees raised from seeds yielding fruits within 3 years of transplanting. Information from C. Mwamba.

⁸ Also known as Natal orange, monkey ball, monkey apple, elephant orange, spiny monkey orange, amahlala (Zulu), klapper, and other names. Its smooth (rather than corky ridged) branchlets help distinguish it from the very similar *Strychnos cocculoides*.

fruits,” and are, for instance, one of the favorites of Mozambique, where they sell well in the markets of Maputo.

The skin of the fruit is so hard it must be physically cracked open, but the pulp then comes out as a whole. It is whitish, yellow, light tan, or dark brown in color, and in flavor can be either acid or very sweet and delicate. On the tongue it can be jelly-like or juicy, and the taste is described as “somewhat like a lightly fermented tart apple, with a cinnamon-like odor that intensifies on cooking.” Although mostly eaten fresh, the pulp is used in many other ways. In Madagascar, for example, it is often cooked with cereals to form a sweet porridge or it is dissolved in water to create sweet and tasty drinks. These latter are also fermented to an alcoholic beverage.

Little is known about nutritional value, but monkey oranges are reportedly rich in B vitamins and vitamin C. Tartness, as in lemons, derives from citric acid. One analysis in Malawi found it to be the highest in fat (31 percent) and energy (460 calories per 100 g) of 16 wild fruits tested, although these levels may be exceptional or anomalous, as the fruit is not normally considered oily.⁹

Two basic fruiting forms of this tree are distinguished. One, the so-called sweet type, has sugar-rich fruits clustered on short stalks. The other, the so-called bitter type, has long stalks, narrower leaves, and fruits that remain bitter when ripe.

Although slow growing, the tree is not difficult to plant and manage, and it seems to adapt well to many types of locations.¹⁰ A well-drained soil is preferred and, despite a reputation for needing more water than other “lowveld” trees, this is a drought tolerant species. In some cases, the fruits may take several months or even a year to pass from flowering to full ripeness. They are so strongly attached that they must be cut from the trees with a knife or scissors.¹¹ But when ripe, they fall off on their own, especially if coaxed by someone shaking the tree. The shells remain whole unless they hit something as hard as a rock, tree trunk, or each other.

The seeds and bark contain strychnine and are best regarded as poisonous, although authorities differ on this point. The unripe flesh is said to cause vomiting. The rind is very bitter in taste and is to be avoided. The wood is white and is sometimes used for fence posts.

⁹ Saka, J.D.K., J.D. Msonthi, and J.A. Maghembe. 1994. Nutritional value of edible fruits of indigenous wild trees of Malawi. *Forest Ecology and Management* 64:245-248.

¹⁰ It has, for instance, been planted as a curiosity in Florida. It was introduced into Puerto Rico and Florida by the U.S. Department of Agriculture in 1921, and also into the Philippines at about the same time.

¹¹ Pulling them off damages the tree.

Spiny-Leafed Monkey Orange (*Strychnos pungens* Soler.)¹²

A small brittle tree, usually less than 7 m tall, this monkey orange is found from northern South Africa to Angola, Congo, and Tanzania. It often occurs where light frosts are far from unknown in winter. The fruit is round, 10-12.5 cm in diameter, and weighs as much as almost half a kilo. Like other monkey oranges, it has a woody shell, which turns from bluish-green to yellow as it ripens. The pulp is juicy, butter yellow, and has a somewhat rank odor. Although opinions about this fruit differ, some trees produce what are generally considered pleasingly fragrant and pleasant tasting fruits. The presence of citric acid makes them thirst quenching.

Alkaloids are supposedly absent in the seeds of this monkey orange. This should be confirmed. The seeds are very bitter, and if consumed in quantity may cause diarrhea.

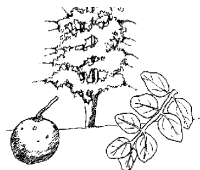
Perhaps a more serious concern is the competition people face in trying to get these fruits. Not for nothing are they named monkey oranges. Indeed, the fruits are eagerly sought by monkeys, as well as by forest antelopes, or even by both together. In Natal, for instance, the miniature antelopes known as duikers commonly search under a tree for flesh enclosed seeds being dropped by careless monkeys.

The whitish colored wood is hard and straight. It is much prized, especially by Zulus, who use the wood of coppice shoots for walking and fighting sticks.

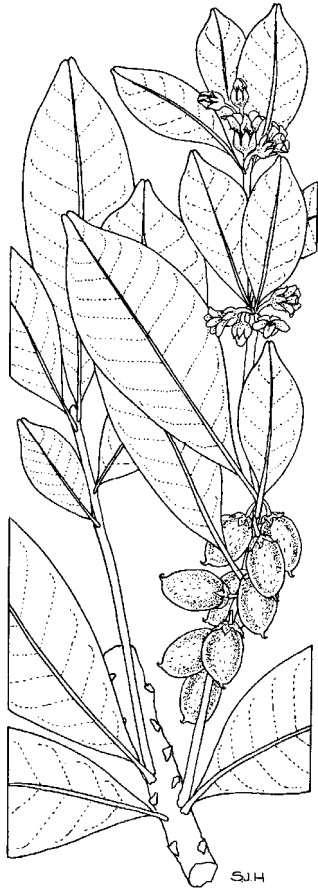
The species is very similar to *Strychnos spinosa*, and (in the absence of flowers) is distinguished by the blue-green color of the immature fruits as well as by small variations in leaf color, shape, and venation.

Like other *Strychnos* species, this is one tough plant. It thrives from sea level to high altitude. It is to be seen in woodland, wooded grassland, and urban settings. It occurs commonly in stony places or at the base of rocky outcrops (kopjies), not to mention deep sandy soils and open woodland, riverine fringes, and coastal forests. In the harshest sites it is commonly reduced to a small shrubby shadow of itself, with many stems sprouting from the base.

The seed germinates readily and reportedly the plants grow fairly fast.



¹² Also known as wild orange, black monkey orange, swart klapper, botter klapper, shiny-leaved mukwakwa, and other names. According to some botanical authorities, *Strychnos madagascariensis* is a synonym for *Strychnos innocua* (or at least of *Strychnos innocua* subspecies *dysophylla* and subspecies *gerrardi*).



S.J.H

Bequaertiodendron natalense

STAR APPLES

Two common dooryard trees in tropical American countries are the star apple (*Chrysophyllum cainito*) and satinleaf (*C. oliviforme*). Everybody loves having them grow near the house. Their leaves are deep green on top and have a satiny coat of golden brown shiny hairs underneath. Wind rustling the foliage creates a striking effect as the green and gold flash sequentially in the sunlight.¹ In addition, these beautiful trees produce some of the most beloved local fruits. Their apple-sized delights have a sweet flesh with small seeds arranged in a typical star pattern.

Both trees are widely planted in the Americas. They grow rapidly, often rising more than a meter each growing season. Once established, they become almost trouble free, resisting among other things pests, diseases, and high winds. As long as they remain unexposed to freezing temperatures, they burden the grower with almost no problems and continue to produce quantities of delicious fruit year after year.

What is not well known is that Africa has its own counterparts. The vastnesses below the Sahara contains more than a dozen species related to the American star apple and satinleaf.² These too are attractive trees producing delicious fruits. They also are candidates for producing trouble-free dooryard delights, and perhaps more. But these African relatives remain horticulturally undeveloped and their nutritional qualities are not yet clear.

Despite neglect, Africa's star apples are esteemed in many places. The fruits are green, purple, apricot, yellow, or copper in color. Their smooth skin encloses a white, sweet-tasting pulp arranged in segments. Cut transversely, most of them display the family crest: the star-shaped arrangement of seeds. The pleasantly acid pulp is almost always eaten fresh.

