

NON-WOOD FOREST PRODUCTS

6

Gums, resins and latexes of plant origin



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**Gums, resins
and latexes
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by
J.J.W. Coppen

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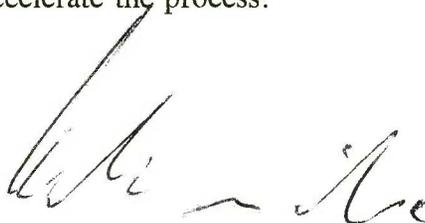
FOREWORD

Gums, resins and latexes are employed in a wide range of food and pharmaceutical products and in several other technical applications. They form an important group of non-wood forest products (NWFPs) and are the basis of a multi-billion dollar industry. These products, particularly gums, enter into world trade in a significant way and this is indicative of the potential of NWFPs for value addition at various stages from harvesting of raw materials to the end-uses.

This publication deals with important gums, resins and latexes following a standard format, covering description and uses, world supply and demand levels, plant sources, collection and primary processing, value-added processing, other uses and developmental potential.

This document was prepared by J.J.W. Coppens of the UK/ODA Natural Resources Institute, who is an authority on the subject. Formatting and proofreading of it were ably done by Elisa Rubini. Its preparation and publication was guided and supervised by C. Chandrasekharan, Chief, Non-Wood Products and Energy Branch. I am grateful to them for their contributions.

Some of these products presently suffer competition from synthetic products. There is, however, clear evidence of re-emergence of awareness and interest in these natural products and it is expected that this publication can accelerate the process.



Karl-Hermann Schmincke
Director
Forest Products Division

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ABBREVIATIONS

BP	British Pharmacopoeia
CIF	Cost, insurance and freight
EC	European Community
EOA	Essential Oil Association of USA
FAO	Food and Agriculture Organization of the United Nations
FAQ	Fair average quality
FOB	Free on board
ha	hectare
HPS	Hand picked selected
ISO	International Standardization Organization
JECFA	Joint FAO/WHO Expert Committee on Food Additives
NAS	National Academy of Sciences (USA)
US\$	United States dollar
WHO	World Health Organization

In all Tables:

- indicates nil
- ~ indicates < 0.5 tonnes
- na indicates not available

GLOSSARY OF TECHNICAL TERMS

Absolute

A highly concentrated extract, usually liquid but occasionally semi-solid or solid, prepared by alcohol extraction of a material which is either (a) already in the form of a natural balsam or oleoresin, (b) is a resinoid or (c) has previously been prepared by extraction of plant material with a hydrocarbon solvent. Absolutes are much used in perfumery.

Balsam

A resin or oleoresin exudate characterized by a high content of benzoic or cinnamic acids and their esters. They have a characteristic "balsamic" odour.

Gum

Vegetable gums, i.e., those gums obtained from plants, are solids consisting of mixtures of polysaccharides (carbohydrates) which are either water-soluble or absorb water and swell up to form a gel or jelly when placed in water. They are insoluble in oils or organic solvents such as hydrocarbons, ether and alcohol. The mixtures are often complex and on hydrolysis yield simple sugars such as arabinose, galactose, mannose and glucuronic acid.

Some gums are produced by exudation, usually from the stem of a tree but in a few cases from the root. The exudation is often considered to be a pathological response to injury to the plant, either accidental or caused by insect borers, or by deliberate injury ("tapping"). Seed gums are those isolated from the endosperm portion of some seeds. (Other vegetable gums can be isolated from marine algae (seaweeds) or by microbial synthesis but these are not discussed in this report).

The term "gum resin" is occasionally found in the literature but it has no precise meaning (and is best avoided) although it is generally used to describe a resinous material which contains some gum. The coagulated part of some commercially important latexes such as chicle and jelutong are often referred to as non-elastic gums or masticatory (chewing) gums, but they are not gums in the proper sense of the word.

Latex

A fluid, usually milky white in colour, which consists of tiny droplets of organic matter suspended or dispersed in an aqueous medium. The most well-known example is rubber latex, in which the solids content is over 50% of the weight of the latex. The solids can normally be coagulated to form a solid mass by boiling the latex. The principle components of the coagulum are *cis* or *trans* polyisoprenes and resinous material. If the polyisoprene is mainly *cis*, it confers elasticity to the solid and makes it rubber-like; if it is mainly *trans*, the solid is non-elastic and gutta-like.^{1/}

^{1/} The terms *cis* and *trans* denote the particular molecular geometries exhibited by certain types of chemical compound, in this case the polyisoprene. The term gutta is a short form of gutta percha, the coagulated latex obtained from *Palaquium* spp.

Latexes are usually obtained by cutting the plant to make it bleed. Latex-yielding plants occur in fewer families than those which produce gums and resins; Apocynaceae, Euphorbiaceae and Sapotaceae are among the important ones.

Oleoresin

A resin which, because of a high content of volatile oil, is softer than one which contains little or no oil. The term is, nevertheless, sometimes shortened to resin when describing soft resins. (The term is also used in another context to describe prepared extracts of spices or other plant materials – after evaporation of the solvent used to extract the spice a soft extract, or oleoresin, remains.)

Resin (natural)

A solid or semi-solid material, usually a complex mixture of organic compounds called terpenes, which is insoluble in water but soluble in certain organic solvents. Oil-soluble resins are soluble in oils and hydrocarbon-type solvents; spirit-soluble resins are soluble in alcohols and some other solvents.

Resins are very widely distributed in the plant kingdom although a few families are notable in accounting for a large proportion of the resins of commerce (e.g., Leguminosae, Burseraceae and Pinaceae). Resins can occur in almost any organ or tissue of the plant; a few (such as lac) are produced from insects. Most resins of commerce are obtained as exudates by tapping.

Resinoid

A viscous liquid, semi-solid or solid prepared from a natural resin by extraction with a hydrocarbon-type solvent. They contain any volatile oils originally present in the resin and are often used for fragrance purposes.

INTRODUCTION 1

Apart from essential oils, which provide an array of flavours and fragrances, gums, resins and latexes are perhaps the most widely used and traded category of non-wood forest products other than items consumed directly as foods, fodders and medicines. A recent estimate put the value of the world market for gums used as food additives at about US\$ 10 billion in 1993, of which the two largest "forest" gums (gum arabic and locust bean) accounted for just over 12%; the remainder were mainly the seaweed gums, starches, gelatin and pectin (NAUDE, 1994). This takes no account of non-food uses of gums.

Some idea of the quantities of natural gums and resins which enter international trade can be gained by examining trade statistics. Imports into the European Community of "natural gums, resins, gum-resins and balsams", excluding gum arabic, are given in Table 2 for the period 1988-93. Annual imports averaged approximately 20 000 tonnes. Inclusion of gum arabic (Table 6) adds a further 28 000 tonnes to this figure.

Indonesia, India and the People's Republic of China are among the world's biggest producers of gums and resins, and exports from these countries are shown in Tables 3, 4 and 5, respectively. Note that some of the figures in Table 3 (and Table 2, Brazil) are distorted by the inclusion of pine resin^{2/}. Sudan (Table 12) and Indonesia are the world's two biggest exporters of natural gums and resins.

The uses of the gums discussed in this report are elaborated in the sections concerned, but they embrace food, pharmaceutical and miscellaneous technical applications. In the food industry, advantage is taken of their thickening, stabilizing, emulsifying and suspending properties and they are employed in a very wide range of products, both foods and drinks. In the pharmaceutical industry they are used as binding agents in tablets and as suspending and emulsifying agents in creams and lotions; some have specific applications in the dental and medical fields. Miscellaneous end users include the printing and textile industries.

Resins, including oleoresins and balsams, have an equally diverse range of applications, although the volumes which are traded have declined considerably (with the exception of pine resin) over the last 50 years.

Their use in paints, varnishes and lacquers, in particular, has suffered as cheaper, synthetic alternatives have become available. Some resins, however, are still used in this way. Others, especially the soft resins and balsams, are used as sources of fragrances and pharmaceuticals, usually after preparation of a suitable solvent extract or distillation of a volatile oil.

The decline in use of certain types of natural product at the expense of synthetics, referred to above in the case of resins, has been even greater for most of the latexes discussed in this report. In their heyday in the early part of the century, they were produced in large volumes

^{2/} Annual world production of pine resin is almost one million tonnes, making it by far the most important natural resin of commerce. It is obtained by tapping pine trees and is used as a source of turpentine and rosin, but it has been reviewed in detail elsewhere (COPPEN and HONE, 1995) and is not discussed in this report.

to meet the needs of the growing chewing gum industry and for use in specialized applications such as insulating materials and the manufacture of golf balls. Today, their use is but a fraction of what it was.

The decline in use of many gums, resins and latexes is a reflection of industry's general preference for raw materials which are of consistent, predictable quality, which are not subject to the vagaries of weather, insect pests and economic and political stability in producing countries, and which are available at an attractive price. In many cases, the synthetic alternatives which meet these needs are also technically superior to the natural products they replace. Notwithstanding these remarks, however, some natural gums and resins do enjoy continued use – gum arabic is a prime example – either because they have functional properties which synthetics cannot match or because they are available at a price which makes it cost-effective to continue to use them. In food use, particularly, any change of formulation requires a change in the labelling of the end product, which is very costly to the manufacturer and not something which is done without very good reason. (Equally, if a switch is made away from using a natural gum then that market cannot easily be regained at a later date). There are also some marketing advantages for manufacturers in being able to label their products as containing natural, rather than synthetic, additives.

The above remarks apply, essentially, to the large-scale consumer markets and take no account of the use of gums, resins and latexes at the local level, by the communities which collect them. This use is not easily quantified but is clearly very important. Some of the resins are used for making torches and for caulking boats and baskets, or as sources of incense. Many are used for medicinal purposes.

The permitted use of gums in foods is a subject of some concern and much legislation. Recent changes in the toxicological status of gums, including the exudate and seed gums discussed in this report, have been summarized by ANDERSON (1991). Present and future European legislation on food hydrocolloids (gums) has been summarized by GRAY and PENNING (1992). Where applicable, specifications for gums (and resins) used in foods and dealt with in this report have been included in the selected bibliography at the end of each section. However, any prospective new producer or exporter of gums intended for food use should consult either their national standards organization (for information on local quality requirements) or international organizations or importers (for up-to-date advice on requirements in end-user countries).

OPPORTUNITIES FOR DEVELOPMENT OF NEW OR IMPROVED SOURCES OF GUMS, RESINS AND LATEXES

ROBBINS (1988) has stated, "in spite of the problems which have beset the gums market in recent years, the fact remains that in many cases the gums provide a valuable source of income for many poor smallholders or itinerant labourers, either in very poor countries or in the poorest regions of rather more developed countries. As such they are important commodities ...". This remains true today. Tens of thousands of people worldwide, living in regions ranging from semi-arid lands to moist rainforest, depend on the collection of gums, resins and latexes as a means of cash income. Equally, many millions of people in consuming countries make use of these products in their everyday life.

Markets for many of the products have undoubtedly declined over the years and, for some, these markets will never be recovered. This is especially true for some of the latexes. However, for others, there will continue to be a demand, and provided quality and price are

right (and, in the case of food gums or resins, legislation continues to permit them) the end-user industries in the consuming countries will wish to continue using them.

The need to maintain quality or, better still, improve it, in order to retain or increase markets cannot be over-emphasized. The quality of the consignment of gum or resin received by an importer depends on a number of factors:

- The intrinsic properties of the gum or resin, i.e., genetic factors which are determined mainly by the particular species from which the gum or resin is obtained, although there may also be provenance and individual tree differences in quality. Thus, all other things being equal, *Acacia senegal* furnishes a better quality "gum arabic" than any other *Acacia* species.
- Environmental factors. Climatic and edaphic factors have some effect on gum and resin quality, although the nature and size of the effects are not well documented.
- Harvesting, cleaning and handling practices. Apart from the species of plant which is exploited, and over which there may be no choice for the producer, these man-made effects have the greatest influence on quality.

Every effort should therefore be made to improve the collection and post-harvest handling of gums and resins. The use of improved methods of tapping will have the added incentives of increasing yields and minimizing or eliminating damage to the forest resource. Quality control measures should be in place which ensure that there is no mixing of gums from different botanical sources, either accidentally or deliberately by the collector or trader. And excessive handling should be avoided which increases the risk of contamination, including microbial contamination.

In the past especially, but to some extent even now, the wild sources of gums, resins and latexes have been damaged by the methods employed for tapping and by over-exploitation of the resource. The introduction of better tapping techniques is one way of avoiding damage, but the use of cultivated sources can also reduce the pressure on the natural forest, and by improving the accessibility of the trees to the collector can increase the efficiency of collection. Cultivation may be on a large scale (as, for example, with some of the plantations of *Acacia senegal* in Sudan which are tapped for gum arabic) or in an agroforestry context (as in the case of *Shorea javanica* in Indonesia which is being grown as a source of damar). Some species of *Canarium* have the potential for multipurpose use as a source of edible fruits or nuts and elemi resin.

There are good grounds for optimism that despite the changes which have occurred in the markets over the years there will continue to be a demand for gums, resins and latexes (albeit more for some than others) and that there are opportunities for people in the producing countries, providing due attention is given to such aspects as quality control of the product and sustainable management of the resource.

COVERAGE AND FORMAT OF THE REPORT

Many thousands of plant species yield gums, resins or latexes, and probably several hundreds are utilized to produce items of trade, either local or international. Of these, the 22 listed in Table 1 are the subject of this report.

All except one enter world trade, and those which do range from large volume gums such as gum arabic – where over 30 000 tonnes were exported from producer countries in 1994 – to small volume resins and latexes, where less than 50 tonnes/year are traded. Mesquite seed gum is not yet produced commercially but has the potential to do so.

Except for tragacanth and asafoetida/galbanum, which come from small shrubby plants, all the products are obtained from trees, although these vary in size from relatively small *Acacia* to *Dyera* species up to 50 m or more tall. They have been chosen to illustrate the diversity of the products and their applications, and the different types of forest cover, ecological zones and geographical regions from which they come – from food additives, flavours and fragrances to pharmaceuticals and industrial applications; from small shrubs or trees of the arid and semi-arid zones of Africa and India to medium-sized trees of the Mediterranean region, and large trees of the Amazonian and Southeast Asian rainforests. The developmental potential of the products discussed ranges from those with high potential such as gum arabic, locust bean and damar to those with very little potential such as dragon's blood and balata.

A standard format has been adopted when discussing each product:

- **Description and uses.** The physical form of the gum, resin or latex when it enters trade, and its physical and chemical properties; a brief note on its botanical and geographical origin; its uses including, where appropriate, the form in which it is used (for example, if an extract or distilled oil is prepared from it).
- **World supply and demand trends.** The export markets and producer countries as indicated by trade statistics and other sources of information; quality variation, grades and prices. (N.B. Although extensive use is made of trade statistics, they should always be interpreted with some caution; where recognized, instances of misclassification are noted in the report.)
- **Plant sources.** Botanical and common names of the main species concerned; their description and distribution (the description is not intended to be a detailed botanical one but simply one which indicates the approximate size and form of the plant and any characteristic features); an indication of whether wild or cultivated sources are exploited.
- **Collection/primary processing.** Methods of tapping and treatment prior to the gum, resin or latex entering trade, including cleaning; yields, including quantitative data, where available, and an indication of the factors which influence yields.
- **Value-added processing.** The type of value-added processing which is carried out in consuming countries and the opportunities for doing so in producer countries.
- **Products other than gum, resin or latex.** Any other products of economic value obtained from the plant (such as timber, fruits or feedstuffs).
- **Developmental potential.** The opportunities for new or improved production (having regard for the demand which exists), particularly under conditions of sustainable agroforestry when there is a threat to the wild resource using present methods of harvesting; research needs.

- **Selected bibliography.** A listing of what are judged to be the more important references so that those who wish to obtain more detailed information on the subject can do so. Where possible, and unless they are the only sources of information, old references have been avoided. (N.B. A bibliography of general articles and books on gums, resins and latexes is given as Appendix 1.)
- Statistical tables are appended at the end of each product discussed, following the selected bibliography.

A large number of gums, resins and latexes have inevitably had to be omitted from this report, including some which are traded internationally in significant quantities. A few have been omitted because they have already been the subject of recent publications:

- Olibanum (frankincense), myrrh and opopanax resins from *Boswellia* and *Commiphora* spp. (*Flavours and Fragrances of Plant Origin*. Non-Wood Forest Products 1. Rome: FAO, 1995).
- Pine resin and its primary products from *Pinus* spp. (*Gum Naval Stores: Turpentine and Rosin from Pine Resin*. Non-Wood Forest Products 2. Rome: FAO, 1995).

Some have been omitted because they are not forest products. These include (a) seaweed gums, (b) those produced as agricultural crops and (c) some produced commercially by microbial biosynthesis:

- (a) Agar
 - Alginates
 - Carrageenan
- (b) Guar gum from *Cyamopsis tetragonoloba*
 - Psyllium gum from *Plantago* spp.
 - Guayule latex from *Parthenium argentatum*
 - Rubber latex from *Hevea brasiliensis*
- (c) Gellan gum
 - Xanthan gum

Processed gums such as modified starches and celluloses are excluded. Others have been omitted in order to keep the present report to a reasonable size or because there is insufficient published information to enable an adequate account to be given of the particular gum, resin or latex. These include:

Gums

- Cashew from *Anacardium occidentale*
- Ghatti from *Anogeissus latifolia*
- Gum arabic-like gums from *Combretum*, *Albizia* and *Leucaena* spp.
- Gum from *Cassia* spp. (e.g., *C. tora*)
- Gum from *Sesbania* spp. (e.g., *S. bispinosa*)
- Semla from *Bauhinia retusa*
- Tamarind from *Tamarindus indica*

Resins

Accroides from *Xanthorrhoea* spp.
Gaharu resin-soaked wood from *Aquilaria* spp.
Gamboge from *Garcinia* spp.
Guaiacum from *Guaiacum* spp.
Gumweed from *Grindelia camporum*
Gurjun balsam from *Dipterocarpus kerrii*
Kauri from *Agathis*
Labdanum from *Cistus* spp.
Lac (shellac) from the lac insect
Sandarac from *Tetraclinis* and *Callitris* spp.

Latexes

Chilte from *Cnidoscolus* spp.

Many other gums, resins and latexes have been the subject of research reports but these are not discussed further here.