Clearly, the various African species deserve at least preliminary horticultural and nutritional investigation. An overarching requirement for

¹ For this reason, star apple is also called golden leaf tree. Victorian novelist Charles Kingsley described it as, "like an evergreen peach, shedding from the underside of every leaf a golden light—call it not shade? A star apple."

² Some botanists divide African star apples among different genera: *Chrysophyllum*, *Bequaertiodendron*, and *Manilkara*. *Gambeya* is a synonym sometimes used for *Chrysophyllum* (especially in the tropical-wood trade). Family: Sapotaceae.



Equateur Province, Congo D.R. Despite the fact that African star apples are currently unexplored and their value in organized plantings untried, they hold promise. They produce delicious fruits that are popular wherever they are grown. Selecting elite cultivars could create new consumers both locally and in far-away places. (Roy Danforth and Paul Noren)

greater progress is genetic selection. A huge diversity of different types exists. Fruits can be found, for instance, in an array of colors, shapes, sizes, and tastes. The trees also exhibit differing sizes, forms, features, and productivities. Some trees, for example, fruit heavily, others lightly. Little of this genetic wealth has been evaluated or even explored, let alone exploited.

Although named varieties and organized production are now unknown, superior plants are to be found and almost certainly can be propagated vegetatively. This needs doing. Elite clones will likely transform this wild crop by raising quality and reliability as well as by yielding fruits at a much younger age. Budgrafting white star apple, for example, has produced fruiting within 3 years in Nigeria.³

When superior fruits become available they seem likely to find ready outlets in both subsistence and commerce. However, at present not even the basics of production and use are well described. Little is known, for example, about the management of the trees, let alone the nutritional qualities of the fruits. Probably, though, the nutritional composition is not too different from those in American star apple, which is much like that of citrus fruit, except for the vitamin C which is less than half that in oranges.

³ Information from J.C. Okafor. Other vegetative methods likely to succeed are air-layering (marcotting), cuttings, and tongue-inarching.

One particular problem is that the fruits must be allowed to ripen on the tree; when picked immature they are sticky with latex and astringent to the palate. Today, they are allowed to ripen and fall, and are then picked up from the ground. It seems likely that this process can be improved upon. Probably, fruits can be picked immature and subsequently ripened using ethylene—a gas now widely used to ripen oranges, tomatoes, and other fruit on demand. This would extend the shelf life as well as the distance they could be shipped to market.

For their ornamental value alone these trees merit attention. They might make useful reforestation species as well. Fully grown, they reach up to 30 m in height and 2 m in girth, and their hard, white wood is famous for quality. It is in international demand, and is traded under the name longhi (or longui). One website touts it for “interior joinery, furniture components, domestic flooring, stairs, decorative sliced veneers, plywood, interior fittings, turnery, construction, vehicle bodies, handles, sporting goods, carvings, agricultural implements.”

Particularly promising for investigation are the following:

White Star Apple

This forest tree (*Chrysophyllum albidum* G. Don) is native across much of tropical Africa. In recent times, however, it has sadly become uncommon in the wild. Today, it occurs mostly in villages, where it tends to exist as solitary specimens. In southern Nigeria and other areas of West Africa, such household plantings are the only remnants of what was once a common forest occupant. In those villages, however, the people look after the tree, commonly managing it in at least a rough-and-ready manner.

During the harvest season the fruits are put on sale, but mostly only in nearby villages; seldom are they shipped even to the cities. That is a pity because this fleshy, juicy fruit is wildly popular. It is nearly spherical, slightly pointed at the tip. When ripe, it is orange-red, yellow, or yellow-brown in color, sometimes with brownish speckles. Inside is a yellowish pulp surrounding five brown seeds arranged in the regular star shape.

To eat the fruit people first split it open, usually by squeezing it between the fingers of both hands. This exposes the pulp, which is commonly the color of flesh and tears apart not unlike meat. This very tasty fruit flesh is eaten directly, but only after any milky sticky juice has dripped away. It is said to have potential as a soft-drink flavoring. It is even now fermented into wine and sometimes distilled into spirits. High in pectin, it forms an excellent jam, said to have a shelf life of up to a year even in the tropics.

In some areas the white star apple is exclusively a food of children, some of whom prefer to chew the immature fruit, which at that stage is like gum.⁴

⁴ This is not as unusual as might at first appear. These fruits are part of the same family



Fruits of white star apple (*Chrysophyllum albidum*). African star apples remain horticulturally undeveloped and their nutritional qualities are undocumented. Despite scientific neglect, however, they are esteemed in many places, are likely to have nutritional merit of at least a modest nature, and good selections undoubtedly await recognition among its vast genetic diversity.

(J.D. Mollon/Petroc Sumner, <http://vision.psychol.cam.ac.uk/jdmollon>)

However, in southern Nigeria, where the fruit is called udala, it has become popular among adults, especially pregnant women, who believe it facilitates an easy birth.

Today, this species' broader potential is unexplored and the white star apple's value in organized commercial plantings remains untried. It deserves better. An important feature is that its fruit comes available in the dry season, a time when all too often there is not enough to sell or eat.

In parts of West Africa, seeds are occasionally collected and their oil extracted for soapmaking or cooking. Latex is also tapped from the trunk and used as rubber. The bark and tender leaves have medicinal applications. Local dancers use the hard, sharp, beanlike seeds in rattles. Easy to saw and plane, the brownish-white wood nails well, takes a fine polish, and is highly sought for construction work, tool handles, and much more.

(Sapotaceae) as Central America's chicle tree, the original source of chewing gum.

African Star Apple

This tall West and Central African tree (*Chrysophyllum africanum* A. DC or *Chrysophyllum delevoyi* De Wild.)⁵ is found from Sierra Leone to the Congo basin and Angola. Its fruits have an apricot color and a pleasant acid pulp that is much esteemed. Although children scavenging the hillsides grab most of them, enough surplus occurs that they are sold in both rural and urban markets and eaten with relish by many adults. Across most of its range there are no organized plantings. However, in villages in Benin and southern Nigeria the tree is apparently deliberately cultivated.

Internationally, the species is known for its top-grade timber, marketed under the name longhi (or longui) rouge.

Milkplum

This small evergreen tree (*Bequaertiodendron magalismontanum* (Sond.) Heine & J.H. Hemsl.)⁶ is distributed widely, from Guinea to Tanzania and from Nigeria to South Africa, where it is one of the more popular “veld fruit.” Its bright scarlet, plumlike fruits have a pinkish-purple pulp of pleasant flavor. Women often collect large quantities, crush them in water, and boil the resulting extract with maize to produce a colorful and tasty porridge. The fruits are so relished that there are seldom enough on hand to meet the demand. Jam and jelly, not to mention vinegar, wine, brandy, and syrup, are also made. The jam—not unlike plum jam in appearance and flavor—is slightly, and deliciously, tart. It has been called “excellent.”

The small tree, often hardly more than a shrub, is relatively drought-resistant and at least some types seem frost-hardy. It grows on many soils, but seems to occur most commonly on dry and well-drained slopes. In South Africa, for instance, it is found in ravines (kloofs) or small rocky hills (kopjies), notably in the Gauteng-KwaZulu-Natal region. The fruits cluster along the branches, hanging like small, bright-scarlet plums. Inside, they lack the segments and star-shaped arrangement of seeds. Instead, there is a single central seed. The fleshy pulp is rich in sugars and contains moderate amounts of vitamin C and minerals.

Regardless of its food value, this species is promising for protecting and improving stressed sites. It could prove useful, for example, in land reclamation, erosion control, and especially wind erosion reduction. Its use as a fruit crop in orchards or mixed cropping systems is as yet unexplored, but that also seems to be a promising line of investigation.

⁵ The taxonomy of this species remains somewhat murky. *Chrysophyllum africanum* (*C. delevoyi*) is so similar to *C. albidum* that it may be just a variety of it. *C. edule* Hoyle may be another synonym. Common names include omumu, alasema, or odara pear.

⁶ Synonym are *Chrysophyllum magalismontanum* Sond and *Englerophytum magalismontanum* (Sond.) T.D.Penn. It is also called wild plum, stem fruit (stamvrug in Afrikaans), or red milkwood.

Although native to lowland tropical or subtropical climates, the tree is said to adapt to a wide range of environments and climatic conditions.

Forest Milkplum

This large tree (*Chrysophyllum viridifolium* J.M. Wood & Franks) is native to eastern South Africa (notably the Natal coast), Swaziland, and Mozambique. Its fruits are yellow and smooth with a yellowish-white pulp. They are shaped and sized like little apples, and are said to ripen irregularly throughout the year. Little else has been reported about them so far.

Milkwood

Found from the mountains bordering Zimbabwe, Mozambique, and Malawi as far north as the highlands of Cameroon, Uganda, and Kenya, this tall, stately montane-forest tree (*Chrysophyllum gorungosanum* Engl.) produces well-liked fruits. These large oval berries, usually containing four or five brown seeds and a milky pink flesh, have a pleasantly acid taste. They are said to make a splendid jam. Owing to the tree's height most are now accessible only to birds, bats, and monkeys. However, the species might make a useful cultivated crop. In orchard production or village plantings horticultural manipulation such as pruning could be employed to control the height and produce a reachable harvest.

Other edible-fruited African *Chrysophyllum* species, about which even less is known, include:

Chrysophyllum lacourtianum De Wild. Large, yellow, acid-tasting fruits the size of oranges. Found in West Africa, producing good timber.

Chrysophyllum natalense Sond. (*Bequaertiodendron natalense* (Sond.) Heine & J.H. Hemsl.) The red fruits have a tart but pleasant flavor and are much enjoyed by humans and animals alike. Found in South Africa (Natal coast).

Chrysophyllum obovatum (Sabine & G. Don) Hemsl. Agreeable tasting fruits, the size of small apples. Found in Central Africa.

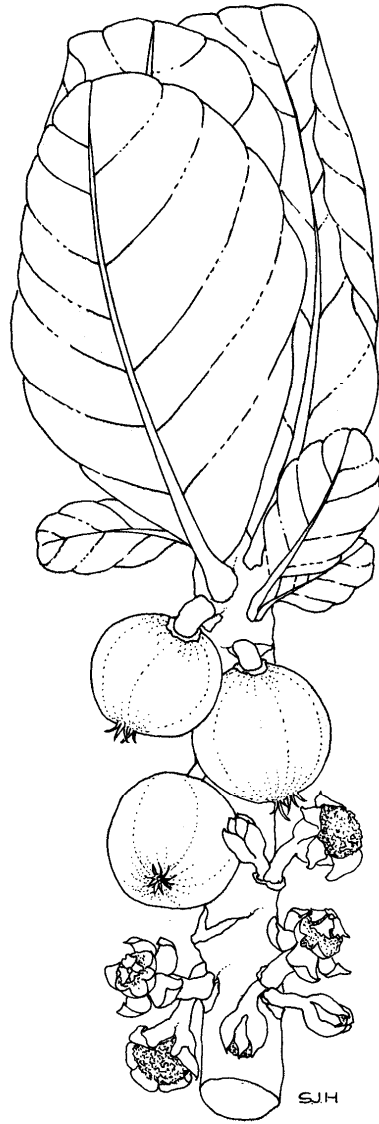
Chrysophyllum pruniforme Pierre ex Engl. Known as forcados star apple or Gabon plum, this tree bears yellow fruits the size of tennis balls. Found across West and Central Africa, it can be found at least as far eastward as western Uganda.



₦30



White star apple
(*Chrysophyllum albidum*)
NIGERIA



SJH
Uapaca kirkiana

12

SUGARPLUMS

Africa is home to more than 30 species of wild fruit trees belonging to the genus *Uapaca*. Several produce fine flavored and attractive looking fruits that are in high demand in various parts of the continent. They are an African heritage that adds zest to traditional foods from porridges to desserts. But so far none has been accorded much—or even any—horticultural recognition.

This should change. These are promising resources for widespread cultivation. They are highly respected; farmers clearing land normally leave the wild groves standing. The public likes the fruits so much that in several countries an organized trade occurs, much as if the harvest came from orchards rather than wild stands. And in nature the trees seem fully at home on adverse sites where food production is generally poor. Indeed, because of that feature they have traditionally helped people survive famine.

Fully ripe, these typically plum-sized fruits are yellow-brown in color, juicy and honeylike in taste. They enclose several white seeds, each with a characteristic ridge along its back. Most are eaten fresh, but some are pounded with water and served as a refreshing drink. If left to ferment, this sugary liquid develops into a pleasant fruit wine. In addition, tasty snacks are made from the pulp by adding water, flour, and sometimes egg, flattening the doughy mixture into round cakes, and frying them.

Although little is known about these fruits' nutritional value, it is thought to be outstanding. The level of vitamin C can be especially high. In part, this is what makes sugarplums important foods in time of famine.

When left on the tree, fruits tend to ripen unevenly. Thus, although they can be picked up effortlessly from the ground, most are picked green and stored several days in the dark. They may be put into plastic bags or other containers. Commonly, they are placed in a shallow hole in the ground and covered with leaves from the tree. Other times they are placed in the village grain bins. In each case, they are exposed to ethylene, the fruit-ripening hormone, and they ripen evenly. Once ripe, they exhibit a good shelf life.

These valuable trees could be useful components of several cultivation systems, including backyard gardens or orchard-like plantings, as well as in agroforestry operations. They are ideal tools for projects proposing to protect soil and/or conserve habitats and native biodiversity. They are promising for



More than 30 species of wild fruit trees belonging to the genus *Uapaca* can be found across Africa. Several produce fine flavored, attractive fruits that are loved wherever they occur. These yellow-brown plum-sized delights add sparkle and zest to traditional foods from porridges to desserts. Fully ripe, they are juicy and honeylike in taste. Shown here is *Uapaca kirkiana*, near Vumba Junction, Zimbabwe. (B. Wursten, www.zimbabweflora.co.zw)

food security and poverty reduction enterprises. They seem suitable for public health initiatives aimed at balancing diets and reducing malnutrition.

But no one yet knows how to get the most out of the various sugarplum species. Indeed, so much remains to be done that the possible next steps seem overwhelming. From food science to soil science, opportunities for important advances abound on all sides.

Some might advocate that a deep understanding be given priority before anyone venture into growing these fruits on a bigger scale. That was, in fact, the opinion of one contributor, who felt “popularity on the market might little affect production.” The view has merit, but as with other fruits highlighted in this book there are open opportunities for immediate amateur and professional endeavors that should not be dismissed out of hand. Indeed,

a collection of incremental improvements coming from many committed and observant people may produce faster progress than any laboratory or experiment station can deliver. Thus, in addition to formal projects, a sugarplum website might be created as a nexus for gathering and comparing information, catalyzing individual and team efforts, and sharing ideas and planting materials. And even small awards for special successes in research or promotional activities would likely stimulate dedicated investigations and outstanding developments far-exceeding any cash value of a prize.