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Table 1. Gums, resins and latexes described in the report

Gum, resin or latex	Main genera	Family	Main producing regions
Exudate gums			
Gum arabic	<i>Acacia</i>	Leguminosae	Africa
Karaya	<i>Sterculia</i>	Sterculiaceae	Asia, Africa
Tragacanth	<i>Astragalus</i>	Leguminosae	Asia Minor
Seed gums			
Locust bean	<i>Ceratonia</i>	Leguminosae	Mediterranean
Mesquite	<i>Prosopis</i>	Leguminosae	Americas, Africa, Asia
Tara	<i>Caesalpinia</i>	Leguminosae	S America
Hard resins			
Copal	<i>Agathis</i>	Araucariaceae	SE Asia
Damar	<i>Shorea, Hopea, Vatica</i>	Dipterocarpaceae	SE Asia
Mastic	<i>Pistacia</i>	Anacardiaceae	Mediterranean
Dragon's blood	<i>Daemonorops</i>	Palmaceae	SE Asia
Soft resins/balsams			
Benzoin	<i>Styrax</i>	Styracaceae	SE Asia
Styrax	<i>Liquidambar</i>	Hamamelidaceae	Asia Minor, C America
Peru/Tolu balsams	<i>Myroxylon</i>	Leguminosae	C/S America
Copaiba	<i>Copaifera</i>	Leguminosae	S America
Elemi	<i>Canarium</i>	Burseraceae	SE Asia
Asafoetida/ Galbanum	<i>Ferula</i>	Umbelliferae	Asia Minor
Latexes			
Chicle	<i>Manilkara</i>	Sapotaceae	Americas
Jelutong	<i>Dyera</i>	Apocynaceae	SE Asia
Sorva	<i>Couma</i>	Apocynaceae	S America
Gutta percha	<i>Palaquium</i>	Sapotaceae	SE Asia
Balata	<i>Manilkara</i>	Sapotaceae	S America
Maçaranduba	<i>Manilkara</i>	Sapotaceae	S America

Table 2. Gums and resins^a (excluding gum arabic): imports into the European Community, and sources, 1988-93 (tonnes)

	1988	1989	1990	1991	1992	1993
Total	15754	21238	22774	25161	22718	13521
<i>Of which from:</i>						
Brazil ^b	1056	3959	8197	10041	7431	1427
Indonesia	2599	3033	2680	2567	3609	3239
India	1694	2108	690	796	1111	1352
Senegal	1182	1735	1824	1477	1329	919
Iran	956	969	779	910	689	808
Singapore	863	737	1186	813	855	630
Germany	827	683	711	649	912	801
France	561	797	894	1041	676	614
UK	409	504	694	527	676	522
China, People's Rep. of	285	457	202	2010	1871	33
Nigeria	359	698	503	294	201	381
Philippines	207	259	515	143	177	291
Mali	104	446	549	560	484	197
Sudan	343	318	234	433	317	279
Spain	197	227	391	320	438	101
Portugal	463	122	143	548	59	88
Ethiopia	220	231	285	139	131	62
Somalia	108	167	121	151	237	202
South Africa	1288	1478	363	-	1	7
Netherlands	283	262	87	226	307	267
USA	232	271	331	186	114	115
Australia	101	111	152	186	134	209
Turkey	114	242	55	33	25	6
Albania	18	185	-	257	72	277
Others	1285	1239	1188	854	862	694

Source: *Eurostat*

Note:

a "Natural gums, resins, gum-resins and balsams".

b A significant proportion of Brazilian exports is believed to be crude pine resin imported into Portugal.

Table 3. Gums, resins and latexes^a: exports from Indonesia, by type, 1988-93
(tonnes; US\$ millions)

	1988	1989	1990	1991	1992	1993
Total	17114	33236	40531	41270	35052	41961
FOB value	9.8	19.6	24.8	23.4	22.1	24.9
<i>Of which:</i>						
Damar ^b	10343	11372	10878	12573	10175	13285
Jelutong ^c	2358	5373	6495	3700	2712	
1182						
Copal	2485	1811	1766	1880	1863	1886
Gum arabic ^d	-	2937	2050	2405	1988	361
Benzoin ^e	1157	975	884	1126	806	824
Lac	411	227	703	221	245	311
Gutta percha	3	75	156	316	366	241
Dragon's blood	26	59	71	87	47	25
Gahuru	-	39	44	47	181	204
"Other gum" ^f	107	9947	16557	18602	16454	23255
"Other resin"	129	391	927	311	177	387
Others	95	30	-	2	38	-

Source: National statistics

- Notes: *a* Excludes agar-agar (a seaweed gum) and "Resin pine" (= pine rosin, a processed product of crude pine resin).
b Includes "Damar", "Resin batu" and "Resin mata kucing" (see section on DAMAR).
c Includes raw, pressed, refined, and other.
d Very improbable that this is genuine gum arabic.
e Classified as "Frankincense" (see footnote to Table 23).
f From 1989, it is probable that a large proportion of this is crude pine resin.

Table 4. Gums and resins: exports from India, by type, 1987/88-1993/94^a
(tonnes)

	87/88	88/89	89/90	90/91	91/92	92/93	93/94
Total	8013	9674	7818	8257	7299	7124	8513
<i>Of which:</i>							
Lac ^b	5038	7157	5169	6958	5673	4989	5935
Karaya	2001	1831	1628	599	574	843	1443
Asafoetida	140	144	149	130	164	231	205
Olibanum	167	81	19	75	70	113	66
Gum arabic	6	3	30	30	1	80	83
Asian gum	23	41	6	37	12	6	19
"Other natural gums"	484	331	683	374	567	660	592
"Other gum resins"	102	42	61	51	214	97	116
"Other resins"	21	30	66	1	18	87	45
Others	31	14	7	2	6	18	9

Source: National statistics

Notes: *a* Year runs April-March

b Includes shellac, seedlac, button and garnet lac, stick lac, dewaxed and decolourised lac, bleached lac, and other lacs including lac dye.

Table 5. Gums and resins^a: exports from the People's Republic of China, and destinations, 1990-92
(tonnes)

	1990	1991	1992
Total	8701	340	2755
<i>Of which to:</i>			
Hong Kong	6575	212	1497
India	2105	-	304
Spain	-	-	350
Viet Nam	-	-	305
Indonesia	-	29	55
Thailand	15	-	52
Singapore	3	59	3
Nigeria	-	-	72
Russia	-	-	50
USA	-	12	12
Japan	-	-	22
Iran	-	-	14

Source: *China's Customs Statistics Yearbook*

Note: *a* "Natural gums, resins, and balsams excluding lac and gum arabic"

GUM ARABIC, GUM TALHA AND OTHER ACACIA GUMS

DEFINITION

The term gum arabic is used with varying degrees of precision by different groups of people. In the context of its use as a food additive the most recent international specification, published by FAO (FAO, 1990), defines gum arabic as the "dried exudation obtained from the stems and branches of *Acacia senegal* (L) Willdenow or closely related species". The specification then proceeds to give limits for certain parameters which have been selected to try and ensure that only gum from *A. senegal* (and closely related species) satisfies the specification (see **Quality and prices** below). The need for such legislation arises from the need to assure the public on safety grounds that there are no hazards associated with ingestion of gum arabic; gum arabic which complies with the definition and specifications has been tested and shown to be safe to consume.^{3/}

In Sudan, the term gum arabic is used in a wider context to include two types of gum which are produced and marketed, but which are, nevertheless, clearly separated in both national statistics and trade: "hashab" (from *A. senegal*) and "talha" (from *A. seyal*). In a still wider sense, gum arabic is often taken to mean the gum from any *Acacia* species (and is sometimes referred to as "Acacia gum"). "Gum arabic" from Zimbabwe, for example, is derived from *A. karroo*.

In practice, therefore, and although most internationally traded gum arabic comes from *A. senegal*, the term "gum arabic" cannot be taken as implying a particular botanical source. In a few cases, so-called gum arabic may not even have been collected from *Acacia* species, but may originate from *Combretum*, *Albizia* or some other genus. In the discussion which follows, the term "gum arabic" will generally be used in the generic sense as any *Acacia* gum unless it is qualified by some other statement or the botanical source is specified.

Statistical data originating in Sudan and shown in Tables 11a, 11b and 12 separate gum hashab and gum talha. Figures relating to Sudan in other statistical tables (Tables 6, 7, 9 and 10) are assumed to combine both types of gum arabic (hashab and talha).

DESCRIPTION AND USES

Gum arabic from *A. senegal* is a pale to orange-brown coloured solid, which breaks with a glassy fracture. The best grades are in the form of whole, round tears, orange-brown in colour and with a matt surface texture; in the broken, kibbled state the pieces are much paler and have a glassy appearance (see section on quality below). Inferior grades, and gum from species other than *A. senegal*, may not have the characteristic tear shape and are often darker in colour. Gum from *A. seyal* (gum talha) is more friable than the hard tears produced by *A. senegal* and is rarely found as whole lumps in export consignments.

^{3/} These specifications are currently (mid-1995) under review by JECFA and it is planned to publish revised ones in 1996.

The gum arabic-yielding Acacias grow in semi-arid areas and the vast majority of gum arabic which enters international trade originates in the so-called gum belt of Sub-Saharan Africa, extending from the northern parts of West Africa eastwards to Sudan and Ethiopia. A little gum is of Indian origin.

Gum arabic is a complex, slightly acidic polysaccharide. The precise chemical and molecular structure differs according to the botanical origin of the gum, and these differences are reflected in some of the analytical properties of the gum. As a result, the functional properties and uses to which gum arabic can be put (and its commercial value) are also very dependent on its origin.

Unlike some other gums such as tragacanth, locust bean and the seaweed gums, gum arabic is very soluble in water and forms solutions over a wide range of concentrations without becoming highly viscous. The combination of high solubility in water and low viscosity confers on gum arabic its highly valued emulsifying, stabilizing, thickening and suspending properties. Despite some substitution of gum arabic by cheaper alternatives, brought about in the past by shortages of supply and high prices, it has remained the most important of the exudate gums and in some applications it has technical advantages which make it difficult to substitute completely. Its uses fall into three main areas: food, pharmaceutical and technical.

Food use

As noted earlier, the FAO specification for gum arabic intended for food use stipulates that it should come from *A. senegal* or closely related species. Even apart from legislative requirements, the quality and technical performance of gum arabic from this source makes it the material of choice in most cases. In Europe, the food additive number of gum arabic is E414.

Confectionery remains a major use for gum arabic, although supply and price pressures have led to a marked reduction in the amount of gum arabic used in some traditional items such as "fruit gums" and pastilles. The role of gum arabic in confectionery products is usually either to prevent crystallization of sugar or to act as an emulsifier. In candy products it is also used as a glaze.

It finds wide application as a means of encapsulating flavours (for example, spray-dried flavours and citrus oils) and is also used in a range of dairy and bakery products (especially as a glaze or topping in the latter). It is used in soft and alcoholic drinks, either as a vehicle for flavouring or as a stabilizer or clouding agent.

Pharmaceutical use

Gum arabic's use in pharmaceuticals is much less than it once was, and it has been displaced in many of its applications by modified starches and celluloses. However, it still finds some use in tablet manufacture, where it functions as a binding agent or as a coating prior to sugar coating, and it is also used as a suspending and emulsifying agent, sometimes in combination with other gums.

Technical and miscellaneous uses

An important non-food/pharmaceutical application of gum arabic is in the printing industry, where it is used to treat offset lithographic plates: as a protective coating to prevent oxidation;



Tapping *Acacia senegal* var. Senegal using "sunki", in Sudan. Plantation ca. 12 years old. (Photo: J.J.W. Coppen)



Exudated gum, formed into a pale to orange brown coloured solid, ready for collection. (Photo: The Gum Arabic Co., Ltd., Khartoum)



Primary cleaning and grading of gum arabic at the Gum Arabic Co. depot, El Obeid, Sudan. (Photo: J.J.W. Coppen)



Final inspection of mechanically cleaned gum arabic at the Gum Arabic Co. export depot, Port Sudan. (Photo: J.J.W. Coppen)

as a component of solutions to increase hydrophilicity and impart ink repellency to the plates; and as a base for photosensitive chemicals.

Other technical uses include ceramics, where gum arabic helps to strengthen the clay, certain types of inks, and pyrotechnics. Use in textiles, paints and adhesives (including the traditional office glue and postage stamps) has decreased to very low levels in recent years, at least in Western markets.

WORLD SUPPLY AND DEMAND TRENDS

Markets

The use of gum arabic has a very long history but in modern times production and trade has been dominated by Sudan. Levels of supply from Sudan are therefore a good indicator of consumption.

A more detailed discussion of production levels in Sudan is given below, but towards the end of the 1960s total gum arabic production (hashab + talha) was in excess of 60 000 tonnes/year; supplies of gum arabic from other countries meant that total world usage was around 70 000 tonnes. Events in the 1970s and 1980s led to fluctuations in both the supply and price of gum arabic and, as a consequence, to changes in demand. The severe Sahelian drought of 1973/74 resulted in a world shortage of gum arabic and high prices which, in turn, accelerated the replacement of gum arabic by substitutes such as modified starches. A low point of approximately 20 000 tonnes of Sudanese exports was reached in 1975, which recovered to around 40 000 tonnes during 1979. A further drought in 1982–84, combined with political and civil unrest, saw levels of exports fall to below 20 000 tonnes in some years in the mid-/late 1980s and early 1990s.

Demand for gum arabic has therefore been constrained at times by the supply, and under these circumstances end-users who switch to alternatives do not always revert to gum arabic when supply problems are eased. It is unlikely, therefore, that world markets for gum arabic will reach the heights that they once did, although the superior properties of gum arabic (especially good quality material from *A. senegal*) will ensure that it retains substantial markets if availability is assured and prices are favourable.

The European Community is by far the biggest regional market for gum arabic and imports into it, with sources, are given in Table 6 for the period 1988–93. Imports averaged almost 28 000 tonnes/year over the six years, with a peak of over 32 000 tonnes in 1991.

A breakdown into destinations of imports within the EC is given in Tables 7 and 8 for Sudanese and Nigerian gum arabic, respectively. France and the United Kingdom are the biggest markets (although they both re-export a large proportion of their imports) followed by Italy and Germany. The United Kingdom has been a consistent buyer of Nigerian gum, although France and Germany have imported large quantities in recent years. France is the main importer of gum arabic from the Francophone countries of West and Central Africa.

Outside the EC, the United States is the largest market for gum arabic. Imports for 1991–94, and their sources, are given in Table 9; they averaged 7 500 tonnes annually but exceeded 10 000 tonnes in 1994.

Japanese imports averaged 1 900 tonnes/year during 1988–94; year-by-year details are shown in Table 10.

Supply sources

The gum belt referred to earlier occurs as a broad band across Sub-Saharan Africa, from Mauritania, Senegal and Mali in the west, through Burkina Faso, Niger, northern parts of Nigeria and Chad to Sudan, Eritrea, Ethiopia and Somalia in the east, and northern parts of Uganda and Kenya. Most of these countries appear in the trade statistics as sources of gum arabic, although they differ greatly in terms of the quantities which are involved.

Sudan is the world's biggest producer of gum arabic, and since very little is consumed domestically it is also the main source of gum in international trade. Sudanese production data are given in Tables 11a and 11b: 5-year annual averages since 1960 are given in Table 11a and yearly figures for the crop years 1988–94 are shown in Table 11b. In both cases, gum hashab is distinguished from gum talha.

The data in Table 11a show a drop in production by more than half in the last decade compared to that in the 1960s (when it averaged about 48 500 tonnes/year). In the ten years 1950–59 (not shown) production averaged just under 41 000 tonnes/year. The more detailed data in Table 11b show an all-time low of 7 600 tonnes in 1992. Since then, production has increased and it is expected to be the highest for some years in 1995.

The proportion of gum talha in Sudanese production of gum arabic (Tables 11a and 11b) is usually around 5–15%. However, in recent years (Table 11b) it has varied from less than 200 tonnes (3%) in 1992 to over 11 000 tonnes (33%) in 1994.

Exports from Sudan averaged 20 300 tonnes/year in the period 1988–94 (Table 12). Comparison with production data is difficult because of the uncertainty in the level of carry-over of stocks from one year to the next.

Nigeria is the second biggest producer and exporter of gum arabic after Sudan. Direct imports into the European Community from Nigeria averaged 4 500 tonnes/year during 1988–93 (Table 6). Import data for the United States (Table 9) show that Nigeria was the second biggest primary source of gum arabic.

Of the other producers, Chad is the next most important after Sudan and Nigeria; direct imports into the EC for 1988–93 averaged 2 000 tonnes/year (Table 6). However, a significant proportion of the gum exported from Chad, as well as from the Central African Republic, is believed to originate in Sudan and enter the neighbouring countries through illegal cross-border trade. Likewise, some gum from Cameroon originates in Chad. The 1 000 tonnes of gum arabic imported into the EC from the former Soviet Union in 1988 represents re-exports of bartered gum from Sudan.

A few countries which have gum-yielding Acacias produce gum for the local market, but not in sufficient quantities to enable exports to be made. Two such examples are Zimbabwe and South Africa, which produce gum arabic from *A. karroo*.

Outside Africa, India produces small amounts of gum, similar in quality to gum talha, but a proportion of her exports of gum arabic consists either of re-exports of African gum or locally produced gum ghatti (from *Anogeissus latifolia*) misclassified as gum arabic.

Quality and prices

The quality of gum arabic as received by the importer is very dependent on the source. Gum arabic (hashab) from Sudan is the highest quality and sets the standard by which other "gum arabics" are judged. Not only does Sudanese gum come from a species (*A. senegal*) which intrinsically produces a high quality exudate with superior technical performance, but the collection, cleaning, sorting and handling of it up to the point of export is well organized and highly efficient (see **COLLECTION/PRIMARY PROCESSING**). Within Sudan, gum arabic from the Kordofan region has the highest reputation, and traders and end-users in importing countries often refer to "Kordofan gum" when indicating their preferences.

Nigerian gum arabic, on the other hand, has a reputation for very variable quality. Some gum is comparable to the best Sudanese quality but much of it is poorer. A major problem for importers and end-users is the inconsistent, and often heterogeneous, nature of the consignments: gum of varying degrees of cleanliness and colour is present, which reflects the less rigorous methods of harvesting and post-harvest treatment practised in Nigeria compared with Sudan. One aspect, in particular, which adversely affects the quality is the mixing of different types of gum, i.e., gum collected from different species of *Acacia*.

Gum talha from Sudan (produced from *A. seyal*) is intrinsically a poorer quality gum than hashab – it has inferior emulsifying properties and even light-coloured samples of whole gum sometimes form dark solutions in water due to the presence of tannins and other impurities. It is more friable than hashab.

Quality criteria

As noted earlier, an FAO (JECFA) specification exists for gum arabic intended for use as a food additive; in the United States, a Food Chemicals Codex specification exists. For pharmaceutical use, gum arabic appears in many pharmacopoeias, including the British Pharmacopoeia.

The JECFA specification has undergone a number of revisions over the years. The present one (published in 1990) specifies limits on such things as loss on drying, ash, acid-insoluble matter, arsenic, lead and heavy metals. A departure of the present specification from earlier ones (other than a modified definition) is the inclusion of limits on optical rotation and nitrogen content. Their inclusion, and the numerical limits, are designed to ensure that as far as possible only gum from *A. senegal* or closely related species is able to satisfy the requirements (and that, for example, gum talha is excluded).

Although gum arabic intended for pharmaceutical use needs to be of high quality, the BP specification is not as demanding as the JECFA one. Neither optical rotation nor nitrogen content are specified.

Quality control measures in Sudan include a small laboratory at the cleaning and sorting warehouses in Port Sudan. Samples of gum are regularly checked and each export consignment receives a certificate giving analytical data such as moisture content, acid-insoluble matter and optical rotation.

Grades and prices

There are four main grades of Sudanese gum arabic (hashab), although two of these (HPS and Cleaned) are the main ones to enter international trade. The names of the four grades arise from the way in which the gum is cleaned and sorted. Small amounts of "Natural" gum (i.e., gum which has not been cleaned or sorted) used to be available but there is very little demand for this. In addition, since 1994, a processed grade (kibbled) has been available (see **COLLECTION/PRIMARY PROCESSING**). The grades and their export prices for 1994/95 (FOB Port Sudan) are as follows:

Kibbled	US\$ 5 000/tonne
HPS (Hand Picked Selected)	US\$ 4 850/tonne
Cleaned (or Clear Amber Sorts)	US\$ 4 200/tonne
Siftings	na
Dust	US\$ 2 760/tonne

The prices are set by the organization which controls the whole system of gum arabic production in Sudan, the Gum Arabic Company. They are set just before the start of the tapping season (around September/October) and remain fixed for that year.