Seen in overview, sugarplums need the same basic help as Africa's other outstanding wild fruit species. For one thing, wild resources need protection. For another, selection and perhaps breeding are needed to bring out exceptional fruits that are bigger, better, more attractive, and more valuable. Thirdly, promoting the fruits through individual, government, or group action can change attitudes toward a neglected food that has long been a traditional mainstay. And application of horticultural techniques can go far toward transforming sugarplums into crops. One specific horticultural feature to surmount is the trees' apparent tendency toward alternate bearing.

All in all, for food and health, these are worthy producers of quality fruits and, given improvement, are likely to produce far better ones than the forest fruits of today. Indeed, tomorrow's sugarplums could be astounding.

Species especially deserving of attention include the following.

Mohobohobo

The best known species (*Uapaca kirkiana* Müll. Arg.), this is one of the most popular wild fruits in the zone where eastern Africa meets southern Africa.¹ Throughout Zimbabwe, Zambia, Malawi, and Mozambique people like its sweet and pleasant taste, which is said to be somewhat reminiscent of pears. Vast quantities are eaten. Indeed, in some locations collecting parties, which may extend over several days and yield basketfuls of fruits, are organized for the enjoyment of everyone in the village. A very pleasant wine is made from them as well.

This is one of the few wild fruits with an organized distribution system. The districts where the trees grow send the fruits to distant markets. In Zimbabwe, for example, agents in Mashonaland, where the trees are abundant, truck enormous quantities of the fruits into Harare, where they are mostly sold by street vendors.

The tree producing these delights is a many-branched evergreen. Normally 5 to 6 m in height, it sometimes towers to 12 m. Commonly found on poor soils, it is often locally dominant on leached quartz sand and gravelly sites that are of little use for agriculture. In nature, it occurs mainly

¹ Mahobohobo is a Shona name. Other names include wild loquat, mazhenje, muzhanje (tree), and masuku (Zambia and Malawi). In both Malawi and Zimbabwe, the name mohobohobo is also applied to white sapote (*Casimiroa edulis*), a fruit from America.

in open woodland at medium altitudes (trees have been reported as thriving at 700-2,000 m). It seems to grow poorly at low elevations, although that may be due solely to temperature. Indeed, the plant is so frost sensitive its presence is used as an absolute indicator of frost-free zones.

Fruits are borne in clusters close to the stem. Their hard skin reddens as it ripens. Although renowned for surviving in dry areas, the most succulent fruits are said to come from wetter areas, e.g., eastern districts of Zimbabwe, where the rainfall is fair, the land slopes, and surface water drains well. Fruit here is said to ripen evenly on trees and not to need any special treatment.

Mohobohobo is a nutritious food. The ripe edible part is especially high in vitamin C (1.8 mg per g of pulp)—higher even than guava.

It is not just Zimbabwe that admires these fruits extravagantly. In Zambia *masuku* are much sought after, and for part of the year they can basically underpin the diet. The fruits are also commonly seen across Malawi, although by default the trees generally occupy the drier and poorer soils.

Reportedly, certain trees have exceptionally sweet fruits. In addition, it has been said that most trees bear a particularly heavy crop every second year. This may reflect the genetic condition known as alternate bearing or may result solely from cyclical environmental stresses on the plants.

The timber is attractive, with a reddish color and fine grain. It works easily and takes a high polish. It is fairly resistant to termites, and so is used for construction purposes. It provides a good charcoal, also.

***Uapaca heudelotii* Baillon**

This West African tree—an evergreen up to 30 m—bears strongly scented flavorful fruits containing three seeds. It extends from rainforest regions into wetter parts of the savannas. Throughout its range, people not only value the fruits, they revere the charcoal from the wood, considering it the finest of all. Goldsmiths and silversmiths throughout the area seek it out.

***Uapaca nitida* Muell. Arg.**

A small to medium sized evergreen tree reaching 10 m or more in height, this widespread species is found in Central and southern Africa, including Congo, Burundi, Zambia, Zimbabwe, Mozambique, and Angola. Its ovoid fruits are three-celled and up to 2 cm long. When ripe, they are yellow-brown and tasty, but not as tasty as the mohobohobo, which overlaps its geographical range.

The wood is used for framing beds and as a structural timber. Charcoal made from it also has a high reputation.

Sugar Plum (*Uapaca guineensis* Muell. Arg.)

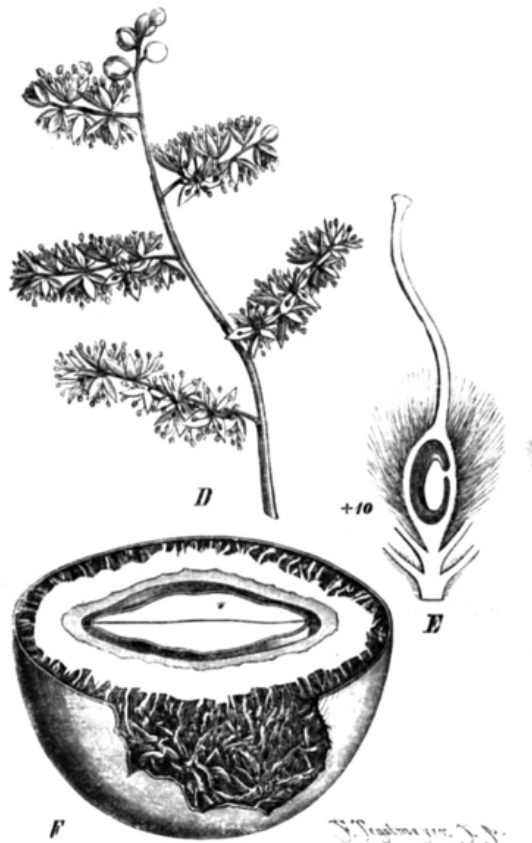
This fruit, with two distinct grooves, 3 to 4 seeds, and a sweetish pulp, comes from a forest tree of the Guinean savannas, extending from Sierra Leone eastward to the Central African Republic and Congo. It is most commonly found on steep slopes in open savanna woodlands, where the fruits are yellow or red when ripe. This savanna type is not highly esteemed, and seldom enters commerce. In the moist forest, however, the fruits are yellow, larger, fleshier, and much sweeter. Those forest types are sold in markets. In the unripe state they are also used as a cough medicine.²

An evergreen tree growing up to 30 m tall, this species produces a reddish timber whose many lines and intricate figures make it very attractive. Hard, durable, and a respectable cabinetmaking wood, it has been called a fine substitute for oak.³



² Information from P. Kio.

³ This is not southern Africa's *Uapaca guineensis*, a rare swamp forest tree now designated *Uapaca lissopyrena* Radcl.-Sm.



SWEET DETAR

Throughout much of tropical Africa the tree called detar (*Detarium senegalense* J. Gmelin)¹ is common and its rounded pods are well known. It occurs in two types. The so-called forest type is tall (to 40 m) and has reddish pods whose yellow pulp tends toward bitter and inedible. The so-called savanna type is much smaller (5-10 m) with brownish pods whose greenish pulp makes good eating. At first sight fruits of the latter type look like apricots, but physically they are more like tamarinds with a crisp shell enclosing a rather flaky pulp and a single seed. These are what are known as “sweet detars.”²

As with tamarinds (see part 1 of this volume), sweet detars are especially enjoyed in West Africa. Most are eaten fresh, but some are dried in the sun and sold in markets. Although sweet detars are today eaten largely by children, they have potential throughout society. The hard shell and dry pulp give them an exceptional shelf life and the sweet-and-sour flavor appeals to all palates.

¹ The savanna form is these days usually classified as a separate species, *Detarium microcarpum* Guillemin & Perrottet, which we treat jointly here. For taxonomic details see Berhaut, J. 1967. *Flore du Sénégal*. 2d ed. Clairafrique, Dakar.. In this treatment, *D. senegalense* has 10-13 leaflets; foliate stipules; 15-25 translucent points between 2 lateral veins; and a tomentitious calyx. By contrast, *D. microcarpum* has 7-10 leaflets; 40-50 translucent points between 2 lateral veins; and a glabrous or glabrescent calyx. (See also Lock, J.M. 1989. *Legumes of Africa: a Check List*. Royal Botanic Garden, Kew.)

² Other English common names include tallow tree, dattock, and dittock. Although sweet detar is little known to science, the tree and its fruit have an abundance of names in languages across western Africa. The following list is far from inclusive. *Arabic*: abu leita, abu leila; *Amharic*: gudi; *English*: sweet detar, sweet dattock (*D. microcarpum*), tallow tree (*D. senegalense*); *French*: détar, ditax, detah de Sénégal, niey datah, datah ney, boiré; *Wolof*: ditah (*D. senegalense*); dank (*D. microcarpum*); daha, dak, detax, detakh, ditakh, ditarh, wanta; *Serer*: ndoy (*D. microcarpum*); *Bambara*: bodo (*D. microcarpum*); *Mossi*: kaguédéga (*D. microcarpum*); *Hausa*: tsada (*D. microcarpum*); *Igbo*: ofo (*D. microcarpum*); *Hausa*: taura (*D. microcarpum*); *Kanuri*: gatapo (*D. microcarpum*); *Nupe*: gungorochi (*D. microcarpum*); *Tiv*: agashidam (*D. microcarpum*); *Jola*: bugungut, butchanjack, boubounkouté, fulibehen, mounhayona; *Mandika*: bodo, mamboda, taba, taleo, tallo saranokke, woko; *Fula*: boto, boto-burareh, botomel, dile, karkehi, konkehi, mobdey

Although normally consumed out of hand, sweet detars are also processed in different localized ways. In northern Nigeria, to mention just one locale, they are mixed with other fruits,³ and boiled, strained, and concentrated into a sweetmeat resembling fruit leather. In Sierra Leone, they are made into refreshing drinks. One interesting feature: if a ripe fruit dries out, it can be revived by a soak in sugar water—the result being eaten as if it were freshly picked and the liquid being used separately as a fruity drink.

Sweet detar is an outstanding source of vitamin C—perhaps the finest of all. In 1988, researchers studying 29 fresh fruits consumed in Senegal discovered it to be the richest in vitamin C (up to 1,180 mg per 100 g). Nothing else came close.⁴ One analysis of the pulp showed it about half sugar, with about 20 percent fiber, 4 percent protein, and 2 percent fats (on a dry-weight basis).⁵

Botanically speaking, this species, a legume, is related to tamarind. It produces equally vast quantities of fruit—indeed, the tree sometimes becomes almost enshrouded in dangling pods. Robust and resilient, it is a candidate for reforestation purposes. Although leguminous, it is probably not nitrogen fixing. Like tamarind, carob, and honey locust, it belongs to the Caesalpinoideae, a subfamily whose species usually possess few or no nodules, let alone rhizobial bacteria. Nevertheless, it survives in harsh and infertile sites and it tolerates some drought and much heat.

All in all, sweet detars seem likely to make good backyard-, village-, and street trees, providing welcome shade and copious food. Among its other useful outputs are the following:

Seeds The purple-brown, sweetly scented seeds have edible kernels. To extract those kernels, the fruit is broken open, the seeds are boiled for an hour, and their seedcoats removed. The resulting naked kernels are normally pounded into powder. In part of southern Nigeria this *ofò* flour is commonly added to egusi soup or cooked separately with leafy vegetables.⁶ It is notably nutritious, having about 12 percent of a protein that is rich in the amino acids lysine and tryptophan.

³ Notably jackal berry (see Ebony chapter) and black plum (Chocolate Berries chapter).

⁴ It was followed by baobab at 165 mg per 100 g (see Baobab), guava (156 mg), and cashew (150 mg); both guava and cashew are tropical-American in origin. Diop, P.A., D. Franck, P. Grimm, and C. Hasselmann. 1988. High-performance liquid chromatographic determination of vitamin C in fresh fruits from West Africa. *J. Food Compos Anal.* 1(3):265-269. It should be noted, however, that detars vary in their vitamin C content, depending on their level of sourness, with some exceeding 1,200 mg per 100 g.

⁵ Favier, J-C., J. Ireland-Ripert, C. Toque, and M. Feinberg. 1999. *Répertoire Général Des Aliments: table de composition* (2nd ed.). Le Centre Informatique sur la Qualité des Aliments (CIQUAL), Maisons-Alfort cedex, France.

⁶ It is eaten notably with leaves of *Pterocarpus*, tree legumes that produce tasty leaves and some of the world's great timbers. Egusi and egusi soup are dealt with in the companion volume on African vegetables.



Sweet detar keeps well, and this traditional fruit could soon become available not just in regional cities but places far away from home. Although most sweet detar is still eaten fresh from the tree (especially by children), entrepreneurs in West Africa are bringing it to market in juices, extracts, purees, jams, dried fruit “leathers,” and even as a “paté” with other fruits. (Amadou Malé Kouyaté)

The kernels are also crushed to extract their oil for culinary use. The solid residue remaining from this process is employed as animal feed. The seeds are also fashioned into ornaments. Indeed, they are commonly beaded onto strings to form necklaces that exude their own natural fragrance.

Wood The trees furnish excellent timber. Often called “African mahogany” (a name applied to other woods as well), the heartwood is dark, reddish-brown, and very heavy. Hard yet easily worked, it has a fine and regular grain and is eagerly sought for carpentry, joinery, and other premium purposes. It resists moisture, weathering, borers, and termites, so it is also prized for houses, boats, and fences, not to mention firewood and charcoal.

Resin If damaged, the bark exudes a sticky, pleasantly scented gum used to fumigate clothes and huts, especially in hopes of banishing mosquitoes.

For all its utility, this tree remains a wild plant. Presently, it is unknown in intensive plantations, or even in extensive village plantings. Rather, it occurs in outlying forests or farm fields where scattered specimens remain from the days the land was cleared. The wood is much sought-after, but neither sweet detar nor the several other *Detarium* species has yet been

accorded much silvicultural investigation. Now is the time. As a legume, it is tolerant, adaptable, generally reliable, and relatively insensitive as to site, soil, altitude, heat, or humidity. Silvicultural success could catapult into widespread use a new forestry resource that reduces malnutrition and contributes to rural development while it grows a great timber.

PROSPECTS

Because sweet detar is among the least understood of Africa's useful trees, projecting its prospects is difficult. However, the following seem to be reasonable expectations:

Humid Areas Uncertain but probably good prospects. Although unreported from locations where rainfall and humidity are high, the tree should thrive there (absent any particularly devastating pest or disease). It could possibly become a viable resource in all locations where tamarinds grow. Prospects seem especially good in Senegal (notably in the tropical province called Casamance), Gambia, and Sierra Leone where local interest in sweet detars is especially high. In those and the nearby countries the trees are carefully preserved whenever land is cleared.

Dry Areas Excellent prospects. These are climatic zones where detar finds its greatest humanitarian prospects. All trees providing resources in these hot, dry, exasperating locales will be welcomed as a boon.

Upland Areas Fair prospects in limited locations. Today, no one can say for sure just how well this untamed tree will do beyond its geographical home in the tropical lowlands. Certainly, however, it deserves testing at altitude, but only where temperatures remain well above freezing.

NEXT STEPS

To boost sweet detar into its rightful place in the food-resource base several initiatives can be envisaged. Most are suited to small-scale local actions because they require determination and intelligence more than international intervention, elaborate facilities, or academic perfection. Following are examples.