Gum talha from Sudan has traditionally only been sold as one grade but from 1995 it is being cleaned and graded to form three grades:

Super	US\$ 950/tonne
Standard Clean	US\$ 850/tonne
Siftings	US\$ 400/tonne

Nigerian gum arabic is sorted into three grades. The top grade (Grade 1) is gum produced from *A. senegal*, and although comparable to Sudanese Cleaned gum it is discounted in price by US\$ 400–500/tonne. Grade 2 is gum produced from other species of *Acacia* (such as *A. seyal* and *A. sieberana*). Grade 3 gum is much darker and very mixed in quality; it may consist of gum from species other than *Acacia* (such as *Combretum* and *Albizia*). Prices in early 1994 (when Sudanese Cleaned gum was US\$ 4 000/tonne) were:

Grade 1	US\$ 3 500/tonne
Grade 2	US\$ 600–700/tonne
Grade 3	na

PLANT SOURCES

Botanical names

Family Leguminosae (Mimosoideae):

Acacia spp., especially:

A. senegal (L.) Willd.

A. seyal Del.

Numerous *Acacia* species yield gum, either by natural exudation or after tapping, but almost all gum arabic of commerce originates either from *A. senegal* or *A. seyal*. There is

disagreement over some aspects of *Acacia* taxonomy but *A. senegal* is generally regarded as occurring as four varieties:

- A. senegal* (L.) Willd. var. *senegal*
(syn. *A. verec* Guill. & Perr.)
- A. senegal* (L.) Willd. var. *kerensis* Schweinf.
- A. senegal* (L.) Willd. var. *rostrata* Brenan
- A. senegal* (L.) Willd. var. *leiorhachis* Brenan
(syn. *A. circummarginata* Chiov.)

A. seyal occurs as two varieties:

- A. seyal* Del. var. *seyal*
- A. seyal* Del. var. *fistula* (Schweinf.) Oliv.

Other species of *Acacia* from which gum is, or has been, collected for local use or as minor components of poorer quality shipments for export include:

- A. karroo* Hayne
- A. paoli* Chiov.
- A. polyacantha* Willd.
- A. sieberana* DC.

Description and distribution

A. senegal var. *senegal* is the most widely distributed of the four varieties of *A. senegal* and the most important and best quality source of gum arabic. It is the only variety found in Sudan, where both natural stands and plantations are tapped. It is a small to medium sized thorny tree, with a stem which is irregular in form and often highly branched. In leaf, like many other Acacias, it has a dense, spreading crown. In common with other members of the *A. senegal* complex it has characteristic sets of prickles on the branches, usually in threes with the middle one hooked downward and the lateral ones curved upward. The bark is not papery or peeling. In Africa it occurs throughout the gum belt described earlier but is also found in the arid or semi-arid areas of Tanzania, Zambia, Zimbabwe and Mozambique. It has a limited occurrence in India and Pakistan.

The other varieties of *A. senegal* have a much more restricted distribution than var. *senegal* and provide only very tiny amounts of gum to the market. *A. senegal* var. *kerensis* has a slightly yellowish, sometimes peeling bark and smaller pods than var. *senegal*. It occurs in parts of Somalia, Uganda, Kenya and Tanzania. *A. senegal* var. *leiorhachis* is also found in parts of East Africa but it occurs also in Central and Southern Africa (Zambia, Zimbabwe, Botswana and South Africa). In Kenya it occurs in two growth forms: as a well-formed tree with spreading crown and as a "whippy" form in which three or four spindly branches extend upwards and away from the rest of the tree. *A. senegal* var. *rostrata* is also variable and occurs as a tree with flaking, papery bark or in a more shrubby form. It is mainly confined to parts of Central and Southern Africa.

A. seyal var. *seyal* is the source of gum talha and has a much more extended range than var. *fistula*. It has a single straight stem with a characteristic, pronounced colour, usually orange-red, to the powdery bark, and straight thorns rather than the curved prickles of *A. senegal*.

It has a wide distribution in Africa and is found in most of the countries where *A. senegal* occurs; in Sudan it occurs in greater numbers than *A. senegal*. *A. seyal* var. *fistula* is distinguished from var. *seyal* by its creamy white bark and the presence of ant galls. It is limited to the eastern half of Africa and is not known to be used as a source of gum.

Gum from *A. karroo* is produced in Zimbabwe and South Africa, although the species has a much wider distribution. It occurs over a wide range of altitudes and in many different habitats. In Ghana, *A. polyacantha* and *A. sieberana* occur in the hotter, drier, northern parts of the country and are occasional sources of gum.

COLLECTION/PRIMARY PROCESSING

In Sudan and Nigeria, virtually all gum from *A. senegal* is obtained by tapping the trees; there is very little natural exudation. The reverse is true with *A. seyal* gum. In countries such as Kenya *A. senegal* does produce gum naturally and all of the gum which is collected comes from harvesting natural exudate.

The following account describes the collection, handling and primary processing (cleaning) of gum hashab – gum arabic from *A. senegal* – in Sudan. Tapping methods have been developed which do not damage the trees, and handling and cleaning practices have been optimized to produce a superior quality product.

Tapping begins when the trees are just starting to shed their leaves, usually about the end of October or beginning of November. After five weeks the first collections of gum are made, with further collections from the same trees at approximately 15-day intervals until the end of February, making five or six collections in total.

The older methods of making small incisions into the tree with an axe have largely been replaced by one which utilizes a specially designed tool, a "sunki". This has a metal head fixed to a long wooden handle. The pointed end of the head is pushed tangentially into the stem or branch so as to penetrate just below the bark, and then pulled up so as to strip a small length of bark longitudinally from the wood. Damage to the wood should be minimal. Several branches are treated in a similar manner at one tapping. In following years, other branches or the reverse side of the previously treated branch are tapped.

After this superficial injury, tears of gum form on the exposed surfaces and are left to dry and harden. As far as possible, the tears are picked by hand from the stems and branches where they have formed, and not by knocking to the ground where they can pick up dirt. They are placed in an open basket carried by the collector; the use of plastic sacks has been found to increase the risk of moisture retention and mould formation.

For trees which have been planted from seed, tapping starts at age 4–5 years; for those planted as seedlings, tapping can start in the third year.

In Sudan, the collector sells his gum at regular gum auctions, either to a trader who then sells it on to the Gum Arabic Company, or directly to the Company if they intervene because the price does not reach the guaranteed floor price. Any trader who buys gum then undertakes the process of cleaning and grading it. This is done by hand, usually by women, who sort it into piles of whole tears and smaller pieces, separating any dark gum and removing pieces of bark and other foreign matter.

The same principles of cleaning and sorting are followed in most other countries and the trader or trading organization then usually exports the graded gum. In Sudan, however, the cleaning process is repeated when the Gum Arabic Company receives consignments of gum from the regional centres at its export warehouses in Port Sudan. Since 1991 the cleaning operation has been mechanized using a system of conveyor belts and shaking and sieving machines. Final inspection of the cleaned gum and removal of any remaining foreign matter or dark coloured pieces is made manually as it moves on a belt to be bagged.

Yields

Yields of gum arabic from individual trees are very variable and little reliable data are available on which to base sound estimates of "average" yields. A figure of 250 g of gum per tree per season is often cited as an average yield. Yields of several kg or more have been reported from individual trees.

In Sudan, yields from cultivated *A. senegal* are said to increase up to the age of 15 years, when they level out and then begin to decline after 20 years. At this stage, if desired, trees can be coppiced and after a suitable period of time (and pruning) tapping can recommence on the new stems. In Mali, the best yields from *A. senegal* are said to be produced between ages seven and 15 years.

VALUE-ADDED PROCESSING

When imported into the consumer countries most gum arabic is further processed into kibbled and powdered forms. Kibbling entails passing whole or large lumps of gum through a hammer mill and then screening it to produce smaller granules of more uniform size. These pieces are more easily dissolved in water, and under more reproducible conditions, than the raw gum and so are preferred by the end-user.

As an extension to its mechanized cleaning process, Sudan recently installed machinery to produce kibbled gum arabic. In so doing, it became the first producer country to gain added value in this way. Production began during the 1993/94 season and approximately 2 500 tonnes of kibbled gum was produced.

Powdered gum may be produced from kibbled gum but it may also be produced by a process known as spray drying. This furnishes a high-quality, free-flowing powder with even better solubility characteristics than kibbled gum. The gum is dissolved in water, filtered and/or centrifuged to remove impurities and the solution, after pasteurization to remove microbial contamination, is sprayed into a stream of hot air to promote evaporation of the water. By altering atomizing conditions, powder can be produced with varying particle sizes and bulk densities, according to the end-user's requirements. Spray drying is an energy-intensive process and this, together with the requirements for large quantities of pure water, makes it something that most gum arabic producers could not consider. The difficulty of handling large volumes of aqueous solutions of gum in a producer country – where ambient temperatures are high – without suffering unacceptable increases in the microbiological load adds further to the problem.

PRODUCTS OTHER THAN GUM

No other items of trade are produced from the gum-yielding Acacias, although they are used locally as sources of fuelwood. Many species of *Acacia* are important sources of browse for livestock.

DEVELOPMENTAL POTENTIAL

A. senegal has been widely planted in Sudan and some other countries as a means of combating the process of desertification; it has also been used more generally for afforestation of arid tracts and soil reclamation. As well as environmental benefits, *A. senegal* provides socio-economic benefits to many thousands of communities in the "gum belt" through the production of gum arabic. In Sudan, especially, tending the "gum gardens" remains an integral way of life for many people and a valuable source of cash income.

However, demand for gum arabic is such that importers in end-user countries are always keen to encourage new sources of supply to supplement traditional sources. Thus, in recent years, Kenya has emerged as a new supplier of gum arabic to the world market, albeit a tiny one in comparison to most of the established African producers. However, the Kenyan experience is one which could be followed in some other African countries. In the semi-arid areas where *A. senegal* is found, the local people are often pastoralists involved in herding activities. Climatic and ecological conditions are not favourable to agriculture and there are few opportunities for growing cash crops. In these circumstances production of gum arabic – either from an existing, wild resource of a suitable *Acacia* species or from *A. senegal* planted as part of an agroforestry system – can generate much-needed cash.

A further attraction of promoting gum arabic collection under the conditions described above is that the realization by the local people that an economic value can be placed on the trees is likely to encourage them to preserve the trees and not to cut them down so readily for use as fuelwood as happens at present.

There are therefore numerous benefits to be gained from the production of gum arabic, either through the utilization of natural stands of *Acacia* or from planted sources, providing it is carried out in a sustainable manner. If due attention is given to the production of high quality gum (in particular, that gum from different *Acacia* species is not mixed) then not only can a new producing country aim to meet domestic needs, but it should also be capable of entering the export market.

Research needs

Of the gum-yielding Acacias, most research on agronomic aspects has concentrated (justifiably) on *A. senegal*, although further work remains to be done. Chemical analysis and quality assessment has been carried out on gum exudates from a large number of *Acacia* species (as well as gum arabic-like exudates from other genera), but relatively little detailed information is available on the intra-specific variation of *A. senegal* gum. Some areas requiring further research are therefore:

- Vegetative propagation. Successful development of vegetative methods of propagation of *A. senegal* would enhance selection and breeding programmes aimed at producing superior gum-yielding trees.

- Chemical screening. In-depth studies need to be carried out to learn more about site-to-site, tree-to-tree and seasonal variations in gum quality. This applies to all gum-yielding Acacias.
- Yield assessment. Trial plots need to be established (in both natural populations and plantations) to measure gum yields on a per tree basis, and to determine the variation between and within sites.
- Resource assessment. There is an urgent need to assess the size and suitability of wild, gum-yielding *Acacia* resources in those countries where they exist but where there is no, or only minor, gum arabic production.

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Table 6. Gum arabic: imports into the European Community, and sources, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	23797	26151	27630	32102	29963	26500
<i>Of which from:</i>						
Sudan	9963	12463	14400	17098	10215	9304
Nigeria	3471	3538	4385	3568	7243	4759
France	1876	2365	1993	2104	3003	2624
UK	2293	1373	1698	1855	2512	1746
Chad	1443	1469	1059	2153	2422	3527
Germany	726	838	670	997	1353	1177
Senegal	716	301	276	273	245	449
Cameroon	344	345	302	75	573	841
India	121	452	587	435	469	369
USA	439	355	432	978	316	163
Netherlands	75	138	1043	1296	184	87
Mauritania	200	595	-	32	48	55
Mali	187	391	69	75	32	77
Tanzania	88	31	27	118	160	176
Ethiopia	74	256	68	20	43	27
Somalia	24	21	82	38	49	1
Niger	41	60	-	20	155	169
Central African Republic	74	72	-	74	79	33
Ghana	93	212	-	-	-	-
Kenya	-	-	-	18	121	102
Soviet Union, former	1077	-	-	-	20	-

Source: *Eurostat*

**Table 7. Gum arabic: imports into the European Community from Sudan,
and destinations, 1988-93
(tonnes)**

	1988	1989	1990	1991	1992	1993
Total	9963	12463	14400	17098	10215	9304
<i>Of which to:</i>						
France	3016	3815	5023	7074	5219	5118
UK	2580	3176	3053	2521	2118	1168
Italy	2205	2645	2675	3431	1007	1935
Germany	1265	1659	1388	1804	1027	478
Denmark	441	716	755	727	608	440
Belgium/Luxembourg	261	200	360	280	80	120
Spain	129	159	96	90	56	45
Greece	65	90	50	31	-	-
Netherlands	-	-	1000	1140	100	-
Portugal	1	3	-	-	-	-
Ireland	-	-	-	-	-	-

Source: Eurostat

**Table 8. Gum arabic: imports into the European Community from Nigeria,
and destinations, 1988-93
(tonnes)**

	1988	1989	1990	1991	1992	1993
Total	3471	3538	4385	3568	7243	4759
<i>Of which to:</i>						
France	437	437	403	167	1256	1152
UK	1982	2204	2862	2411	3244	2315
Italy	2	-	-	-	-	38
Germany	974	873	1119	990	2734	1237
Denmark	54	-	-	-	-	-
Belgium/Luxembourg	-	-	-	-	-	12
Spain	12	14	1	-	-	-
Greece	-	10	-	-	2	-
Netherlands	10	-	-	-	7	5
Portugal	-	-	-	-	-	-
Ireland	-	-	-	-	-	-

Source: Eurostat

**Table 9. Gum arabic: imports into the United States, and sources, 1991-94
(tonnes)**

	1991	1992	1993	1994
Total	8313	5802	5508	10434
<i>Of which from:</i>				
Sudan	5480	2471	1800	5367
France	2511	2430	2699	2951
UK	278	678	740	524
Nigeria	-	143	81	1061
Chad	-	18	60	342
India	~	18	2	102
Germany	2	12	5	22
Egypt	35	10	-	-
Kenya	-	-	80	34
Western Sahara	-	20	-	-
Somalia	-	-	4	-
Djibouti	-	-	-	7

Source: National statistics

**Table 10. Gum arabic: imports into Japan, and sources, 1988-94
(tonnes)**

	1988	1989	1990	1991	1992	1993	1994
Total	1656	1821	2735	2022	2019	1219	1804
<i>Of which from:</i>							
Sudan	1606	1791	2702	1983	1644	741	1447
France	16	10	20	12	60	145	200
UK	6	8	8	20	176	245	110
USA	28	12	5	7	62	43	38
Nigeria	-	-	-	-	-	20	-
Guinea Bissau	-	-	-	-	20	-	-
Kenya	-	-	-	-	12	-	-
India	-	-	-	-	-	20	-

Source: National statistics

Table 11a. Gum arabic: production in Sudan (5-year annual averages), 1960-94 (tonnes)

	1960-64	65-69	70-74	75-79	80-84	85-89	90-94
Annual average	46550	50576	35073	37408	31079	23721	
18358							
<i>Of which:</i>							
Gum hashab	44299	47434	30910	36026	26721	19777	15038
Gum talha	2251	3142	4163	1382	4358	3944	3320

Source: Gum Arabic Company, Sudan

Table 11b. Gum arabic: production in Sudan, 1988-94 (tonnes)

	1988	1989	1990	1991	1992	1993	1994
Total	26000	28948	25733	12351	7616	12865	33227
<i>Of which:</i>							
Gum hashab	20000	24256	22408	11756	7439	11410	22178
Gum talha	6000	4692	3325	595	177	1455	11049

Source: Gum Arabic Company, Sudan

Table 12. Gum arabic: exports from Sudan, 1988-94 (tonnes)

	1988	1989	1990	1991	1992	1993	1994
Total	18603	19352	26912	24978	14068	15730	22735
<i>Of which:</i>							
Gum hashab	16672	17385	22960	21543	8198	9925	18339
Gum talha	1931	1967	3952	3435	5870	5805	4396

Source: Gum Arabic Company, Sudan

KARAYA

DESCRIPTION AND USES

Karaya gum is the dried exudate obtained from trees of *Sterculia* species. Most gum is of Indian origin, although increasing amounts come from Africa. The gum enters trade as irregular-shaped or broken tears, with colour ranging from whitish or tan in the better grades to dark brown in the lower grades. In the early years of large-scale, commercial use it was sometimes used as an inferior substitute for tragacanth, and this led to its alternative name of Indian Tragacanth.

Karaya is an acidic, partially acetylated polysaccharide. It absorbs water very rapidly to form viscous mucilages at low concentrations, although it is one of the least soluble of the gum exudates. Although it does have food use – in Europe it has been assigned the food additive number E416 – its usage is overwhelmingly in pharmaceutical, dental or other medical applications, particularly those which make use of karaya's strong adhesive properties. A very minor amount is used in miscellaneous industrial applications such as papermaking and textiles.

Pharmaceutical and related use

The three most important uses of karaya are as a dental adhesive for false teeth, in the manufacture of colostomy bag fixings, and as a bulk laxative. In the first two applications there has been some substitution of karaya by cheaper carboxymethylcellulose derivatives, although recent American trade reports have suggested that some of these substitutes are not as effective as karaya. An Indian market study (ANON., 1987) reported that in France and the United Kingdom, 95% of imported karaya is used in pharmaceutical products; in the United States and Japan, the proportion was about 85%.

Food use

In foods, karaya is used in small amounts as a texturizer and stabilizer in ice creams, and in ice sherbets to prevent the formation of ice crystals. Its stability in acid media makes it suitable for addition to salad dressings, sauces, cheese spreads and some other products.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Throughout the late 1960s to mid-1980s, Indian exports of karaya were in the range 4 000–6 000 tonnes/year – more than that of all other Indian gums and resins combined – and the United States, France and the United Kingdom (in that order) were the biggest importers. Average exports for the period 1977/78–1982/83 were approximately 5 700 tonnes/year (ROBBINS, 1988).

More recent data, for the years 1987/88–1993/94, are given in Table 13. The six-year annual average for 1987/88–1992/93 is less than 1 300 tonnes, a sharp decline on the same period a decade earlier. The United States, France and the United Kingdom remain the biggest markets for karaya, although demand in the United States has fallen to such a degree that France is now the main importing country. Approximate annual averages over the whole

of the recent period are: France 400 tonnes, United States 360 tonnes and the United Kingdom 210 tonnes; Japan is the next biggest single market (110 tonnes). Germany, Italy, Belgium and the Netherlands have also imported directly from India in most years (averaging 130 tonnes/year between them) so Europe as a whole is about twice the size of the American market.

Indian government controls over pricing and exports of karaya in the late 1980s, which some trade sources feel contributed to the poor supply situation caused by restrictions on tapping and low productivity, have now been relaxed, although there are mixed views in the trade as to whether karaya can regain its former position in the international market.

India is traditionally the biggest producer and exporter of karaya but increasing amounts of gum enter international trade from Africa. The quantities involved are very uncertain but if the data for Senegal in Table 2 (imports into the EC of gums and resins excluding gum arabic) refer mainly to karaya, then they could amount to around 1 000 tonnes or more annually.

Domestic consumption of karaya in India was (and still is) considerable. No recent data are available but in 1972, for example, it was about twice the volume of exports.

Supply sources

India remains the biggest producer of karaya and, apart from lac, karaya is still India's most important export item in the gums and resins category. However, the data in Table 13 indicate a sharp fall in exports in 1990/91 from the previous year, with an all-time low of 570 tonnes in 1991/92. It is not known to what extent supplies from Africa made up for the drop in Indian exports. Since then, Indian exports have recovered somewhat, although they are still below the level at the beginning of the period shown in Table 13, and considerably below the levels a decade earlier.