Survey the Scene First, people throughout tropical Africa (particularly West Africa) should assess local forests and fields and evaluate the various detar trees for productivity, genetic differences, pests, diseases, soil types, fruit quality, and other economic variables.



A mature sweet detar on the St. Augustine Campus of the University of the West Indies. Robust and resilient, sweet detar is a candidate for reforestation purposes. This legume survives in harsh and infertile sites. All in all, it seems likely to make good backyard-, village-, and street trees, providing welcome shade and environmental benefits, not to mention highly nutritious food. (Pat McGaw, Friends of Botanic Gardens of Trinidad and Tobago)

Preservation and Genetic Selection Second, in-depth germplasm collections should be made to preserve any unique diversity discovered. The edible types to be found in different parts of Africa, for example, could be collected together and compared for sweetness. Over time, the best should then be formally identified and propagules disseminated for further tests. Those plants showing the most horticultural promise can subsequently be further propagated, perhaps by vegetative means; if they exist today, so much the better.

Information Exchange Third, the traditional means of handling, processing, marketing, and eating the fruits should be reviewed. The use of the various byproducts—resin, root-sugars, seeds, and seed oil—should also be detailed. This will create the baseline of knowledge whose lack now holds this crop back. Sharing this information electronically is now easy.

Nutrition As of now, no one knows just how good a food it is. Other than the outstanding vitamin C measurements, little nutritional information is

readily available. Detar pulp contains sugar and other carbohydrates, but portions may vary wildly. Chemical analyses and nutritional research could quickly tell much.

In a related vein, tests should be run to answer lingering uncertainties over toxicity. Of possible special concern are small, abortive, galled fruits that sometimes appear. They are unlikely to be mistaken for normal fruits, but they are rumored to be harmful.⁷

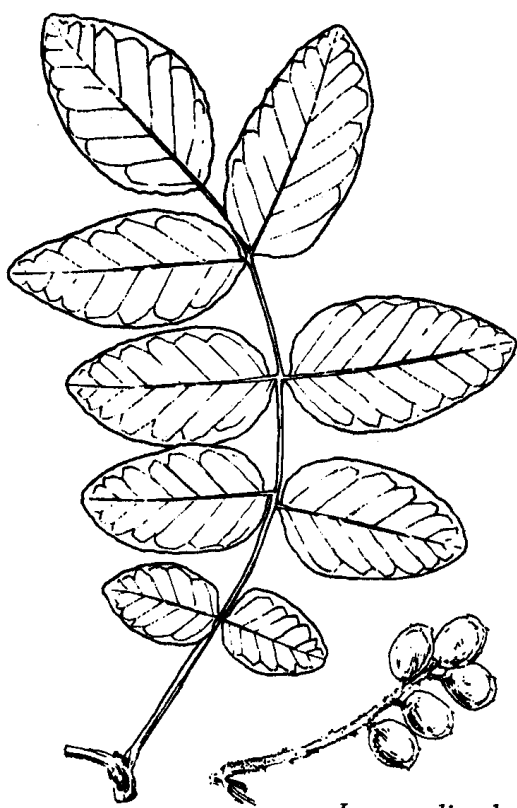
Horticulture Preliminary investigations reveal that the species can be propagated by budding.⁸ This discovery enhances prospects of domestication and multiplication. Therefore, attempts via bud-grafting could be made to grow sweet detar in provenance trials in different parts of tropical Africa. Comparing various types under different environments will provide the means for evaluating their relative performances relatively quickly. Also, for any obviously promising plants bud-grafting could even now be used to develop exploratory commercial plantations.

Plantings The species should be immediately tested as a landscape tree, regardless of the food value of the best-looking types. Detar is a beautiful tree, hailing from the homeland of the tamarind, and perhaps could also help shade and enliven many a now-sun-scorched and dreary vista. Tests of this possibility for making life in the tropics more bearable should be mounted. If the trees in such plantings produce great fruit, so much the better.

⁷ If taken in excess they are reputed to cause vertigo. However, a contributor notes that: "There is no data! It is all hearsay so far."

⁸ Information from J.C. Okafor.





Lannea discolor

TREE GRAPES

About 40 different trees belonging to the genus *Lannea* are about equally divided between the tropics of Asia and Africa. The Asian species have received some horticultural assessment, but the practical literature tells little about the score or more native between Madagascar and Senegal.

Yet out of these African species perhaps a dozen merit consideration as future food resources. Wherever they occur their fruits are avidly eaten; some already play a part in commerce. In West Africa, for instance, people commonly sell them both in city markets and along rural roadsides—a feature to be witnessed in and around Ouagadougou, for example.

Although *Lannea* belongs to the Anacardiaceae, the same family as mango, cashew, and pistachio, the fruits are more like grapes. They come in pendulous bunches and are reddish, purple, or black, with a whitish bloom on the skin. Although some have a resinous taste, many have a pleasant flavor commonly described as “grape-like.”

In other ways, however, lannea fruits differ greatly from grapes. They are borne on trees, not vines. Most are much smaller than today’s cultivated grape—being about 1 cm long at full ripeness. Each is capped at one end with three or four little “horns,” the remains of the flower’s styles. And inside, one finds a central stone. Indeed, botanically speaking, they are more like plums than grapes, and are classified as drupes, not berries.

The trees themselves seem conducive to cultivation. They are resilient, tolerant of drought, and often occur naturally in harsh sites, including some in which the human inhabitants have few food options.¹ They resist burning; the ground fires that are so prevalent and so destructive in the savannas leave them undamaged. The flowers attract bees in such numbers that beekeepers fight to hang their hives amid the branches.

Like the grape of international commerce, African tree grapes have multiple uses. They make a very good jam. Their juice is fermented into

¹ In parts of the Horn of Africa, the roots of some *Lannea* species (mostly *Lannea triphylla*) are often considered more important as food than the fruits. After the rains come, but before anything has grown to eat, these *Lannea* roots swell to become juicy and tasty. Digging the roots can destroy the tree but save lives, and some efforts have begun to turn this desperation food into a sustainable resource.



Tree Grapes. Although in the same plant family as mango, cashew, and pistachio, tree-grape fruits show their grape-like form. They also hang in bunches like grapes. And when ripe they are reddish to purplish-black skins with a whitish bloom. Perhaps most intriguing, many have a pleasant flavor described as truly “grape-like.” These are thought to be *Lannea microcarpa*, photographed at Malamawa Jibrim, 13 km southwest of Zinder, Niger. (Josef Garvi, Eden Foundation)

“wine.” They can be dried like raisins and safely put aside for later use. And those “tree raisins” themselves can be fermented into a beverage—an often-all-too-potent beverage.

Even when the fruits are unwanted, these trees are useful. They coppice well and sprout with vigor if the branches are cut at the proper time of year. This makes them useful for live hedges. The bark yields a water-soluble edible gum and a reddish-brown dye, as well as a fiber used among other things for cordage. The living trees also provide poles and floats for fishing. Oil from the seed kernel is used for soap and unguents.

These versatile wild resources are well worth exploratory research. Tree grapes are plants that could especially reward adventurous botanists, horticulturalists, and ethnologists. For plant physiologists and pathologists they present some fascinating mysteries. For horticulturists, their selection and growth requirements are complex enough to challenge the best minds. And anyone succeeding in overcoming these plants’ problems will reap the satisfaction of having created crops capable of contributing to the health and wealth of some of the world’s most destitute corners.