In Africa, Senegal is the biggest producer of karaya and significant quantities are exported to France and the United Kingdom. Sudan also exports small amounts although it has the potential to produce and export much more.

Quality and prices

There are at least five Indian grades of karaya: HPS (Hand Picked Selected), Superior No.1 and No. 2, FAQ (Fair Average Quality) and Siftings. The first four grades are the main export grades. The main quality criteria at the sorting stage are colour and foreign matter, although even after grading the quality of consignments is often variable. The higher grades should be cleaner and paler than the lower ones, which may be dark brown in colour and have bits of bark present.

A BP specification exists for pharmaceutical grade karaya, and FAO and Indian specifications have been published for karaya intended for food use.

Indicative FOB prices quoted by importers in London for Indian karaya (mid-1995) are in the range US\$ 2 250–6 000/tonne according to grade. FAQ gum is about US\$ 3 000/tonne. Senegalese gum has two grades, hand-picked and standard, which are generally inferior to the Indian export grades, and this is reflected in lower prices.

PLANT SOURCES

Botanical/common names

Family Sterculiaceae:

Sterculia urens Roxb.

S. villosa Roxb.

S. setigera Del.

Description and distribution

S. urens is a deciduous tree, up to 15 m high. It has a smooth, greyish white or reddish bark, which peels off in papery flakes. In India it occurs wild in many places on the dry, rocky hills and plateaus of central and northern regions, but it is also grown in plantations as a timber crop. The greater proportion of recent production has come from Andhra Pradesh state.

S. villosa is a small to moderate sized, spreading tree, distributed in the sub-Himalayan tract of India from the Indus eastwards, as well as more southern regions.

Several species of *Sterculia* occur in Africa but *S. setigera* is the only species known to be exploited commercially for gum. It grows up to 15 m tall and has papery, peeling bark.

COLLECTION/PRIMARY PROCESSING

There is some natural exudation of karaya but most gum is collected by tapping. Descriptions of the tapping vary somewhat according to the source of the information, but all entail removal of sections of bark from the trunk of the tree. Guidance rules have been laid down by the Forest Research Institute, Dehra Dun, in India, but in practice the rules are not adhered to and the dimensions of the "blaze" are often exceeded. Tapping which involves deep and wide wounds to the tree to maximize gum yields is damaging to the tree, and this led to a ban on tapping by one Indian Forestry Department in the 1980s.

In India, tapping should be confined to trees with a minimum girth of 90 cm and the initial size of the blaze should be limited to 15 cm tall, 10 cm wide and 0.5 cm deep. Sixteen successive visits should be made to the tree at two-week intervals, removing a further 2-cm high section of bark above the previous one at each visit, and leading to a maximum depth of the blaze of 2.5–3.0 cm. An additional blaze can be worked for every 50 cm girth increment above 90 cm, providing sufficient space is left between adjacent blazes. By staggering the position of each new season's blazes it is possible to leave a rest period of six years before returning to a previous one, by which time the scar should have healed. Tapping is best done during the hot season to maximize yields.

In India, the collected gum is usually sold by auction to government agencies in each of the producing states, who then undertake final cleaning, drying and grading of the gum.

Yields

No reliable data are available but the yield of gum from mature trees has been variously estimated at 1–5 kg/tree during a season.

VALUE-ADDED PROCESSING

Imported gum is purified by size reduction and removal of pieces of bark by air flotation methods. Other mechanical methods are used to remove sand, dirt and other types of foreign matter.

PRODUCTS OTHER THAN GUM

The wood finds some use although it is not a high class timber. It has been employed for making packing cases, match splints, pencils, picture frames and other miscellaneous items.

DEVELOPMENTAL POTENTIAL

The market appears willing to take good quality gum if it is available, as evidenced by the recent upturn in Indian exports, and pharmaceutical usage of karaya seems to be firm. However, opportunities for exploiting market demand are likely to rest more with existing producers, especially those in Africa with underexploited stands of *Sterculia*, than with new ones. Sudan has very large areas of *Sterculia* and if attention is paid to harvesting and cleaning the gum to produce material of high quality – as it is for gum arabic – then it certainly has the potential to supply much larger quantities of gum than it does at present.

Research needs

Improvement of harvesting, cleaning and handling practices, coupled with market studies, is required more than basic research. Trade evaluation should be undertaken of large, representative collections of gum, by those countries having the raw material resource, in order to ascertain the scope for increased production and to gain the confidence of end-users that they would be a reliable, consistent supplier of gum.

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Table 13. Karaya: exports from India, and destinations, 1987/88-1993/94^a
(tonnes)

	87/88	88/89	89/90	90/91	91/92	92/93	93/94
Total	2001	1831	1628	599	574	843	1443
<i>Of which to:</i>							
USA	708	604	467	215	105	178	287
France	543	466	496	124	112	373	729
UK	485	346	305	17	52	118	181
Japan	123	113	138	78	132	78	133
Germany	58	167	122	50	61	44	35
Italy	48	59	30	50	30	23	16
Belgium	6	14	26	10	34	-	5
Netherlands	5	10	-	15	15	7	-
Thailand	5	1	8	6	~	7	23
Malaysia	8	4	2	-	1	-	3
Singapore	6	1	1	4	1	8	5
Norway	~	21	-	25	7	5	-
Czechoslovakia, former	-	22	-	-	-	-	-
Oman	~	-	13	-	-	-	~
Bermuda	-	-	13	-	-	-	-
Hong Kong	-	-	5	-	-	-	-
United Arab Emirates	-	1	~	~	19	-	19

Source: National statistics

Note: ^a Year runs April-March

TRAGACANTH

DESCRIPTION AND USES

Tragacanth gum is the dried exudate produced by tapping the tap root and branches of certain shrubby species of *Astragalus*, particularly those which occur wild in Iran and Turkey. The gum is exported from the country of origin in ribbon or flake form, and has a rather horny texture. Chemically, it is a complex mixture of acidic polysaccharides, mostly present as calcium, magnesium and potassium salts.

Tragacanth swells rapidly in water to form highly viscous colloidal sols or semi-gels, which act as protective colloids and stabilizing agents. The high viscosity of tragacanth solutions results from the molecular characteristics of the gum, and these depend on the grade and physical form of the gum, and the manner in which it is taken up in water. For example, the same concentration of solution prepared from whole gum is more viscous than one prepared from powdered gum. Unlike many other gums, solutions of tragacanth have a very long shelf life without loss of viscosity.

The most important applications of tragacanth are now in foods and pharmaceuticals. Its use for other, industrial purposes has declined over the years as cheaper alternatives to tragacanth have been developed.

Food use

In Europe, tragacanth has the food additive number E413. Its use in foods is not nearly so extensive now as it was some years ago, when it was widely used in salad dressings and sauces, savoury spreads, milk shakes, ice creams, and confectionery and bakery products. It functions as a thickener, stabilizer or emulsifier, but for many of these applications its advantage over other gums is its stability under acid conditions. Despite this, however, its high price has meant that for some of these end uses it has now been replaced by guar or xanthan gums.

Pharmaceutical use

Tragacanth has long been an important gum for pharmaceutical use: as a binder, suspender or emulsifier in tablets, ointments, lubricating jellies and oral suspensions, and particularly in dermatological creams and lotions. It is also used in toothpastes, hair lotions and other personal care products.

WORLD SUPPLY AND DEMAND TRENDS

Markets

In the 1950s, Iranian exports of tragacanth exceeded 4 000 tonnes/year (90% of it in flake form, the rest in ribbon); the United States and the United Kingdom were the major importers. Political upheavals and military conflict in the late 1970s and 1980s led to shortages of gum from Iran and a sharp increase in prices. Severe competition from other, cheaper gums, particularly xanthan gum, has resulted in a greatly diminished market for tragacanth.

ROBBINS (1988) estimated the world market for tragacanth to be no more than 500 tonnes/year; almost half of this was estimated to be consumed in Western Europe. Severe problems are encountered in estimating consumption of tragacanth: firstly, export data from the major producers (Iran and Turkey) are not easily accessed and, secondly, tragacanth is not listed separately in the trade statistics of many importing countries.

Japan does treat tragacanth separately, however, and Japanese imports during the period 1988-94 are shown in Table 14; they averaged just under 30 tonnes/year. This is not much different to the situation in the early 1980s, although in 1979 imports into Japan were over 100 tonnes.

In the United States, a 1987 trade embargo which prohibits the import of most goods from Iran has influenced direct imports of tragacanth, although the United States still imports the gum from European dealers.

In the absence of any reliable data, and in the light of news items in the trade literature which continue to speak of shrinking usage, it is estimated that world demand for tragacanth is probably in the region of 300 tonnes/year.

Supply sources

Iran and Turkey have been the only significant producers of tragacanth for some years, with Iran being the principal source. They are both listed as sources in Japanese import statistics (Table 14); tragacanth from the other countries represents re-exports (the only Indian shipment may be karaya, sometimes known as Indian tragacanth).

Trade sources in London report that production in Turkey has now virtually ceased, due to the poor financial returns to the collectors.

Quality and prices

Tragacanth is bought from origin as ribbons or flakes; loss of viscosity of gum which has been powdered and stored for long periods means that powdered tragacanth is always produced in the importing country. Iranian tragacanth, which is generally regarded as superior to Turkish, is sold in about 12 different grades: five ribbon (Ribbon no. 1, Ribbon no. 2, etc.) and the remainder flake.

Ribbon no. 1 is the top grade, being the palest and cleanest. Ribbon grades are usually used for pharmaceutical purposes; flake is used for food applications. The lower flake grades are appreciably darker and contain some foreign matter. When powdered for the end-user, tragacanth is sold and specified by viscosity.

An FAO specification exists for food grade tragacanth and includes limits on arsenic, lead and heavy metals, as well as some other parameters. Tragacanth is also specified in many pharmacopoeias for pharmaceutical use, including the British Pharmacopoeia.

Trade sources in London quote current (mid-1995) prices at around US\$ 22/kg FOB for the top grade (Ribbon no. 1), US\$ 16/kg for Ribbon no. 4 and falling to US\$ 3-4/kg for the lowest grades. These prices are higher than they were a year earlier although, historically, tragacanth has always been one of the most highly priced gums, and has been considerably

higher in some previous years. In the mid-1980s it fetched around US\$ 20-70/kg, depending on grade.

PLANT SOURCES

Botanical names

Family Leguminosae (Papilionoideae): *Astragalus* spp.

Astragalus is a very large genus and includes many Asian species. *A. gummifer* Labill. is usually cited as the source of tragacanth but there is surprisingly little evidence to support this, and it is likely that other species which occur in the gum producing areas contribute to the total amount which enters world trade; whether to a greater or lesser degree than *A. gummifer* is not known. These other species include *A. adscendens* Boiss., *A. echidnaeformis* Sirjaev, *A. gossypinus* Fisch., *A. kurdicus* Boiss. and *A. microcephalus* Willd. Numerous other *Astragalus* species occur in the region.

Description and distribution

The better gum-yielding species are small, low, bushy perennials, frequently with a cushion-like form. However, they have relatively large tap roots and it is these which are the primary source of the gum. *A. gummifer* is a low shrub, up to 1 m tall, and is thorny and branching. *A. microcephalus*, which produces a high quality gum, is a low, spreading bush, 8-12 cm tall.

The Asiatic species of *Astragalus*, which are the sources of commercial gum, are native to countries of Asia Minor: Iran, Turkey, Iraq, Syria, Lebanon, Afghanistan and parts of Russia. They are usually found in the drier mountainous regions, although they require some water.

COLLECTION/PRIMARY PROCESSING

The most striking feature of the gum-producing *Astragalus* is a central gum cylinder in the tap root, which is contained by the woody cylinder and may be as much as half the total diameter of the root. The gum is contained in the cylinder at high pressure and, when cut, exudes rapidly and hardens into the characteristic ribbons of tragacanth.

Some gum is collected from spontaneous exudation but most is obtained by tapping. The process of tapping entails clearing away the earth surrounding the tap root and making one or two cuts into the upper part of the root. The cuts are usually made longitudinally or cross-angled to the root, 2-5 cm long. Sometimes the branches are also cut but this usually yields an inferior gum. After a period of time which varies according to local custom or circumstances, but may be a few days or a week or more, the tapper returns to the plants he has cut to collect the gum. Further collections may be made thereafter but the quality of the gum soon deteriorates to a point when it is not worth while to continue. Flakes of gum, rather than ribbons, are usually produced later in the season.

Tapping is carried out in the dry summer months and continues until the autumn rains. The collector sells the gum to the local merchant who then sells it on to the main trader. He, in turn, takes it to the main sorting and grading centre where it is graded and packaged for export.

Yields

GENTRY (1957) lists a number of factors which influence gum yields. Some species are intrinsically better yielders than others. Older plants, and those with a large gum cylinder in the root, produce greater quantities of gum, and good spring rains prior to tapping also favour gum production. Unlike exudate gums obtained from the trunks of trees, where warm sunlight shining on the tree increases gum flow, most exudation of tragacanth occurs at night, under conditions which minimise drying out of the gum and maintain the outward flow under high osmotic pressure.

Based on experimental fieldwork, Gentry estimated the average yield of gum from *A. microcephalus* at 15 g per 100-day tapping season.

VALUE-ADDED PROCESSING

As has been noted earlier, further processing such as grinding the gum to a powder is only done in the importing country, usually immediately before onward shipment to an end-user, so as to minimize loss of viscosity. Careful grinding, classifying according to particle size and, if necessary, blending, is essential to produce tragacanth gum of the prescribed viscosity.

PRODUCTS OTHER THAN GUM

No other products of economic value are obtained from the bushes.

DEVELOPMENTAL POTENTIAL

The decline in consumption of tragacanth gum is largely due to the high price brought about by the shortage of supply. If it were available in greater quantities, and at a lower price, it would be the gum of choice in most of its traditional applications. On the other hand, once end-users have switched to cheaper alternatives it is expensive for them to return to previous formulations. Much depends on the end-user. If *Astragalus* could be cultivated and gum produced at a cost which would make it significantly cheaper to the end-user than at present, then it *may* be possible to regain some markets. In these circumstances, *Astragalus* would be a crop worth developing in those countries with the appropriate ecological conditions for it to grow well.

Research needs

It is odd that so little research appears to have been carried out on the cultivation of *Astragalus*, given the high value of the product obtained from it. Gentry made some theoretical estimates of gum yield from cultivated plots based on 25 000 plants/ha and 15 g/plant (= 375 kg/ha). The following aspects need to be researched:

- Basic biology, propagation and cultural techniques. More needs to be learned about the response of *Astragalus* to attempts to cultivate it.
- Differences between species in their adaptation to cultivation. Planting trials, coupled with determination of gum yields (and quality), need to be carried out on a number of different sites to identify the best species for exploitation.
- Frequency of tapping. How often can the plants be tapped and for how many years?

- Economic assessment. The economics of production under optimum conditions of cultivation and harvesting need to be assessed.
- Market for the gum. Close contact needs to be made with importers and end-users to determine whether a secure supply of tragacanth from cultivated sources would encourage them to maintain or increase their consumption.

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Table 14. Tragacanth: imports into Japan, and sources, 1988-94
(tonnes)

	1988	1989	1990	1991	1992	1993	1994
Total	20	37	31	32	23	33	20
<i>Of which from:</i>							
Iran	12	13	13	9	5	13	5
Turkey	8	17	12	15	11	1	1
UK	-	5	4	8	6	9	11
Germany	~	2	~	-	1	4	-
India	-	-	-	-	-	6	-
USA	-	~	-	-	-	-	2

Source: National statistics

LOCUST BEAN (CAROB)

DESCRIPTION AND USES

Locust bean (or carob) gum is the whitish powder obtained from grinding the endosperm of the seeds of *Ceratonia siliqua*, a tree widely cultivated in the Mediterranean region. It consists mainly of galactomannan-type polysaccharides, with a galactose:mannose ratio of about 1:4.

Unlike guar gum (produced from *Cyamopsis tetragonoloba*), locust bean is only partially soluble in cold water, but it has better water retention characteristics than guar. Solutions of locust bean gum have relatively high viscosities at low concentrations. Dispersions of the gum do not gel well unless it is in combination with other gums. Its strong synergistic action in the presence of other gums contributes to it having wide applications where good stabilizing, thickening and emulsifying properties are required.

Uses of locust bean gum are divided between food and other, miscellaneous applications.

Food use

Its use as a food additive is the most important outlet for locust bean gum. In European Community legislation it has an "E" number of E410. It is employed in a wide range of products, among the most important of which are ice cream, baby foods and pet foods. In these applications its texturizing properties are of great value and hard to replicate using other gums; in ice cream the gum slows the rate of melt-down and improves its storage properties.

Locust bean gum is an important constituent of many soups, where its property of fully dissolving and thickening only at high temperatures is critical. In sausage products such as salami and bologna it acts as a binder and lubricant. Other food uses include the manufacture of soft cheeses, bakery products, pie fillings, powdered desserts, sauces and salad creams, and dairy products other than ice cream.

Miscellaneous applications

The paper industry used to be the biggest consumer of locust bean gum and its derivatives, but its use in this field has diminished considerably. It was added during the paper-making process to improve the physical characteristics of the paper.

In the textile industry, locust bean is used either alone or in combination with starch and synthetics as a sizing agent for cotton and other natural fibres. It is also used as a print-paste thickener in both roller and screen printing to help provide greater purity and uniformity of shades and deeper penetration of dyes.

Other, minor uses include incorporation in oil-drilling fluids, and some pharmaceutical and cosmetics applications.

WORLD SUPPLY AND DEMAND TRENDS

Markets

ROBBINS (1988) details exports and imports for most of the major countries concerned for the years 1979-85, and most of the following discussion draws on his data. Up-to-date information on Japanese imports of locust bean gum, 1988-94, are provided in Table 15.

Robbins estimated total world exports of locust bean gum at about 12 000 tonnes/year. In the period covered by his report, Western Europe was the biggest market (and still is), although substantial quantities are re-exported. Within Europe, the United Kingdom was the biggest importer (averaging about 2 900 tonnes annually), with Germany the next biggest (about 1 700 tonnes/year). The United States' imports averaged 2 300 tonnes/year but were in decline due to prevailing high prices at the time.

Japan is another major market and imported an average of 1 500 tonnes/year during 1979-85. The more recent data given in Table 15 (1988-94) gives an average level of imports of just under 1 700 tonnes/year, not much different to the earlier figure.

At the time of Robbins' report, high prices were posing problems for end-users and there was evidence that locust bean gum was suffering partial substitution by a number of alternatives, notably xanthan gum, carboxy-methylcellulose and modified starches. Since that time, although prices recovered somewhat, they have recently been increasing again; this has been due to a crop shortage in 1994 caused by droughts in the Mediterranean region. In the United States, carrageenan has been making up some of this shortfall.

Supply sources

Estimates over the last 10 years of world production of pods have been in the range 350 000-500 000 tonnes/year. The main gum-producing countries are Spain, Italy and Portugal. Robbins estimated their contributions to the 12 000 tonnes total annual production of locust bean gum to be about 5 000 tonnes, 3 000 tonnes and 1 500 tonnes, respectively. The remaining 2 500 tonnes was accounted for mainly by Morocco, Greece, Cyprus and Algeria. Turkey, Israel, India and Pakistan produce locust bean but were not, then, believed to be significant traders of gum.

Exports of locust bean seed from Cyprus for 1988-92 are shown in Table 16. Apart from the United Kingdom, all other exports from Cyprus go to the three main gum producers, Spain, Italy and Portugal. The level of exports fluctuated but averaged approximately 1 000 tonnes/year.

All the major producers of locust bean gum are shown as recent sources of imports into Japan (Table 15), together with smaller producers such as Greece, India and Morocco, but the data also highlight the extent of re-exports from such countries as Denmark, Netherlands and the United States.

Quality and prices

A number of grades of locust bean gum are available, and for each grade it is possible to have different particle sizes according to the requirements of the end user. The highest grades are in the form of a near-white powder, free from specks of seed hull; particles of

seed germ, produced during the primary processing of the seed, are at a minimum. The top grades have the highest viscosity. An average quality gum contains about 12% moisture.

An FAO specification exists for "carob bean gum" employed in foods and this specifies upper limits on such things as moisture content, acid-insoluble matter and protein, as well as arsenic, lead and heavy metals.

An ISO specification also exists but this is for carob pods intended for human consumption, forage or industrial use, and not the seeds or gum.

Current (mid-1995) prices of gum, following a short crop, are very high, in the range US\$ 24-30/kg. Prices are expected to fall back to a third of this when the new crop becomes available in September/October.

PLANT SOURCES

Botanical/common names

Family Leguminosae (Caesalpinioideae):

Ceratonia siliqua L. Locust bean, carob, St John's bread

Description and distribution

C. siliqua is a long-lived evergreen tree, up to 15 m tall in favourable conditions in the wild, but under cultivation it is much smaller. It displays great variation in biological form and floral types; in unfavourable habitats it takes a shrubby form with multiple stems. A large number of named cultivars have been developed. The size, shape and thickness of the pod containing the seeds varies greatly depending on the cultivar, but up to 18 hard, brown seeds are contained in each pod; the pod may be up to 30 cm long.

The tree thrives under the hot, dry summers and cool, wet winters of the Mediterranean climate and it is distributed throughout the Mediterranean region. Its cultivation is centred on Spain, Italy and Portugal, but is also undertaken in southern Greece, Turkey, Israel, Lebanon, Syria, Cyprus and other islands in the Mediterranean. More recently, commercial exploitation has developed significantly in several North African countries, including Morocco and Algeria. It has also been introduced to the warmer parts of the United States, Mexico, South Africa, Australia and India.

COLLECTION/PRIMARY PROCESSING

The first commercial fruits can be harvested after about 5-7 years. After flowering, the pods take about 6-8 months to mature, turning from green to chocolate brown in late summer. They are usually harvested by knocking them off with long poles, preferably aimed at the bunches of pods themselves rather than by indiscriminate beating of the branches.

The harvested pods are taken to the kibbling factories where they are left to dry for about a month. They are then crushed and broken in the kibbling machines, which are usually of the hammer mill type, and put through a series of sieves which sorts the broken pieces according to size. The seeds are further separated from pieces of pod of the same size by blowing air through the mixture.

The seeds usually comprise 8–10% of the pod by weight. The approximate composition of the seed (by weight) is:

Endosperm	40–50%
Hull	30–33%
Germ	20–25%

Locust bean gum (endosperm) may therefore comprise as much as half of the seed's weight.

The separation of the seed components is a process which requires careful conditioning of the seed prior to fractionation, as well as expensive machinery, and is not always carried out in the country where the pods are harvested. However, because separation of the endosperm constitutes the first stage of gum production, the basic principles of the process are described here, rather than under **VALUE-ADDED PROCESSING**.

Details of the processing are not public knowledge but the first stage involves removal of the seed hull. This is achieved either by mechanical abrasion or by chemical treatment. In one method, the seeds are roasted, which loosens the hull and enables it to be removed from the rest of the seed; the remaining part is cracked and the crushed germ, which is more friable than the endosperm, is sifted off from the unbroken endosperm halves. An alternative method is to treat the whole seed with acid at an elevated temperature; this carbonizes the hull, which is removed by a washing and brushing operation, and the dried germ/endosperm is then processed as before. Efficient removal of the hull prior to separation of the germ and endosperm is important since residual specks of it will detract from the quality and value of the final product. The pieces of endosperm are then ground to the required particle size to furnish locust bean gum.

Yields

Yields of pods are extremely variable and depend very much on the cultivar in question, as well as climatic and other conditions where the trees are growing. Individual trees have been reported to yield up to 0.5–1.0 tonne of pods but average yields in cultivated stands rarely exceed 2.5 tonnes/ha. Average yields in Cyprus for 1967 (based on 55 000 tonnes production) were equivalent to approximately 2 tonnes/ha or 22 kg/tree. However, another report gives much higher yields: average yields in Cyprus, Israel and Mexico are stated to be equivalent to 10–17 tonnes/ha.

Yields increase steadily up to 25–30 years of age, but may vary in alternate years, being high one year and low the next. Well cared for cultivated trees have a productive life of 80–100 years.

VALUE-ADDED PROCESSING

Further processing involves either chemical modification of the gum or blending with other gums to produce a final product with a range of physical and functional properties designed to suit the end-user's requirements.

PRODUCTS OTHER THAN GUM

Locust bean pods, after grinding into a flour, have traditionally been used as a source of low-grade protein in animal feeds. The pods are especially rich in sugars and are very palatable

to cattle and pigs. However, they also contain appreciable amounts of tannins, which reduce digestibility of the protein, and locust bean meal is usually limited to around 10% incorporation in the feed. Germ meal – which is separated from the rest of the seed during gum production – is richer in protein and free of the tannins, and can be used at a higher level of incorporation in feeds, and in all classes of livestock.

The high carbohydrate content of the pod husks enables them to be used for the production of a sugar syrup. Some research has been carried out on the possible use of this syrup as a substrate for microbial protein production. The extracted sugars can also be fermented to alcohol.

In recent years, toasted carob flour produced from the pods has been widely used as a chocolate substitute, particularly in bakery and confectionery products and low calorie snack foods.

DEVELOPMENTAL POTENTIAL

C. siliqua has a number of attributes which make it well suited to promotion as a multipurpose tree in the drier parts of the world. It grows on a wide variety of soils, including marginal and rocky ones, and requires relatively little attention. It is reasonably drought resistant, although it needs some rain if it is to yield commercial quantities of pods. In return, it offers feed (for animals) and, in times of hardship or famine, food for human consumption. It also provides shade and shelter.

If it is intended to develop locust bean as a crop for international trade, rather than local use, then the labour-intensive nature of the harvesting and the increasing costs of labour in southern Europe give some advantages to potential producers in developing countries.

Research needs

If the developmental potential of *C. siliqua* is to be realized in countries outside its present area of exploitation, then the following research needs must be addressed:

- Market information. Information should be sought on the prospects for local use of pods for animal feeds and other uses, and on the export markets for seeds (since it is unlikely that production of gum itself will be feasible).
- Germplasm selection. Planting trials should be carried out, and pod/seed yields per hectare determined, for a range of cultivars tentatively judged to be most suitable for developing countries according to the particular climatic and edaphic conditions.

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Table 15. Locust bean gum: imports into Japan, and sources, 1988-94
(tonnes)

	1988	1989	1990	1991	1992	1993	1994
Total	1720	1531	1686	1781	1524	1573	1899
<i>Of which from:</i>							
Portugal	788	667	725	713	698	472	613
Denmark	234	225	213	196	201	250	316
Netherlands	219	206	223	203	205	188	230
Spain	156	169	226	380	157	325	284
Italy	128	125	156	146	122	170	243
USA	95	92	98	91	62	71	93
Greece	84	41	26	36	69	46	51
Switzerland	16	4	18	14	10	20	21
Germany	-	-	-	2	~	28	2
India	-	2	-	-	-	-	20
Morocco	-	-	-	-	-	-	10
France	-	-	-	-	-	3	9

Source: National statistics

Table 16. Locust bean seed^a: exports from Cyprus, and destinations, 1988-92
(tonnes)

	1988	1989	1990	1991	1992
Total	1578	868	1199	752	466
<i>Of which to:</i>					
UK	na	687	750	409	na
Italy	na	80	308	184	na
Spain	na	101	-	159	na
Portugal	na	-	122	-	na

Source: National statistics

Note: ^a Includes decorticated, crushed or ground seed and non-decorticated seed

MESQUITE

DESCRIPTION AND USES

The term "mesquite gum" is used here to denote the ground endosperm of the seed from *Prosopis* spp., in particular *P. juliflora*, a leguminous tree native to Central America, but now widely distributed elsewhere. An exudate gum, similar in composition to gum arabic, can also be obtained by making incisions into the trunk of the tree, but it is produced in poor yields, and although it has occasionally been offered for sale in North America it is not a widely known item of commerce and is not considered further here.

The ground endosperm of mesquite seed consists mainly of galactomannan-type polysaccharides, similar to those in locust bean and guar gums. Mesquite gum is not yet produced on a commercial scale, but *P. juliflora* is widely grown as a source of animal feed, fodder and fuel in some countries such as Brazil and India, and since some research has been carried out involving pilot-scale processing of the seed with a view to recovering the gum, it is possible that mesquite may come to be produced commercially in the future.

WORLD SUPPLY AND DEMAND TRENDS

Discussions with members of the gum trade in London have confirmed that mesquite is not a seed gum which is known in Europe. No other information has been found to suggest that it is traded elsewhere.

PLANT SOURCES

Botanical/common names

Family Leguminosae (Mimosoideae): *Prosopis* spp., especially *P. juliflora* (Swartz) DC.

Mesquite is a common name applied to several *Prosopis* species. In South America, the term "algarrobo" (Spanish) or "algaroba" (Portuguese) is used.

The taxonomy of *Prosopis* is complex and even today the nomenclature used to identify *Prosopis* species growing in some parts of the world is not consistent.

Description and distribution

Mesquite is a shrubby tree which shows a high degree of genetic diversity in pod size and shape, as well as other features. Various *Prosopis* species are native to South, Central and North America, Africa and Asia. In addition, several species are widely naturalized outside their native ranges. *P. juliflora*, for example, is native to Central America but is now very widely distributed, and has colonized large areas of semi-arid wastelands in India, northeast Brazil and elsewhere. In India the species has two distinct forms and occurs either as a single-stemmed tree or a multi-stemmed shrub.

The ability of *Prosopis* to tolerate severe heat and drought has meant that it has been used to check erosion and the encroachment of desert in arid and semi-arid areas. It has been used for this purpose in Sudan. However, *Prosopis* is also very invasive, and while this is an advantage when it comes to reforestation of degraded lands, it also poses threats if it gets out

of hand. The difficulties in eradicating it, once established, mean that it is a species with opponents as well as proponents as far as its suitability for large-scale planting is concerned.

COLLECTION/PRIMARY PROCESSING

As with other seed gums, the galactomannan component of mesquite seed is contained in the endosperm, which constitutes about 30% of the seed by weight. The seeds themselves are embedded in a hard endocarp and represent about 10% of the pod weight.

A major obstacle to the economic recovery of the seed gum is the toughness of the seed pod and the difficulty, firstly, of separating the seeds from the surrounding pulp and, secondly, splitting and cleanly separating the endosperm from the germ. (One consequence of the hardness of the seed – which contributes to the ability of *Prosopis* to spread so easily – is that it remains intact during ingestion of the pod by browsing animals and emerges later in a suitable state for germination).

Yields

Yields of 10 tonnes/ha of pods have been reported from cultivated mesquite in Brazil, equivalent to a yield of about 1 tonne/ha of seeds or 300 kg/ha of gum (endosperm). Elsewhere, 2.3 tonnes/ha/year of pods have been reported from a density of 118 trees/ha, equivalent to a yield of about 20 kg/tree.

PRODUCTS OTHER THAN GUM

Since ancient times, *Prosopis* has been used in the Americas as a source of food, fodder and fuel. The pods are high in fibre and the seeds are rich in protein, although the full nutritional value is only gained if they are ground to make a flour. The sweetish pulp surrounding the seeds makes the pods relished by browsing animals. The proliferation of flowers which are produced by *Prosopis* makes them attractive to bees, thus supporting honey production.

In several countries where mesquite is grown the tree is a valuable source of fuelwood – in the arid tract of Rajasthan in India up to 70% of the fuelwood demand is met by mesquite. The wood has a high calorific value and, since the plant also coppices well when cut, the one-year old coppice regrowth is frequently cut and used to make charcoal.

Prosopis timber is generally very hard and durable and it has been used for such things as railway sleepers and parquet flooring, and in joinery; the poor stem form of the tree does not make it suitable for large timber applications.

DEVELOPMENTAL POTENTIAL

There would be several benefits to accrue from the use of mesquite for seed gum production. It would give those farmers who presently grow it as a means of providing protein to livestock an alternative source of cash income from the same crop. And in those regions where "wild" *Prosopis* grows extensively as part of soil conservation measures (and might be used as a source of fuelwood or charcoal by local people) there would be similar opportunities for income generation.

However, the risks associated with the introduction of mesquite have been referred to earlier and they should not be underestimated. Great care should be exercised in any research that entails planting mesquite in new areas.

Research needs

The most pressing practical problem to be overcome is that of separating the seed from the pod and obtaining reasonably pure endosperm from the seed. If this was to be done with the aim of producing gum for the international market it would have to be achieved at a cost which compares favourably with locust bean or guar, but still gives the farmer an adequate economic return. For a farmer who presently grows mesquite as a source of animal feed, the economics of gum production still need to be favourable enough to divert him from feed to gum.

The research needs should therefore include:

- Techno-economic evaluation of methods for obtaining seed endosperm of a satisfactory quality from mesquite.
- Investigation of the functional properties of mesquite gum *vis-à-vis* other seed gums.
- An investigation of the potential market for mesquite gum (domestic and international) and the economics of production (assuming the other aspects, above, have favourable outcomes).

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TARA

DESCRIPTION AND USES

Tara gum constitutes the clean, ground endosperm of the seeds of *Caesalpinia spinosa*. It is a white to yellowish white powder and consists chiefly of galactomannan-type polysaccharides. The ratio of galactose to mannose in tara gum is 1:3 (compared to 1:4 in locust bean gum and 1:2 in guar gum).

Tara gum is used as a thickening agent and stabilizer in a number of food applications. A solution of it is less viscous than a guar gum solution of the same concentration, but more viscous than a solution of locust bean gum. Blends of tara with modified and unmodified starches can be produced which have enhanced stabilization and emulsification properties, and these are used to advantage in the preparation of convenience foods.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Tara gum is a relative newcomer to international trade and developmental work aimed at exploring the range of applications for which it might be suitable is still being undertaken.

Peru is the major exporter of powdered tara pods, which are used as a source of tannin (see **PRODUCTS OTHER THAN GUM** below), but data on tara gum are not readily available. A recent estimate of 1 000 tonnes annually was given by WIELINGA (1990) for total world production of tara gum, but no indication was given either of the trend or of the main markets.

Supply sources

Peru, as stated above, is believed to be the biggest (and, perhaps, the sole) exporter of tara gum. Bolivia and Ecuador are known to harvest small quantities of tara and there may be some production, also, in Chile and Colombia.

Quality and prices

The highest grades of tara gum are white and free from specks of husk and germ.

An FAO specification exists for tara gum which specifies upper limits on parameters such as moisture, ash, acid-insoluble matter, arsenic, heavy metals and protein.

Prices for tara gum are not known.

PLANT SOURCES

Botanical/common names

Family Leguminosae (Caesalpinioideae):

Caesalpinia spinosa L. Tara, huarango

Description and distribution

C. spinosa is a shrub or tree, with spreading, grey-barked leafy branches. The pods are flat, about 10 cm long and 2.5 cm wide, containing 4–7 large round seeds; the seeds are black when mature.

The tree is native to the Cordillera region of Bolivia, Peru and northern Chile and also occurs in Ecuador, Colombia, Venezuela and Cuba. It is also cultivated in most of these countries. It has been introduced to other parts of the world, including North Africa (notably Morocco) and East Africa.

It grows in ecological zones ranging from Warm Temperate Dry through Tropical Very Dry to Tropical Wet forest zones.

COLLECTION/PRIMARY PROCESSING

No easily accessible information is available on the harvesting of tara or on yields of seed to be expected from the tree. Most seed is harvested from wild trees although these are subjected to simple pruning operations.

The physical composition of tara seed (by weight) is approximately:

Germ	40%
Hull	38%
Endosperm	22%

Yields of tara gum (endosperm) from the seed are therefore relatively small (22%), and less than that for the two other principal seed gums, locust bean (40–50%) and guar (*ca* 35%).

Like locust bean, the hull of tara is tough and hard, and special processes have to be used to remove the hull before separating the endosperm and germ. Acid treatment or roasting processes (as described for locust bean) are used to obtain the endosperm.

VALUE-ADDED PROCESSING

Like guar gum, further processing entails blending tara with other gums or chemically modifying it to produce the range of functional properties that are sought. This further processing is capital-intensive and is only carried out on a large scale by companies who process other gums in a similar manner.

PRODUCTS OTHER THAN GUM

Once separated from the hull and endosperm, it should be possible to use the germ of the seed as a source of protein, perhaps in animal feeds. However, it is not known whether this occurs in practice.

Tara pods are rich in tannin and are a regular item of trade in Peru for tanning purposes. The tannin is used extensively in South America and Morocco for tanning sheep and goat skins, and produces a good quality, light-coloured leather. Peruvian exports of powdered tara for tanning purposes averaged just over 5 000 tonnes/year during 1990–93.

C. spinosa is sometimes grown as a live fence in Peru for keeping out animals.

DEVELOPMENTAL POTENTIAL

There is very little documented information available to know to what extent tara has been investigated as a dual purpose seed crop. Since the pods are utilized for tannin extraction purposes it is logical to think, also, in terms of gum production from the seeds. In this way, further economic value can be derived from a single harvested product (i.e., pods containing the seeds).

The opportunities for increasing production of tara depend very much on the markets for both tara gum and the tannins derived from the pods. If both markets are supplied from present production, then a disproportionate upturn in one market will, if met by increased production, cause an oversupply in the other. The greatest need in ascertaining the developmental potential of tara is therefore to investigate the markets for the seed (as a source of gum) and the pods (as a source of tannin).

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COPAL

DESCRIPTION AND USES

The term copal applies to a large group of resins characterized by their hardness and relatively high melting point. They are soluble in alcohol. Up until the 1940s, or thereabouts, they were among the best of the natural resins for use in varnish and paint manufacture, and traded in very large volumes. In the oil-soluble form they were also used in the manufacture of linoleum. Copal has been produced from a large number of different tree species from many parts of the world - Africa, Asia and South America. Today, most copal of commerce originates from *Agathis* species of Southeast Asia: the Malay and Indonesian archipelagos in particular and, to a lesser extent, the Philippines.

Today, the major use of copal is as a varnish for wood and paper. It still finds use in road-marking paints, where the capacity of the resin to prevent bleed-through of road-making materials is beneficial, and there are numerous other, minor uses.

Until the decline in demand for copals brought about by the use of synthetic resins for varnish and paint manufacture, much of the copal was collected in the fossilized or semi-fossilized form. Nowadays, most of it is collected by tapping the living tree. Furthermore, many of the trees which are now tapped have been planted, and there is no longer dependence on the wild forest.

Historical introduction

Historically, the copals have been classified according to their geographical origin:

- **Congo copal.** In the 1920s, 1930s and 1940s, the quantity of copal produced from the former Belgian Congo (now Zaire) far exceeded that from any other region of the world. From 20 tonnes in 1900, production rose to 12 000 tonnes in 1923 and 23 000 tonnes in 1936. The resin was all of the fossilized type, having fallen to the ground from the tree where it was produced as a result of natural exudation or from accidental injury. In many cases, the trees were no longer standing and the resin was recovered from below the surface of the earth, where it was located by exploratory prodding with a stick. The very hard, acidic materials were traditionally converted into oil-soluble forms for use in varnishes by a process known as "running" (subjecting them to high temperature heat treatment).
- **West African copals.** These were collected and exported in moderate amounts before Congo copal became so important. Again, most of the resin was fossilized, and the copals were known in the trade by their country or place of origin, e.g., Sierra Leone, Cameroon, Angola and Accra copals.
- **East African copal.** This was produced mainly in Tanzania and Kenya and was collected either in semi-fossilized form (from the soil below the tree where it fell), fossilized form (from the soil where the tree no longer existed), or by tapping the living tree.