Whether any of these species have a future in substantial cultivation, or even in enhanced production in the wild, is unclear. Finding out is important. One first step might be the documentation of traditional usages. As the plants are already widely known, information on the various local ways of using it will enable an assessment of their continent-wide potential. Nutrition research and consumer trials could complement this local-uses information. After the plants' baseline information becomes better known, the practical research and development activities can be undertaken with more confidence. Also, it will then become easier to carry out awareness campaigns leading to greater popularity, improved production, and perhaps new profit in terms of subsistence and income.

Certainly, it will not be easy to advance these resources. Tree grapes are notoriously difficult to propagate vegetatively.² This poses a problem because plants grown from seed take years before they start flowering, and growers must wait an inordinate time before learning whether an individual tree is male, female, hermaphrodite, or hermaphrodite-but-functionally-female, and whether the fruit is worth eating. The adventurous souls who address such challenges typically plant groups of seeds, and then later rogue out all of the unwanted types. This is wasteful of time, effort, and money, and is unlikely to ever be widely adopted in everyday practice.

One advance that would make everything else more successful is the selection of types that provide the best eating. Such genetic selection yet awaits the dedicated, observant, and practical pioneers.

Following are brief descriptions of the best-known species.

Lannea edulis (Sond.) Engl. The "wild grape" of the southern half of tropical Africa³ is a common and well-liked fruit that grows on what has been called an "underground" tree. The mass of this amazing plant is mostly buried out of sight beneath the soil. The subterranean trunks, often as thick as fenceposts (13 cm in diameter), creep along just beneath the surface. The branchlets bearing the leaves, flowers, and fruits stick up only slightly (3-30 cm) above ground. The whole tree nonetheless can be very big. A single specimen may cover many square meters, but disguised in the dirt, its massive size is seldom realized. In addition to its self-burying trunks, a deeply penetrating root system anchors the tree and endows it exceptional survivability under drought stress.

Moreover, this is not the only unusual botanical feature of this strange species. At the end of the dry season, bunches of small flowers pop out

² Information from J.D. Carr.

³ It is known, for example, in South Africa, Botswana, Namibia, Zimbabwe, Zambia, Malawi, Angola, and Congo. In Zambia and Zimbabwe, it is a common shrub of woodland and vlei margins on the high veld. The trees are often so inconspicuous as to be noticeable only in land cleared for cultivation.

directly from the leafless stems, each bunch hanging from the bare wood and looking for all the world like creamy-yellow tinsel sprinkled over the land. People like these almost magical flowers, which are harbingers of the rains and of the better times soon to arrive.⁴

Later, the fruits begin forming. Eventually, they hang in grape-like bunches almost touching the ground, ripening slowly from pink through scarlet to wine-red and eventually black. Inside their thin skin is found smooth green flesh and a bean-shaped stone. In most the layer of pulp is thin, but whatever there is normally is juicy and pleasantly sour. They are exceptionally popular, particularly with children. Throughout much of southern Africa, kids squeezing tree grapes between their fingers and shooting the pulp into their mouths is a common sight.

Lannea discolor (Sond.) Engl. The plant known as “live-long” is also from the southern regions, but it grows in the normal fashion above ground. It is common in open grassland, bush, and woodland from Swaziland and South Africa (Gauteng) to northern Namibia, Mozambique, Botswana, Zambia, Zimbabwe, and Congo. It is deciduous and grows above ground, reaching 15 m in height. It is one of the first trees to drop its leaves as the rainy season winds down.

Interestingly, this is one of the few plants of any kind that are established by planting branches.⁵ The ends of even large limbs are jabbed into the soil, where they strike new roots and flourish. In this manner, people get living fenceposts—hence the name “live-long.” Several cultures revere these trees, believing them to be favorite haunts of ancestral spirits.⁶

The fruit is reddish to purple, and merely the size of a pea. It has a pleasant grape-like flavor, and is popular. At least in Zimbabwe, the plants flower in spring and normally fruit before the onset of the main rains.⁷

Lannea microcarpa Engl. This tree grape of western Africa is enjoyed for both its fresh fruits and dried “raisins.” In either form, it is mostly boiled up into a sweet beverage. Particular types (sometimes designated as a separate species, *Lannea oleosa*) are apparently raised as a fully domesticated fruit crop in certain parts of West Africa. Indeed, this resource is even now of

⁴ Although the flowers normally come before the rains and the leaves after, it is not unusual for both to appear together.

⁵ This process of planting large woody cuttings may be more practical than professionals have assumed. Today, with the availability of rooting hormones and a desperate need for trees, the possibility of planting branches deserves a thorough exploration. Not only would it create “instant forests,” but it might circumvent hazards that take out tree seedlings, and thereby dramatically raise reforestation’s success rate (now miserably low in all too many locations).

⁶ Swazis call it “the tree of forgetfulness,” believing it to harbor benevolent spirits who reconcile any enemies that meet in its shade.

⁷ Information from Ray Perry.

commercial importance. It is widely consumed in Burkina Faso, for example, and the tree is often seen cultivated in and around villages. It grows to 15 m tall, and because of the shade and tasty bounty it is typically protected when farmers clear wood from future cropland.

And there are other useful products as well. The seed comprises a thin shell surrounding a kernel, whose copious oil is sometimes used to make soap or skincare products. The young leaves are edible and nutritious, containing 18 percent protein and 5 percent minerals. Cattle as well as passing humans commonly “browse” the foliage. Also, an edible (and soluble) gum exudes when the trunk is damaged.

Lannea acida A. Rich. Notably common from Senegal to Niger and Benin, this West African tree grape is found as far to the east as Cameroon and the Central African Republic.⁸ A tall tree (up to 18 m), it occurs chiefly in the untouched bush far from villages. Its berry-like fruits (about 1 cm across and 1.5 cm long) occur in large clusters. Red to purple in color, they are popular and are consumed either fresh or dried. In dried form they look like currants and can be stored for use months later. To the tastebuds, the fresh fruits are slightly acidic and somewhat resinous. Both fresh and dried types are widely eaten and both are also fermented into drinks reminiscent of apple cider.

The tree has only a brief fruiting period, but this coincides with the months when other foods—especially nutritious foods—are scarce. The young leaves are also edible, and they develop even before the rainy season begins. Both features help allay vital food-security fears.

The plant tolerates dry soils but apparently requires either moist sites or annual precipitation of at least 600 mm to yield fruits well. It has above-average fire resistance, a critical feature in savannas where summer ground fires devastate any sensitive species.

Although not cultivated on an organized basis, this tree grape can be deliberately planted and it grows well under human care. Prior to planting the seeds need a good soaking in warm water. A 2-minute acid bath, followed by washing and soaking 12 hours in water, is also recommended.⁹ The seeds then germinate well in soil-filled plastic bags. In the nursery, protection against rodents is necessary. The plant is dioecious, so to produce fruits a few males must be interspersed among many females.

⁸ It is called variously npekuni (Bambara), bembo (Mandinka), peguhi, bembey (Fula), sabaga, sabgha (More), and sonn (Wolof).

⁹ Bellefontaine, R. 1995. Synthèse des espèces des domaines sahélien et soudanien qui se multiplient naturellement par voie végétative. Pp. 95-104 in d'Herbès, J.M., J.M.K. Ambouta, and R. Peltier, eds, *Actes de l'Atelier "Fonctionnement et gestion des écosystèmes forestiers contractés sahélien"*, Niamey, Nov. 1995. ORSTOM - CIRAD - Ministère de l'Agriculture, Niamey.

Whether other African tree grapes have any merits is uncertain. Among those recommended to us are the following.

Lannea grandis. (Dennst.) Engl. West Africa. Shrub of the forested savannas.

Lannea alata Engl. Tropical Africa. Fruits are edible. "Wool" stripped out of the root bark is used for padding and for stuffing mattresses.