- **South American copals.** Brazilian copal is the best known and is still produced to a very small extent today, where it is known as jutaicica. It is usually collected as a semi-fossilized resin.
- **East Indian and Manila copal.** These were copals produced from what is now Indonesia and nearby islands, and the Philippines. The term Manila copal arose from the time when Manila was the main port of export. Total production from this region in some years during the early part of the century reached 15 000 tonnes; then, the copal was collected both in the semi-fossilized form and by tapping. Today, this is the most important copal-producing region of the world and all of it is produced by tapping.

Apart from brief reference to the botanical sources of the African and South American copals (**Plant Sources**), the rest of the discussion below is confined to those copals which are still produced today: copal of mainly Indonesian origin and Manila copal ("almaciga"). Both are produced from *Agathis* species.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Exports of copal from Indonesia and the Philippines for the period 1988–93, and their destinations, are given in Tables 17 and 18, respectively.

Total exports from Indonesia and the Philippines averaged about 2 300 tonnes annually during 1988–93. Most Indonesian copal (and some Filipino) is shipped via Singapore but Germany, which also imports directly from Indonesia, is a major onward destination and the most important in Europe. India and Japan import modest quantities directly from Indonesia. China (Taiwan) is the biggest importer of copal from the Philippines.



Cleaning and sorting copal, Java, Indonesia. (Photo: J.J.W. Coppen)

Imports of copal and damar into Japan during 1985–87 are shown in Table 19, although it is not possible to separate the two commodities. After 1987, copal and damar are not separated from "Natural gums, resins, gum-resins and balsams, n.e.s.". Combined imports of copal and damar averaged just over 400 tonnes/year in 1985–87.

Supply sources

Indonesia is by far the biggest producer and exporter of copal. After the fall in exports in 1989 from almost 2 500 tonnes the previous year (Table 17), levels have been remarkably constant at about 1 850 tonnes/year.

The Philippines is the second biggest producer of copal; exports during 1988–93 averaged about 350 tonnes/year with no clear trend.

In 1982, Sarawak exported just over 50 tonnes of copal; Malaysian exports since then record only very small quantities of copal.

Papua New Guinea has been a small producer and exporter in the past but the present scale of production from this source (if any), and other islands of the Pacific, is not known.

Quality and prices

The quality of copal which is collected is very variable, depending inherently on the species from which it is obtained (which may affect its solubility properties) and the manner in which it is collected: whether by tapping or by picking from the ground in a fossilized form. After cleaning (removing pieces of bark and other foreign matter), different grades of copal in trade are distinguished by their hardness, colour and size of the pieces, as well as the state of cleanliness. Pale, clean pieces, with good solubility in alcohol, are the best quality.

Present (mid-1995), indicative prices for some Indonesian copal grades shipped from Singapore (CIF London) are:

"Clean scraped chips"	US\$ 1 500/tonne
"Medium scraped chips"	US\$ 1 000/tonne
"Small chips"	US\$ 900/tonne

Prices have been fairly stable in recent years.

PLANT SOURCES

Botanical names (present day Asia/Pacific copals)

Family Araucariaceae: *Agathis* spp.

The taxonomy of *Agathis* has been, and still is, confused and in the past, numerous different species names have been cited as the source of copal; the most common one has been *A. alba*. In some cases, even now, plantation trees, grown and tapped in Indonesia, are referred to simply as "*Agathis* spp.", with no attempt to give a full name.

WHITMORE (1977, 1980) and de LAUBENFELS (1989) recognize more than a dozen species of *Agathis* – which extend from peninsular Malaysia, across the Malay and Indonesian archipelagos to islands in the Pacific (as far east as Fiji), and south to the coastal regions of Queensland, Australia, and New Zealand – although the authors differ on some points. They agree that the natural stands on Peninsular Malaysia, Sumatra and Borneo which are sources of copal are those which should be designated *A. borneensis* Warb., but trees in the

Philippines and Sulawesi are considered to be *A. dammara* (Lamb.) Richard by Whitmore and *A. philippinensis* Warb./*A. celebica* (Koord.) Warb. by de Laubenfels. Other copal producers include *A. labillardieri* Warb.

The identity of the extensive plantation *Agathis* which are tapped on Java is not known (to the present author) and to avoid confusion no species name is attached to *Agathis* hereafter in this discussion.

Historical copals

(N.B. The genera given below all belong to the family Leguminosae. However, the species listed are those attributed by HOWES (1949); their current acceptance in terms of botanical nomenclature is not known and some of the names may be obsolete.)

Congo copal

Mainly or entirely from *Copaifera demeusei*.

West African copals

Copaifera copallifera, *C. demeusei*, *C. mopane*.

East African copal

Almost entirely from *Trachylobium verrucosum*.

South American copals

Various *Hymenaea* spp., especially *H. courbaril* L.

Description and distribution (Asia/Pacific copals)

Agathis is the most tropical of all conifers. The copal-yielding species are very tall trees, up to 60 m high, often with a near-cylindrical bole. However, there can be some variation in the characters of the living tree, as well as the ecological conditions under which it occurs. It is grown widely as a timber tree on Java (over 100 000 ha) and other parts of Indonesia.

The distribution of *Agathis* has been discussed above.

COLLECTION/PRIMARY PROCESSING

Nowadays, most copal, at least that intended for international markets, is obtained by tapping the tree, rather than collecting fossilized resin from the ground. In the tree, the resin resides in the living inner bark of the trunk and tapping involves making incisions into the bark and collecting the exudate. Fresh cuts are made at suitable intervals – a few days or a week or more – gradually moving up the tree. The size and shape of the cuts, the extent to which they might penetrate the wood, and their frequency of application have changed over the years and still vary according to the country or region in which tapping is undertaken, or the traditions of the communities involved.

Present practice on Java is for the tapper to return to the tree to make fresh incisions every 3–4 days; up to four or more small tin cups may be in place at different points on the tree at any one time, depending on the size of the tree. In the Philippines, research has been undertaken using tapping methods very similar to those used in tapping pine trees (involving use of sulphuric acid as a chemical stimulant), but it is not known whether such methods are used commercially.

Collected resin is cleaned by sieving and hand picking to remove foreign matter, and packed in sacks for transfer to points of sale, either nationally or internationally.

Yields

Resin yields are very variable and depend on a large number of factors: genetic, environmental and practical (i.e., method of tapping used). Annual yields of 16–20 kg have been reported from good trees in the Philippines and Papua New Guinea, while average yields have been variously estimated at 2 kg or as much as 10–12 kg. Recent tapping trials at three sites in the Philippines resulted in average annual yields of 1.2 kg, 3.7 kg and 5.6 kg/tree.

Recent research in Indonesia and the Philippines has shown that thick-barked *Agathis* yields significantly more resin than thin-barked trees (in one study in Indonesia, almost nine times as much), and that tapping in the morning and at the side of the tree which maximizes the length of time that sunlight falls on it is beneficial to resin yields.

VALUE-ADDED PROCESSING

No further processing is carried out until the copal is formulated for use by the end-user; this may involve heat treatment, dissolution in a suitable solvent and/or chemical processing. The latter may be carried out by a specialist chemical processor and usually involves preparation of copal esters to neutralize the natural acidity of copal and render it oil-soluble.

PRODUCTS OTHER THAN RESIN

Agathis produces a high class, much valued, utility timber and it is grown widely as a timber tree. In Malaysia, it is the most important commercial softwood, and it is also widely planted in Indonesia.

DEVELOPMENTAL POTENTIAL

Resin-yielding *Agathis* are planted for timber, rather than as a source of resin, and tapping of plantation trees is therefore a secondary activity to that of timber production. The proportion of planted trees which are tapped commercially is not known, but it is probable that it is a relatively small proportion and that copal production from such sources could be increased significantly if demand and the economics of production were favourable.

By nature, the trees are very large and there is little scope for agroforestry-type interventions. However, taking into account the fact that there is a steady demand for copal, that some copal will continue to be obtained from wild sources, and that importers are always prepared to consider new, reliable sources of supply, there may be some opportunities for new producers – perhaps for some of the Pacific islands where cooperatives can be organized.

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Table 17. Copal: exports from Indonesia, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	2485	1811	1766	1880	1863	1886
<i>Of which to:</i>						
Singapore	1807	1233	1130	1173	1332	1362
Germany	262	405	435	495	390	258
India	38	45	90	105	15	57
Japan	38	60	38	63	25	25
Hong Kong	22	51	30	14	30	83
China (Taiwan)	270	-	15	-	-	-
Pakistan	-	-	28	30	71	87
UK	45	-	-	-	-	-
Netherlands	-	17	-	-	-	-
France	-	-	-	-	-	14

Source: National statistics

Table 18. Manila copal: exports from the Philippines, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	407	345	288	363	272	382
<i>Of which to:</i>						
China (Taiwan)	184	196	139	224	171	286
Hong Kong	91	72	78	84	60	52
Singapore	70	57	60	44	30	-
USA	56	20	-	5	-	14
France	6	-	11	6	-	-
Germany	-	-	-	-	11	30

Source: National statistics

Table 19. Copal and damar: imports into Japan, and sources, 1985-87
(tonnes)

	1985	1986	1987
Total	441	441	347
<i>Of which from:</i>			
Indonesia	426	414	302
Singapore	15	27	15
Malaysia	-	-	30

Source: National statistics

DAMAR

DESCRIPTION AND USES

"Damar" (sometimes spelled dammar) is a Malay word meaning resin or torch made from resin. Although, today, the word is used in a more restrictive sense, it is still applied as a collective term to a great variety of hard resins. Damars of international commerce come from the dipterocarp forests of Southeast Asia, mainly from Indonesia. Damar from the sal tree is produced in India. Production is mainly by tapping living trees, although some is still collected from the ground in fossilized form.

Damars are solid resins, generally less hard and durable than the copals, and white to yellow in colour. They are distinguished from copal by their solubility in hydrocarbon-type solvents and drying oils. Like copals, however, their main use is still in the manufacture of paper or wood varnishes and lacquers, and some paints, although consumption has inevitably declined over the years with the widespread use of synthetic materials. They used to be an important ingredient in many types of cellulose lacquers, imparting gloss and adhesive qualities and preventing after-yellowing. Nowadays, they find particular use as a varnish for the fine arts.

Miscellaneous minor uses include the manufacture of inks, polishes, water-resistant coatings and injection moulding materials. A little is used in foods as a clouding or glazing agent. In the countries where damars are produced, they find local use for caulking boats and baskets. In India, sal damar is widely used as an incense and in the indigenous system of medicine.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Interpretation of trade statistics for damar is made more hazardous than usual by the use of different terms for resins which are, nevertheless, damars of one type or another. Examination of Indonesian trade statistics reveals three different damars: "Gum damar", "Mata kucing" and "Batu". Mata kucing ("cat's eye") is a term applied to the crystalline damar resin (usually in the form of round balls) obtained from certain of the dipterocarp species. Batu ("stone") refers to the opaque, stone or pebble-shaped damar collected from the ground.

Indonesian exports of the three types of damar for 1988–93, and their destinations, are given in Tables 20a, 20b and 20c. Average annual exports have been approximately 2 000 tonnes (gum damar), 6 300 tonnes (Batu) and 3 200 tonnes (Mata kucing), making about 11 500 tonnes in total. There is some year-to-year fluctuation, but nothing that indicates a downward trend.

Exports of damar from Thailand for the period 1988–93, and destinations, are shown in Table 21. Exports have averaged approximately 1 800 tonnes/year, with a slight downward trend.

Considering Indonesian and Thai exports with smaller amounts from other countries, total international trade in damar might approach 15 000 tonnes/year.



A damar (*Shorea javanica*) garden in southern Sumatra, Indonesia. First cuts for tapping are made when the tree is about 20 years old. (Photo: Mien Kaomini)



Tapper climbs the tree supported by a rattan belt to collect the solidified exudate (damar) and to refresh the cuts, Sumatra, Indonesia. (Photo: H. de Foresta)

Most Indonesian damar is exported to Singapore from where it is re-exported to consumer countries. Of those other countries which import directly from Indonesia, Germany is a major destination, particularly of batu (taking about 2 000 tonnes in each of 1992 and 1993). Other Southeast Asian countries such as China (Taiwan) and Malaysia import significant quantities, as does India. India is the biggest market for Thai damar and in recent years has taken all, or almost all, of Thailand's exports, around 1 500–2 000 tonnes/year.

Except for 1989, Japanese imports have been limited to "gum damar", usually about 100–140 tonnes annually. Combined imports of copal and damar for 1985–87 have been given earlier (Table 19).

Indian consumption of damar from indigenous sources is believed to be substantial but cannot be quantified.

Supply sources

Indonesia is by far the major source of internationally traded damar. Export statistics are not easily accessible for some of the other countries known to produce damar, but of these, Viet Nam, Laos and Cambodia have exported variable quantities. De BEER (1993) has estimated Laotian production of damar at 500–1 000 tonnes/year and states that most is exported to Thailand; a proportion of Thai exports may therefore simply be re-exports of damar from Laos. Malaysia exports small quantities of damar but the larger level of imports make it a net importer.

Quality and prices

As would be expected for a commodity of such diverse origins, damar is of extremely variable quality. Colours range from very pale grades to those which are grey-black. Physical form and size varies from large irregular lumps or smaller globular lumps to small chips and dust. In past years, damars of recognized quality were usually identified by the port at which cleaning and grading took place and from where they were dispatched, or their geographical origin (e.g., Pontianak and Batavia), and this is still often the case today (e.g., Palembang).

There is an FAO specification for damar which gives a number of limits for such things as arsenic, lead and heavy metal content.

Illustrative of current (mid-1995) prices (CIF London) are the following for grades A–C of Palembang damar:

- A US\$ 1 250–1 370/tonne
- B US\$ 1 225–1 345/tonne
- C US\$ 1 120–1 215/tonne

The lower end of each range is the discounted price for larger (container load) lots. Dealers in London state that prices have been very stable over recent years.

PLANT SOURCES

Botanical names

Family Dipterocarpaceae:

Shorea spp. (including *S. javanica* K. & V. [Sumatra], *S. lamellata* Foxw. [Malaysia, Sumatra, Borneo], *S. virescens* Parijs [Borneo, the Philippines], *S. retinodes* Soot. [Sumatra], *S. guiso* (Blco) Bl. [Thailand, Malaysia, Sumatra, Borneo, the Philippines] and *S. robusta* Gaertn. f. [India]).

Hopea spp. (including *H. dryobalanoides* Miq. [Malaysia, Sumatra, Borneo] and *H. celebica* Burck. [Sulawesi]).

Vatica spp. (including *V. rassak* (Korth.) Bl. [Borneo, the Philippines, Sulawesi, New Guinea]).

Vateria spp.

Balanocarpus spp.

Family Burseraceae: *Canarium* spp.

Description and distribution

Trees of the family Dipterocarpaceae are medium to very large trees, widespread and of very great importance as a source of tropical hardwood throughout the Indian and Southeast Asian regions, including the Malay and Indonesian archipelagos. A large number of species from several genera have been tapped for resin at one time or another, and where the resin which is collected is used locally this is still probably true. The number of species which yield resin which eventually enters world trade is smaller but the identity of the botanical source is usually lost as the damar passes through the various stages of sale.

Shorea robusta is tapped in India. Wild trees of various *Shorea* and *Hopea* species are tapped in Myanmar, Thailand, Laos, Cambodia and Viet Nam. Although many dipterocarps flower and fruit very irregularly (which has hampered attempts to cultivate them) damar is collected from certain species which have been successfully planted by local people in Indonesia: *S. javanica* and *H. dryobalanoides* in Sumatra and *Vatica rassak* in Kalimantan, Sulawesi and Maluku.

Canarium spp. also yield a dammar-type resin, which is occasionally collected although it is not believed to be an important item of commerce.

COLLECTION/PRIMARY PROCESSING

TORQUEBIAU (1984) gives a good description of tapping cultivated *S. javanica* in Sumatra. Traditional methods of tapping trees to obtain damar (whether wild or cultivated trees) involve removal of wood from the stem. Cuts made into the trunk have a triangular form but become circular with age and are arranged in vertical rows around the trunk. The first cuts are made when the tree is approximately 25 cm in diameter (about 20 years old). The cut

is several centimetres wide at first, but becomes enlarged at every tapping and eventually becomes a hole of 15–20 cm in depth and width. The average number of holes for a tree about 30 m high and 60–80 cm diameter is 9–11 in each of 4–5 vertical rows. For the higher holes, the tapper climbs the tree supported by a rattan belt and using the lower holes as footholds.

The exuded resin is allowed to dry on the tree before it is collected; resin which forms hard drops becomes "mata kucing". The frequency with which the tree is visited to refreshen the cut varies from once a week to once a month, depending on how far the tree is from the village. Tapping can continue for 30 years.

In India, tapping involves removing narrow strips of bark from the tree. The resin which exudes solidifies and darkens on drying and is then removed from the tree. Tapping is repeated several times a year.

Yields

When tapped once a month in the manner described above, a fully productive tree has been stated to yield about 4 kg of damar at each tapping, i.e., about 48 kg/year. However, there is known to be genotypic (tree-to-tree) variation in yields and some trees may only be tapped every 3 months because of poor yields. In other cases, if the resin from a good-yielding tree is not collected for 6 months it may completely fill the hole in the tree (10–15 cm wide and deep).

Resin production is reported to fall markedly when the tree is flowering and fruiting, and only reaches previous levels a year later.

VALUE-ADDED PROCESSING

So-called "dewaxed" damar is prepared by dissolving damar in a hydrocarbon solvent and precipitating and removing a high-melting, resinous fraction. The remaining soluble fraction is then more compatible with the cellulose component of cellulose lacquers.

PRODUCTS OTHER THAN RESIN

Damar-producing trees are also highly valued for timber, and felling them for sawtimber or the manufacture of value-added wood products is usually the primary activity. Some local use is made of the fruits.



A *Shorea javanica* tree in later stages of tapping, Sumatra, Indonesia. Tapping continues for a period of about 30 years. (Photo: Mien Kaomini)

In India, an oil is distilled from the resin which is used for fragrance and medicinal purposes. The seeds of sal furnish a fatty oil and the residual cake can be used as an animal feed.

DEVELOPMENTAL POTENTIAL

The "kebun damar" (damar gardens) of *S. javanica* in Lampung, southern Sumatra, are an example of how, over many years, communities have developed a traditional cultivation system which is now regarded as a model of agroforestry technique. Rain-fed rice is grown for one or two years and then coffee, pepper or some other crop is planted, together with *Shorea* and other useful trees such as cloves. While the damar trees are reaching the age at which they can first be tapped (15–20 years), other products can be harvested to provide cash income to the farmers. The whole system converts one of a shifting cultivation to a permanent, sustainable, productive land-use system.

Much is still to be learnt about the biology and silviculture of *S. javanica* but valuable knowledge and experience has already been gained and research is still in progress through BIOTROP in Bogor, Indonesia. It is hoped that the successful development of plantations of *S. javanica* will encourage the use of other dipterocarps and native trees for plantation forestry. There is much potential, therefore, for the agroforestry approach to damar production, not only in Indonesia but in other countries, and the important question may then be that of the market and how much damar it can absorb.