Lannea fulva (Engl.) Engl. Shrub and tree to 20m tall.

Lannea gossweileri Exell & Mendonça Tropical Africa, including Zambia, Congo (Katanga), Angola, and Namibia.

Lannea kerstingii Engl. & K. Krause Tropical Africa.

Lannea velutina A. Rich. Western tropical Africa (Senegal to Ghana). Shrub or tree to 15 m. Fruit edible, foliage browsed.

Lannea welwitschii (Hiern) Engl. West and Central Africa (Côte d'Ivoire to Uganda, as well Congo and Angola). Abundant in Cameroonian forests. The tree reaches 30 m. tall. Its small fruits (6-7 mm long) are blackish, viscous, and smell somewhat of turpentine. Regardless of that, they are widely eaten.



Appendix A

BIOGRAPHICAL SKETCHES OF PANEL MEMBERS

Norman Borlaug, Chair, is Senior Consultant to the Director General of CIMMYT (International Maize and Wheat Improvement Center), as well as Distinguished Professor of International Agriculture at Texas A&M University, and President, Sasakawa Africa Association. A Nobel Peace Laureate, member of the National Academy of Sciences, and Founder of the World Food Prize, he is the recipient of nearly 60 honorary degrees. Dr. Borlaug's early work in plant pathology, wheat breeding, and agronomic systems has led him to become one of the best-known spokespersons and ambassadors for tropical agriculture and food security. Dr. Borlaug remains deeply involved in enhancing African agriculture through the Sasakawa Africa Association and its Global 2000 Partnership with the Carter Center, whose mission is raising the productivity of African farmers through sustainable development and equitable and responsible use of resources. Borlaug is from the U.S., and has a doctorate in plant pathology from the University of Minnesota.

Anthony Cunningham is Professorial Research Fellow at Charles Darwin University in Fremantle, and Director of People and Plants International, the follow-through to the WWF/UNESCO/Kew "People and Plants Initiative," which he helped found and for which he was African Regional Coordinator through 2000. An ethnoecologist whose work focuses on the applied ecology of natural-resource use by people, his early research was on traditional foods in southern Africa. Much of his research is tied to implementation processes promoting collaborative resource management programs between local communities and outside influences such as government, NGOs, and conservation or commercial interests. Cunningham is from South Africa, with a doctorate in botany from the University of Cape Town.

Jane I. Guyer is Professor of Anthropology at Johns Hopkins University, after moving in 2002 from Northwestern University where she was Professor of Anthropology and Director of African Studies from 1994. Professor Guyer, a Woodrow Wilson Fellow in 2003, specializes in African studies, social anthropology, and the study of production and distribution systems, in particular the anthropology of the economy and material life in West and Equatorial Africa. She focuses on the growth and change of indigenous economies, with a special emphasis on food economies and money management outside structured systems. Professor Guyer's most recent book is *Marginal Gains: Monetary Transactions in Atlantic Africa*, which focuses on the function of popular economic systems in Africa, from crisis conditions to ordinary household budgets. Guyer, a U.S. citizen, is from England, and has a doctorate in anthropology from the University of Rochester.

Hans Herren has been President of the Millennium Institute since 2005. Dr. Herren served as Director General of the International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi for twenty years, prior to which he was with the International Institute of Tropical Agriculture. An agronomist and entomologist, Dr. Herren has spent most of his working life in Africa, where his research has been on the field-level union of science-led information with local production systems, particularly emphasizing pioneering applications of integrated pest management. His latest research efforts address poverty alleviation, sustainable agricultural productivity, and biodiversity conservation in Africa. Herren's contributions to improving Africa's food security, particularly research and control of the cassava mealybug through the world's largest biological control project, have been recognized through many awards, including the Tyler Prize for Environmental Achievement and the World Food Prize. A Foreign Associate of the National Academy of Sciences, Herren is from Switzerland, with a doctorate in agricultural sciences from its Federal Institute of Technology.

Calestous Juma is Professor of the Practice of International Development and Director of the Science, Technology and Globalization Project at the John F. Kennedy School of Government at Harvard. He is a Member of the National Academy of Sciences and the Kenya National Academy of Sciences, and Fellow of the New York Academy of Sciences and the World Academy of Art and Science. Dr. Juma is former Executive Secretary of the United Nations Convention on Biological Diversity and founding Executive Director of the African Centre for Technology Studies in Nairobi, an independent public policy research

institution. His research, beginning with field work with indigenous crops in Kenya, includes biodiversity and biotechnology, evolutionary and systems theory, science and technology policy studies, institutional change, and international trade and environmental policy. Dr. Juma has written widely on issues of science, technology and environment, including *Science, Technology and Economic Growth: Africa's Biopolicy Agenda for the 21st Century*. Juma is Kenyan, with a doctorate in science and technology policy studies from the University of Sussex.

Akinlawon Mabogunje was Chair of the Development Policy Centre in Ibadan, Nigeria until retirement, and serves as co-convenor of the international Initiative on Science and Technology for Sustainability. He is also Chairman of the Nigerian Presidential Technical Committee on Housing and Urban Development. Formerly Professor of Geography, Dean of the Faculty of the Social Science, and Director of the Planning Studies Programme, University of Ibadan, he was also President of the International Geographical Union. Dr. Mabogunje served as Advisory Committee Chair for the Urban Management Programme of the United Nations Centre for Human Settlements and Vice-Chairman of the Directorate of Food, Roads and Rural Infrastructure, Office of the President, Nigeria. A Foreign Associate of the National Academy of Sciences, Dr. Mabogunje's work explores continuity and development of rural/urban/regional interactions in Africa over time, with increasing attention to future issues of sustainability. Mabogunje is from Nigeria with a doctorate in geography from University College London.

Barbara Underwood, Adjunct Professor of Nutrition (Pediatrics) at Columbia University, was until recently Scholar in Residence at the U.S. Institute of Medicine, and is Past President of the International Union of Nutritional Sciences. Prior to retirement she was Chemist at the National Eye Institute of the U.S. National Institutes of Health, where she also served a secondment as Scientist in the Nutrition Unit of the World Health Organization. Dr. Underwood has broad experience in international nutritional deficiency and maternal/child health problems, with recent work devoted to development of global policy and guidelines for the control of micronutrient deficiencies of vitamin A, iron, and iodine. Her laboratory developed and first applied in human populations the Relative Dose Response (RDR) test to indirectly identify depleted vitamin A stores. In addition, her research and training interests have focused on nutritional problems of mothers and children in deprived circumstances. Underwood is from the U.S., and has a doctorate in nutritional biochemistry from Columbia University.

Montague Yudelman has been involved in international agricultural development for close to 50 years. A Woodrow Wilson Fellow, he has also been a Senior Fellow at the World Wildlife Fund for Nature (WWF) in Washington. He was on the staff of the Rockefeller Foundation during the gestation of their international agricultural research program, and later Director of Agriculture and Rural Development at the World Bank. He has taught at Harvard University and the University of Michigan and served as Vice President of the OECD Development Center. He was Chair of the Board of Trustees of the Population Reference Bureau and serves on the Board of The Vetiver Network, among other organizations. He has published widely in the field of agricultural development, food production, and pest management, including the 1964 standard, *Africans on the Land*, and the International Food Policy Research Institute's 2020 Vision Discussion Paper (32) on *Integrated Nutrient Management, Soil Fertility, and Sustainable Agriculture: Current Issues and Future Challenges* (with Peter Gruhn and Francesco Goletti). Yudelman, a U.S. citizen, is from South Africa, and has a doctorate in agricultural economics from the University of California at Berkeley.

Appendix B

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INTER FOLIA FRUCTUS
"Among foliage fruit"
Latin maxim