Research needs

Apart from the need to acquire more detailed information on the markets for damar (countries or regions which are important consumers, end uses, customer requirements in terms of quality, etc.), other areas of research (in addition to continued research on silvicultural aspects) should include:

- Improved tapping methodology. The use of chemical stimulants to promote resin flow has already recently been investigated (MESSER, 1990) but the research should be extended. There would be much to be gained if less severe methods of tapping, i.e., ones which did not involve removal of so much wood, could be developed.
- Screening of wild trees to identify superior planting stock. Gains in productivity could be made by identifying high-yielding trees and transferring their progeny to the nursery.

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Table 20a. Damar^a: exports from Indonesia, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	1665	1374	952	2198	2376	3031
<i>Of which to:</i>						
Singapore	659	994	778	1583	1902	2171
Japan	289	136	109	136	121	123
Germany	118	63	30	90	75	90
China (Taiwan)	15	15	15	130	100	229
Malaysia	40	25	15	98	16	76
Pakistan	531	-	-	-	-	-
Netherlands	13	-	-	-	15	-
UK	-	78	-	45	-	-
France	-	25	-	13	48	93
Korea, Rep. of	-	20	-	75	3	-
Viet Nam	-	18	-	-	-	-
Hong Kong	-	-	5	10	20	15
Sri Lanka	-	-	-	18	18	-
India	-	-	-	-	20	234
Colombia	-	-	-	-	38	-

Source: National statistics

Note: ^a Classified as "Gum damar"

Table 20b. Damar^a (batu): exports from Indonesia, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	5749	6549	6571	6206	5214	7440
<i>Of which to:</i>						
Singapore	4563	4890	5021	4581	2962	4242
Germany	700	1408	1105	1250	2092	1966
Malaysia	385	170	264	315	-	163
India	29	28	168	60	121	818
China (Taiwan)	52	15	-	-	16	15
Pakistan	-	14	-	-	23	13
Bangladesh	-	-	-	-	-	223
Netherlands	20	-	-	-	-	-
Poland	-	24	-	-	-	-

Source: National statistics

Note: ^a Classified as "Resin: Batu"

Table 20c. Damar^a (mata kucing): exports from Indonesia, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	2929	3449	3355	4169	2585	2814
<i>Of which to:</i>						
Singapore	2714	3122	2710	3072	2265	2114
China (Taiwan)	160	207	612	821	115	304
India	-	41	20	20	68	219
Germany	-	31	-	15	76	77
Malaysia	55	5	-	5	33	15
Japan	-	27	-	-	-	-
Italy	-	15	-	-	-	10
France	-	-	13	-	-	-
Korea, Rep. of	-	-	-	200	-	-
Ecuador	-	-	-	36	-	-
UK	-	-	-	-	16	32
Saudi Arabia	-	-	-	-	12	-
Syria	-	-	-	-	-	24
China, P. Rep. (excl. Taiwan)	-	-	-	-	-	19

Source: National statistics

Note: ^a Classified as "Resin: Mata kucing"

Table 21. Damar: exports from Thailand, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	2107	2328	1499	1841	1391	1475
<i>Of which to:</i>						
India	2031	2295	1499	1841	1372	1475
Singapore	64	17	-	-	2	-
Pakistan	10	-	-	-	-	-
Tunisia	-	16	-	-	-	-
Bangladesh	-	-	-	-	17	-
Myanmar	2	-	-	-	-	-

Source: National statistics

MASTIC

DESCRIPTION AND USES

Although usually termed a gum, mastic is a hard resin, produced by tapping the stem bark of the small tree *Pistacia lentiscus*, which is cultivated on the Greek island of Chios.

Mastic is produced in the form of small tears, pale yellow in colour, clear and glassy in nature and liable to fracture. Its age-long use in Arab countries has been for chewing, where it sweetens the breath and helps preserve the teeth and gums. Its aromatic properties also make it suitable as a flavouring agent for alcoholic beverages. In the past it was also used in the manufacture of high-grade varnishes for paintings, and for medicinal purposes.

An essential oil can be distilled from the gum and finds some use for fragrance and flavouring purposes.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Since Greece is by far the most important source of internationally traded mastic, production in Chios is also a fair measure of world demand. In the mid-1940s, annual production was around 300 tonnes. Greek sources estimated production at about 250 tonnes and 200 tonnes in 1961 and 1963, respectively. In 1975, production was put at 300 tonnes. Demand appears, therefore, to have been maintained at around 200-300 tonnes annually for some time. Recent figures are not known.

Apart from the Middle Eastern countries, where mastic is used for chewing, the United States and Europe also import it. In the United States and Europe, part of the mastic is distilled to produce essential oil.

Supply sources

Greece is by far the most important (and may well be the only) source of mastic of commerce. Production levels have been indicated above. Countries such as Algeria and Morocco have offered occasional, small quantities in the past.

Quality and prices

There are a number of different grades of mastic corresponding to degrees of cleanliness and size and shape of the tears. Exuded resin that has not been allowed to drop to the ground before collection and has formed perfect tears is the best quality and fetches the highest price.

An illustrative price for small quantities of No. 1 small tears (mid-1995, CIF London) is US\$ 60/kg. Discounts are available for larger quantities. There has been a steady upward trend in prices in recent years.

PLANT SOURCES

Botanical name

Family Anacardiaceae: *Pistacia lentiscus* L. var. *chia*

Description and distribution

P. lentiscus is an evergreen, shrubby tree which normally grows to a height of about 2-4 m; exceptionally, it may grow to about 5 m. It is slow growing and long lived, and attains its full development at 50-60 years. The natural habit of the plant is bush-like, but under cultivation for mastic gum only one or two shoots are allowed to grow and develop into stems; the mature plant consists of one or two thick, contorted stems with an umbrella-shaped crown.

Other *Pistacia* species, such as *P. vera*, yield an exudate resin but *P. lentiscus* is the only one which is tapped commercially.

P. lentiscus prefers an arid, sub-tropical climate and occurs in coastal Mediterranean regions of both southern Europe and north Africa, and some of the islands in the Mediterranean such as Sicily, Sardinia and Cyprus. However, it is only cultivated for mastic on the Aegean island of Chios, where it occurs as *P. lentiscus* var. *chia*; it is often interspersed with olive trees.

COLLECTION/PRIMARY PROCESSING

In Chios, tapping and collection of the resin is limited to a 3-month period in late summer between July and October. The first light tappings are made when the tree is about six years old. A number of short, shallow incisions are made into the bark of the stem and the main branches. The wounds penetrate a few mm into the bark as far as the cambium; the number of wounds depends on the age and size of the tree. Further cuts are made at approximately one-week intervals. The first tapping period continues for 5-6 weeks and after a further 10 days, during which time the last of the exuded resin dries and solidifies, the first collection is made. This entails picking up pieces of resin that have fallen on the ground as well those adhering to the trunk of the tree. A second tapping and collection is made in the second half of the season.

After collection, the mastic is laid out to dry and foreign matter is removed by a combination of sieving and hand picking. The semi-cleaned resin is then soaked in water which serves to remove most of the adhering dirt and smaller impurities; it also gives the pieces of resin an added lustre.

Yields

The mastic plant starts yielding reasonable amounts of resin, about 30 g/year, at 10-12 years of age. Yields then gradually increase to about 300-400 g per tree at the age of 50-60 years. Individual trees have been known to yield up to 1 kg under favourable conditions.

VALUE-ADDED PROCESSING

An essential oil can be produced in 1–3% yield by steam distillation of the resin. Extraction of the resin with a suitable solvent yields a mastic resinoid.

PRODUCTS OTHER THAN RESIN

No other products of economic value are obtained from the tree.

DEVELOPMENTAL POTENTIAL

The market for mastic is firm but modest. If supplies continue to be available from Chios, then there is unlikely to be much scope for new entrants to the market, whether from wild or cultivated plant sources. Given also that *P. lentiscus* is slow growing, that the traditional mastic comes from a particular variety that occupies an ecological niche in Chios, and that it is some years before any economic returns are gained from cultivated plants, there is little developmental potential in mastic as far as new producers are concerned.

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DRAGON'S BLOOD

DESCRIPTION AND USES

The term "dragon's blood" has been applied since ancient times to the red coloured resin obtained from a large number of plant species of different geographic and botanical origin: from the Middle East, Southeast Asia and South America, and from amongst several different families of plants. The resin of commerce is in the form of powder, granules, sticks or friable lumps with a deep, dull red colour.

Traditionally, dragon's blood has been, and still is, used for medicinal purposes, whatever the source. In the past it has found minor use in coloured varnishes, lacquers and wood stains, although its use for this purpose (other than locally) is now largely confined to very specialized markets, such as violin varnish.

WORLD SUPPLY AND DEMAND TRENDS

Markets

It is extremely difficult to estimate the size of the market for internationally traded resin, but it is probably not more than a few hundred tonnes annually, and may be much less.

Domestic consumption in those countries where dragon's blood is popular as a traditional medicine is equally difficult to estimate, but demand in countries such as Peru and Ecuador, where *Croton* is the botanical source, is believed to be significant.

The main source of dragon's blood of commerce is Indonesia, and exports from Indonesia for the period 1988–93 are given in Table 22. Apart from Pakistan in 1991, all recorded exports went to Singapore and Hong Kong, so the final destinations – assuming most is re-exported – are not known.

Supply sources

Indonesian exports, probably originating in Sumatra, averaged just over 50 tonnes/year during 1988–93, with a peak of almost 90 tonnes in 1991. The scale of domestic consumption is not known so it is not possible to say by how much production might exceed the levels of exports.

Resin from plants growing in Yemen, the Canary Islands and sources in South America are not believed to enter world trade.

Quality and prices

Dragon's blood of Indonesian origin is available as sticks ("reed") or cakes ("lump"). In mid-1995, Indonesian dragon's blood was quoted by one London dealer at US\$ 60/kg for small quantities (cf US\$ 42/kg in 1992). Another dealer quoted US\$ 33/kg for No. 1 grade and US\$ 5/kg for No. 2 grade, both of Middle Eastern origin.

PLANT SOURCES

Botanical/common names

Family Palmaceae:

Daemonorops draco Blume East Indian dragon's blood
D. didymophylla
D. micranthus Becc.
D. motleyi Becc.

Family Agavaceae:

Dracaena cinnabari Balf. f. Socotra dragon's blood
D. draco Canary dragon's blood

Family Euphorbiaceae:

Croton draconoides (Muell.) Arg.
C. draco Schlect
C. lechleri L.
C. urucurana Baill.
C. xalapensis H.B.K.

Description and distribution

Daemonorops spp. are climbing jungle palms and the source of cane in Southeast Asia. In *D. didymophylla*, spiny stems bear bunches of scaly fruits which are covered in the red resin. In the past, the main areas of exploitation for resin have been the islands of Sumatra and Borneo, and some parts of Peninsular Malaysia.

Dracaena spp. are mostly trees of the Old World. *D. cinnabari* is endemic to the island of Socotra, Yemen. *D. draco* occurs on the Canary Islands.

Numerous *Croton* spp. which yield a blood red latex (Sangre de Drago) occur in Mexico, Central America and South America (e.g., Venezuela, Ecuador, Peru, Brazil).

COLLECTION/PRIMARY PROCESSING

Dragon's blood resin obtained from *Daemonorops* is present as a brittle layer on the surface of the immature fruit. After picking, the fruits are dried and placed in bags, which are then beaten to dislodge the resin. The resinous powder thus obtained is then sifted and warmed so that it can be moulded into sticks or formed into irregular shaped lumps.

Resin from *Dracaena* and *Croton* is obtained by making incisions into the stem of the plant and collecting the exudate.

Yields

No information is available on yields of resin from any of the botanical sources.

VALUE-ADDED PROCESSING

No further processing is carried out until the resin is ready for formulation by the consuming industry.

PRODUCTS OTHER THAN RESIN

Apart from local use as a source of cane in Southeast Asia, no other products of economic value are known to come from the species which yield dragon's blood.

DEVELOPMENTAL POTENTIAL

Unless some of the traditional medicinal uses of dragon's blood are developed into more widely used products, there appears to be very little developmental potential for the plants or the resins they produce.

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**Table 22. Dragon's blood: exports from Indonesia, and destinations, 1988-93
(tonnes)**

	1988	1989	1990	1991	1992	1993
Total	26	59	71	87	47	25
<i>Of which to:</i>						
Singapore	19	56	59	36	38	23
Hong Kong	7	3	12	20	9	2
Pakistan	-	-	-	31	-	-

Source: National statistics

BENZOIN

DESCRIPTION AND USES

Benzoin is a balsam obtained from trees of the genus *Styrax* from Southeast Asia. There are two types of benzoin of commerce: Siam benzoin from *S. tonkinensis* and Sumatra benzoin (also called gum Benjamin) from *S. benzoin*.

When freshly collected, Siam benzoin is a semi-solid material but it soon hardens to form brittle tears or pebble-shaped pieces, often translucent, and yellowish-red to brown in colour. Sumatra benzoin also hardens to form solid tears. However, both types (but particularly Sumatra benzoin) often enter trade as solid blocks comprising whitish tears embedded in a matrix of reddish-brown resin (often made from damar dust).

In common with other balsams, both types of benzoin contain mixtures of either predominantly benzoic acid and its esters and other derivatives (Siam benzoin), or cinnamic acid and its derivatives (Sumatra benzoin), and these confer on benzoin the characteristic balsamic odour. The lower grades of Sumatra benzoin have a harsher note.

A range of tinctures, "resinoids" and "absolutes" are produced by extraction of the balsam with suitable hydrocarbon or alcoholic solvents and these are the form in which benzoin is usually employed in its end-uses. Unlike many other balsams, benzoin produces negligible amounts of essential oil on distillation.

Both types of benzoin have extensive fragrance applications but the higher quality of the Siam benzoin enables it to be used in the more expensive, delicate perfumes. In the areas where it is produced, benzoin is also traded as an incense.

Sumatra benzoin (and, to a lesser extent, Siam benzoin) is used quite widely in pharmaceutical preparations: as an ingredient of inhalations for the treatment of catarrh and in topical preparations for its antiseptic and protective properties. Benzoin is also used in traditional Chinese medicine.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Siam benzoin

Information provided by PINYOPUSARERK (1994) indicates that production of Siam benzoin in Laos in 1948 was 50 tonnes which, at that time, almost entirely satisfied world demand. Current (1994) production was said to be significantly less than 50 tonnes, although it was suggested that this figure might rise as a result of French interest in securing long-term supplies of 40 tonnes annually. A recent estimate by de BEER (1993) put Laotian production at rather more than this, over 100 tonnes/year (exported to France and the People's Republic of China); Vietnamese exports were estimated at 10 tonnes/year (to France).

Exports of [Siam] benzoin from Thailand (see below) are small, so total world demand for benzoin of this type appears to be between 50 tonnes and 120 tonnes annually, with Europe (and France in particular) being the biggest market.

Sumatra benzoin

Exports of benzoin from Indonesia for the period 1988–93, and their destinations, are given in Table 23. Note that in the Indonesian trade statistics, what is taken to be benzoin (see footnote to Table 23) is classified as "frankincense".

The data in Table 23 show no clear trend but the annual average for the six years is approximately 960 tonnes. This is considerably more than the 100–150 tonnes estimated in 1971 for production of Sumatra benzoin (ADAMSON, 1971), and indicates either that there has been a substantial increase in demand for benzoin in the 20 years since then; or that exports of Indonesian frankincense (if they were recorded in 1971) were not identified as being those of benzoin; or that what is presently recorded as frankincense is not all benzoin.

Whatever the case, the final destinations of most of the exports indicated in Table 23 are not known – most of the benzoin is shipped to Singapore. However, a large proportion of this can be presumed to go on to Europe for both fragrance and pharmaceutical use; some of it might also go to the People's Republic of China for medicinal use. Other, direct importers of Indonesian benzoin are Japan and countries in the Middle East and the Indian sub-continent.

Supply sources

Laos has been noted above as being the major producer of Siam benzoin, with smaller quantities coming from Viet Nam. Recent exports of [Siam] benzoin from Thailand are shown in Table 24, although Thai production is believed to originate from Laos; exports for 1988–93 averaged 10 tonnes/year.

Indonesia is the only producer of Sumatra benzoin and production may be at, or above, the level of exports given in Table 23.

Quality and prices

Siam benzoin is regarded as being of a much higher quality than Sumatra benzoin. The latter is more likely to be sold in the form of block benzoin (see above) and this has led to a very variable quality, with widespread adulteration through the inclusion in the blocks of pieces of damar resin. In India, samples of benzoin from the local market have been found to be adulterated with pine rosin.

Both types of benzoin used to be included in the British Pharmacopoeia (BP, 1980), for which a minimum content of 25% total balsamic acids was required (calculated as benzoic acid for Siam benzoin and cinnamic acid for Sumatra benzoin). The amount of (90%) ethanol-insoluble matter allowable was less for Siam benzoin (not more than 5%) than Sumatra benzoin (not more than 20%). The most recent British Pharmacopoeia (BP, 1993) only describes Sumatra benzoin; included in the specification is a test for checking the absence of damar.

An FAO specification for "Benzoin gum" describes requirements of both types of benzoin for use as a flavouring agent.

The highest grade of benzoin is sold as separate pieces called "Almonds". Blocks of benzoin are usually sold under trade names which vary in quality and price; one such brand of Sumatran benzoin was priced at about US\$ 2 500/tonne in mid-1995 (CIF London).

PLANT SOURCES

Botanical/common names

Family Styracaceae:

Styrax tonkinensis (Pierre) Craib ex Hartwiss (syn. *S. tonkinense* Pierre)

S. benzoin Dryand.

S. paralleloneurus Perkins

The balsam from *S. tonkinensis* is known as Siam benzoin. Balsam from *S. benzoin* and *S. paralleloneurus* is known as Sumatra benzoin (or, less commonly, as gum Benjamin). In Indonesia, Sumatra benzoin is called frankincense, although this term is usually taken to mean the resinous exudate from *Boswellia* spp. of Arabia and Africa.

Other *Styrax* spp. are tapped for balsam locally but the products are not believed to enter world trade (for example, *S. hypoglauca* Perk. and *S. cascarifolia* in the People's Republic of China).

Description and distribution

S. tonkinensis is a tree up to 25 m tall and 30 cm in diameter, with a clear bole for about two thirds of the tree's height. It occurs naturally in the northern parts of Laos and Viet Nam, mainly in secondary rainforests, but its fast-growing nature and suitable fibre properties have led to it being grown as a plantation species for pulp production. The species has also been introduced into southern parts of the People's Republic of China.

S. benzoin occurs wild in Sumatra, Indonesia, and the Malay Peninsula, but is also cultivated on hillsides or dry rice land.

COLLECTION/PRIMARY PROCESSING

Methods of tapping *S. tonkinensis* in Laos have recently been described (PINYOPUSARERK, 1994). The tapper makes a notch 8–10 cm wide and 5–6 cm long into the cambium of the trunk and the bark removed. A number of incisions are made, staggered at intervals of 20–30 cm along the trunk. The lower incisions are made about 30 cm from the ground; the higher ones at the level of the first branches. Sometimes the incisions are made up to a height of 2 m only; a new 2 m section is then tapped the following year. The exuded oleoresin is left on the tree to harden, and it may be as long as 4–5 months after tapping (during the first cold days of winter) that the tears of benzoin are picked from the tree.

The first tapping is made on trees 3–5 years of age in natural forests and trees 6–8 years old in regenerated forests. Tapping continues for up to 6–8 years; it may be less if bark removal is excessive and permanent damage is done to the tree.

After collection, villagers undertake some hand cleaning and sorting, removing pieces of bark but taking particular care to retain (and not break) whole tears.

Collection of Sumatra benzoin from *S. benzoin* is presumed to be carried out in much the same way as that described above for *S. tonkinensis*.

Yields

In Laos, average annual yields of 1–3 kg of balsam per tree are reported to be obtained, although there is much tree-to-tree variation. It has been observed that trees having thin, light-coloured, smooth bark yield less benzoin than those with thick, dark brown, deeply fissured bark.

VALUE-ADDED PROCESSING

A number of tinctures, "resinoids" and "absolutes" are produced by extraction of the balsam with suitable hydrocarbon or alcoholic solvents and these are used by end-user industries in the formulation of fragrances and pharmaceutical preparations.

PRODUCTS OTHER THAN RESIN

The cultivation of *S. tonkinensis* in Viet Nam for pulp production has already been referred to. Over 50 000 ha have been established and the current planting rate is 3000 ha/year; the rotation is 10 years. In the People's Republic of China, *S. tonkinensis* is cultivated for both wood and balsam production.

DEVELOPMENTAL POTENTIAL

In Laos, collection of benzoin is an important cottage industry and widely practised by highland people, despite the relatively small size of the industry. If the figures for Indonesian exports cited earlier are correct, then an even larger number of people are involved in benzoin production in that country. Details are not available on the scale of cultivation of *S. benzoin* in Indonesia, but if it is anything approaching that of *S. tonkinensis* in Viet Nam, and if oleoresin production were coupled with wood production, then the potential for increased production of both types of benzoin is considerable. Whether this could be realized in practice depends on whether the international market can use more benzoin and, if so, whether the price to both the collector and the end-user is attractive enough to encourage increased production.

Research needs

If an appreciable amount of benzoin comes from cultivated sources, or it is sought to increase this proportion, then the economics of production could benefit greatly from the use of superior planting stock (in terms of oleoresin quality and yields). In this case, a screening programme aimed at identifying such material from different provenances of wild trees is desirable.

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**Table 23. Benzoin^a: exports from Indonesia, and destinations, 1988-93
(tonnes)**

	1988 ^b	1989	1990	1991	1992	1993 ^b
Total	1157	975	884	1126	806	824
<i>Of which to:</i>						
Singapore	1099	881	773	1062	735	780
Malaysia	7	36	27	17	39	7
China (Taiwan)	21	30	-	14	-	12
United Arab Emirates	20	-	-	-	-	2
Kuwait	-	16	-	-	-	-
India	-	-	59	-	~	11
Hong Kong	2	-	16	-	-	-
Pakistan	-	-	-	16	-	-
Japan	~	~	1	8	6	12
Saudi Arabia	-	-	~	1	9	-

Source: National statistics

Notes:

a Classified as "Frankincense" which SILITONGA (1994) states is the resin from *Styrax benzoin*.

b Includes 3 tonnes in 1988 and 18 tonnes in 1993 which were classified as "Gum Benjamin".

**Table 24. Benzoin: exports from Thailand, and destinations, 1988-93
(tonnes)**

	1988	1989	1990	1991	1992	1993
Total	17	6	11	14	3	8
<i>Of which to:</i>						
Hong Kong	6	2	7	12	3	-
Singapore	5	2	-	~	-	8
Germany	4	2	3	1	-	-
France	2	-	1	1	-	~

Source: National statistics

STYRAX

DESCRIPTION AND USES

Styrax, sometimes called storax, is a balsamic oleoresin obtained from trees of the genus *Liquidambar*. So-called Asian styrax comes from *L. orientalis* of Asia Minor, while American styrax is obtained from *L. styraciflua* of Mexico and Central America.

Asian styrax is a semi-solid, sticky brown mass, somewhat heterogeneous in both colour and consistency. American styrax is usually darker, but cleaner, than Asian styrax. Like other balsams, both contain cinnamic acid or derivatives of cinnamic acid, although in the case of American styrax the typical balsamic odour is masked by a styrene-like odour.

An essential oil can be distilled from both types of styrax and this is more widely used by the fragrance industry than the oleoresin itself. It has a rich, balsamic odour and is often used in floral-type perfumes. Extraction of the crude oleoresin with an appropriate solvent furnishes a number of "resinoids" or "absolutes" which are also used in perfumery.

There has been some minor use of the balsams in pharmaceutical preparations such as bronchial medicines, and there is still some local use for medicinal purposes, particularly with oleoresins from some of the Asian species of *Liquidambar*.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Trade statistics for styrax are not readily available, and in most cases importing countries do not separate it from other gums and resins. Consumption of both types of styrax might total a few hundred tonnes at most.

Exports of Asian styrax from Turkey ranged from 50 tonnes to 70 tonnes annually in the period 1961-69. The main importers then were the United Kingdom (the largest), Germany, France, Italy and the United States. Europe, where there are many processors and producers of essential oils and oleoresin extracts, probably remains the most important market for Asian styrax. The United States is the largest importer of American styrax.

Supply sources

Turkey is the only source of internationally traded Asian styrax, and since domestic consumption is small, the export data given above are a reasonable reflection, also, of production.

Most American styrax comes from Honduras, although Guatemala (and, to a lesser extent, Nicaragua) has produced small amounts in the past. The size of production from this region is not known.

Quality and prices

Asian styrax is impure and, as a result of its method of production, often contains substantial amounts of water. American styrax is slightly darker but generally of better quality.

An EOA standard specifies certain physico-chemical requirements for oil of American styrax.

Published commodity prices (mid-1995) list Turkish styrax at about US\$ 11.75/kg, CIF London.

PLANT SOURCES

Botanical/common names

Family Hamamelidaceae:

<i>Liquidambar orientalis</i> Mill.	Asian styrax/storax
<i>L. styraciflua</i> L.	American styrax/storax

Description and distribution

L. orientalis is a medium-sized tree, usually 6-12 m tall but sometimes higher. It is native to Turkey and surrounding regions.

L. styraciflua is a large tree which grows wild in some parts of the southern and eastern United States, and in Mexico, Honduras and Guatemala.

L. formosana H. occurs in Southeast Asia (People's Republic of China, Viet Nam and elsewhere) but the oleoresin, although used locally, is not believed to enter world trade.

COLLECTION/PRIMARY PROCESSING

In *L. orientalis*, the balsam is present in the sapwood and bark of the tree. The traditional method of obtaining Asian styrax is to remove pieces of bark and boil them in water. The crude, softened balsam separates out and settles to the bottom of the vessel, from which the water is subsequently decanted. Further quantities of balsam are obtained by pressing the "extracted" bark to remove any residual material. Some styrax is also obtained by making incisions into the exposed stemwood and either collecting the exudate in small cans fixed to the tree or scraping it off directly.

Preliminary cleaning of Asian styrax is undertaken by combining the different lots of crude balsam and washing it in boiling water. The dirty water is again removed by decantation and the soft, fluid oleoresin is separated from the lower layer of sand, dirt, etc.

In Honduras, it is more usual to collect the styrax by tapping only, without treatment of the separated bark. A small gutter and cup are fixed to the tree and a cut is made in the stem where the pockets of balsam are located.

Yields

No reliable yield data are available, although it is known that there can be considerable tree-to-tree variation. In the older literature, average yields of around 20 kg of balsam per tree were claimed for American styrax in Honduras.

VALUE-ADDED PROCESSING

As already noted, crude styrax is rarely used as such. Steam distillation of the oleoresin yields an essential oil which is of more value than the oleoresin itself. The crude balsam is often saponified prior to distillation to release cinnamyl alcohol.

Extracts are also widely used and are prepared using hydrocarbon or alcoholic solvents.

PRODUCTS OTHER THAN RESIN

No other products of economic value are known to be obtained from the trees.

DEVELOPMENTAL POTENTIAL

A judgement on the developmental potential of styrax requires a greater knowledge of the demand for it than is presently available. If labour costs in Turkey increase to the point where it becomes uneconomic to produce, or the people become less inclined to want to undertake the tasks involved in production, then there may be opportunities for producers of styrax from other botanical sources, particularly those in Southeast Asia. This would depend, however, on the balsam (and the oil and extracts derived from it) having quality characteristics that make it acceptable to end-users.

Research needs

Apart from market research, including Japanese and other Asian markets (as outlets for any balsam from newly developed Asian sources), it would be desirable to examine the properties and quality characteristics of alternative sources of styrax. Only if these preliminary investigations showed promise would it be worth expending more effort in examining the technical and economic aspects of production.

- Phytochemical screening and trade evaluation. Collections of oleoresin should be made from a number of provenances of *L. formosana* and other Asian species of *Liquidambar*. After preliminary analysis and preparation of the essential oil, samples should be assessed for commercial value by traders and/or end-users, both local and international.

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PERU and TOLU BALSAMS

DESCRIPTION AND USES

Both balsams are oleoresin exudates obtained from trees of the genus *Myroxylon* which are native to Central America and northern parts of South America. Peru balsam is a dark brown, very viscous liquid, with a typically "balsamic" odour, somewhat resembling vanilla. Tolu balsam is a brownish yellow, plastic solid when fresh, but becomes harder, and eventually brittle, on exposure to air.

Peru balsam

Peru balsam is sometimes used in its natural form in perfumery, where it acts as a fixative, but its dark colour is a disadvantage, as is the insolubility of some of its constituents in other perfume materials. The oil or resin-free preparations of the balsam are therefore more widely used in perfumery than the balsam itself. The odour tenacity of the oil is very great and it is used as a fixative in perfumes.

Peru balsam contains a mixture of benzyl benzoate and benzyl cinnamate and these confer a mild antiseptic action on the balsam; it is used in some pharmaceutical preparations for treating skin disorders.

Tolu balsam

Tolu balsam has a similar mixture of benzoic and cinnamic acid esters to Peru balsam and has fragrance and pharmaceutical uses. The balsam itself is rarely used, but the essential oil is used in perfumery and a few flavour applications, while solvent extracts are employed as fixatives in perfumery. Tolu balsam is used as an expectorant and as a flavouring compound in cough mixtures and other pharmaceutical preparations, often in combination with other balsams, although, today, many Tolu syrups are synthetic mixtures rather than ones which contain the genuine balsam.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Peru and Tolu balsams are not separately identified in the trade statistics of gums and resins for most countries and import data are therefore not readily available. In the 1940s, exports of Peru balsam from El Salvador were around 100 tonnes annually and the United States was the major importer. In 1971 it was estimated that the United Kingdom perfumery industry consumed up to 50 tonnes/year of Peru balsam.

Exports of Tolu balsam were around 80 tonnes/year in the 1940s. Recent import data are available for India (Table 25) and indicate that she normally imports about 10 tonnes/year. Imports were exceptionally high in 1992/93 (30 tonnes) but it is not certain whether the imports from Southeast Asia (which totalled 21 tonnes in 1992/93 and amounted to up to 5 tonnes in previous years) are of genuine Tolu balsam, despite their classification as such.

In the last decade or so, the use of genuine tolu balsam in pharmaceutical preparations has declined, and so-called synthetic Tolu solutions and syrups are manufactured using commercially available benzoic and cinnamic acids and their esters,

Supply sources

Despite its name, El Salvador is the chief source of Peru balsam. Colombia is the main source of Tolu balsam, although Venezuela has been a minor supplier in the past. No production data are available for either of the two products.

European sources of Tolu balsam given in Table 25 represent re-exports of South American material.

Quality and prices

In terms of chemical composition, the quality of the two balsams is very variable. However, balsams (or their oils) which are offered for sale are often compounded or blended materials or, in the case of Tolu balsam, totally synthetic, and analysis of them will not necessarily be a reflection of the composition of the genuine article.

The British Pharmacopoeia defines Peru balsam as containing 45–70% of esters, mainly benzyl benzoate and benzyl cinnamate; it should also have a saponification value of 230–255. Tolu balsam does not appear in the British Pharmacopoeia (only syrups and solutions).

The current (mid-1995) New York listed price of Tolu balsam is equivalent to US\$ 15/kg; a London list price is equivalent to about US\$ 11.75/kg. Peru balsam is listed at US\$ 13.50/kg in London.

PLANT SOURCES

Botanical/common names

Family Leguminosae:

<i>Myroxylon balsamum</i> L. Harms	
var. <i>pereirae</i> (Royale) Harms	Peru balsam
(syn. <i>M. pereirae</i> (Royale) Klotzsch)	
<i>M. balsamum</i> L. Harms	Tolu balsam

Description and distribution

M. balsamum var. *pereirae* is a large tree of Central America, although almost all Peru balsam of commerce originates in El Salvador.

M. balsamum is a tall tree of the forests of northern South America, particularly Colombia and Venezuela; it is also found in Cuba. The name Tolu comes from the province of Tolu in Colombia, where *M. balsamum* was particularly common along the Magdalena and Cauca rivers.

COLLECTION/PRIMARY PROCESSING

Peru balsam

Methods described in the 1950s and late 1960s for the collection of Peru balsam involve firstly the removal of bark from the tree; the balsam is then extracted from both the bark and the exposed trunk in a separate operation.

Rectangular strips of bark are removed from trees which have previously been beaten or scorched by fire and left for 6–8 days (during which time the bark softens). Intermediate strips of bark are left sound to avoid permanent damage to the tree. The removed bark is then crushed and pressed in the presence of hot water which softens the balsam and facilitates its extraction. The exposed trunk wood is covered with rags which absorb the balsam and these are also treated with hot water. In both cases (bark and rags), the balsam settles to the bottom of the containing vessels and is removed after decanting the water. Up to 18 "tappings" can be made each year at approximately two-week intervals.

Older methods of primary processing involved heating the balsam over an open fire to remove residual moisture and straining it while still hot to remove extraneous matter.

Tolu balsam

The traditional method of collecting the balsam is to make V-shaped cuts into the bark of the tree which just reach the phloem but not the cambium. Each cut is about 5 mm thick and the V has a maximum width of 7–10 cm. Two more V-cuts, with a more open V than the first, are made above the original cut, and the resin which is caused to flow runs down the trunk into a suitable receiver fixed to the tree. Several receivers may be in place at any one time. Fresh cuts are made at intervals throughout the year. In the second year, part of the trunk above the first area is worked. This may be repeated for a third year, after which time the tree is rested for three years before further tapping. Alternatively, the tree is tapped in alternate years.

Crude processing is carried out in a manner similar to Peru balsam.

Yields

Average yields of Peru balsam have been reported to be about 2.5–3.5 kg/tree/year. Trees of 25–30 years of age may be tapped but productivity increases as the trees get older, reaching a maximum at about 60 years. Highest yields are obtained during the hot, dry periods of the year.

WILLIAMS (1974) reports that in a year (1968) when yields were generally regarded as low by the tappers, the average yield of Tolu balsam at one collection site was 1.7 kg/tree.

VALUE-ADDED PROCESSING

Steam distillation of Peru balsam gives a very low yield of genuine essential oil, and most oil which is used is obtained either by direct distillation under vacuum or by extraction with a suitable solvent. The true, total oil is semi-solid at ambient temperature, and commercial oils which are viscous liquids are therefore likely to contain diluents.

Tolu balsam oil can be produced in low yields by steam or direct distillation of the balsam. Tolu "absolutes" and "resinoids" are produced by extraction with organic solvents.

PRODUCTS OTHER THAN RESIN

No other products of commercial value are obtained from the trees.

DEVELOPMENTAL POTENTIAL

Myroxylon species are amenable to cultivation and WILLIAMS (1974) reports a *M. balsamum* plantation 3½ years old in which trees planted under shade were less than 1 m in height, but those in the open reached 3–5 m and 10 cm in diameter. The market for both types of balsam is relatively small, although not insignificant, and the economics of production are not known, but if land is available to set aside for such planting – perhaps taking advantage of the leguminous nature of the trees by planting with shorter term crops in an agroforestry context – then the trees could provide a useful cash income in later years.

Research needs

Apart from the pressing need for up-to-date market information, several areas of research are immediately identifiable:

- Germplasm screening. WILLIAMS (1974) reported wide tree-to-tree variation in yields of Tolu balsam. Natural populations of both *Myroxylon* species need to be screened to identify high yielding provenances and/or individual trees, as well as trees with good growth characteristics and other desirable features.
- Growing trials. Selected planting stock should be raised and tested under a number of different agroforestry regimes.
- Tapping trials. The age at which tapping can commence, improved methodologies for collecting the oleoresin, and the best regime under which tapping can be sustained so as to maximize economic returns all need to be investigated.

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Table 25. Tolu balsam: imports into India, and sources, 1987/88-1992/93^a
(tonnes)

	87/88	88/89	89/90	90/91	91/92	92/93
Total	12	11	7	9	13	30
<i>Of which from:</i>						
Germany	4	7	5	2	4	3
UK	3	1	2	1	6	4
France	2	1	-	1	~	1
Indonesia	-	-	1	3	-	-
Malaysia	2	1	-	-	-	-
Singapore	-	1	~	4	-	5
Thailand	-	-	-	-	-	16

Source: National statistics

Note: *a* Year runs April-March

COPAIBA

DESCRIPTION AND USES

Copaiba balsam is an oleoresin obtained from certain Amazonian species of *Copaifera*. Although distillation of the oleoresin provides an essential oil, the term "copaiba oil" is sometimes also applied to the oleoresin itself, since the crude material occurs naturally in a very liquid form.

Crude copaiba balsam is a clear, pale yellow oil which darkens and becomes less fluid on prolonged storage or exposure to air. It is employed by the fragrance industry as a fixative in perfumes and in other products such as soaps.

In Brazil, which is the main source of copaiba balsam, it is also employed in pharmaceutical applications, mainly as an antiseptic and anti-inflammatory. Most pharmacies sell copaiba oil, either in small bottles over the counter or in the form of capsules. The oil is also added to shampoos, soaps and cosmetics, which are promoted for their value in treating skin complaints and numerous other disorders.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Exports of copaiba from Brazil for the period 1986–92, and their destinations, are shown in Table 26. The international market for copaiba (either the balsam or distilled oil) is probably around 100 tonnes/year. The major importers are the United States, France and Germany – accounting for approximately 50%, 30% and 15%, respectively – and the major consumer is the fragrance industry. Use by the international fragrance market largely depends on prices of substitute materials. Copaiba oil is considered relatively inexpensive by the perfume industry, suggesting that there is little scope for increased use.

The Brazilian market is larger than the international one and is, perhaps, of the order of 300–500 tonnes annually. Usage is divided between the fragrance and pharmaceutical industries.

Demand for copaiba oil internationally is only likely to increase if there were to be wider use of it for pharmaceutical purposes. Demand on the domestic Brazilian market appears secure although, equally, the established markets are unlikely to grow significantly in the medium term.

Supply sources

Brazil has historically been the major producer and exporter of copaiba and this remains the case today. Neighbouring countries produce small amounts of copaiba but this is mostly used domestically.

Some Brazilian production data are shown in Table 26. There must be some considerable under-recording since production figures for the years shown are consistently less than exports, without taking into account the even larger domestic consumption. Smaller quantities

have been available to the market from Venezuela, the Guianas and Colombia. In all these countries, primary production has been dependent upon the tapping of wild forest trees.

Annual fluctuations in Brazilian production are due to variations in river levels, which give access to the collection areas. Transportation of both collectors and the balsam is by means of boats and the upstream sites cannot be visited in years when river levels are low. More than 90% of Brazilian copaiba production comes from Amazonas state; most of the balance comes from Pará.

Brazilian exports of copaiba shown in Table 26 are at a similar level to those recorded since 1978 (COPPEN *et al.*, 1994) and have fluctuated around 70 tonnes/year with no discernable trend.

Quality and prices

There are no international standards for copaiba or its distilled oil, although in the United States an EOA standard for the oil specifies various physico-chemical requirements. Copaiba which has stood for some time without protection from the air or light is liable to be rather variable in quality, and may show signs of discolouration and resinification.

Export data indicate an average FOB value of US\$ 7–8/kg in 1990 and 1991, and about US\$ 3.90/kg in 1992. Traders in Brazil were quoting prices of around US\$ 7.50/kg FOB Belém in early 1993.

Published wholesale purchase prices for copaiba balsam in New York are currently (mid-1995) US\$ 10.50–11.00/kg. In London, copaiba is listed at around US\$ 10.25/kg (CIF).

PLANT SOURCES

Botanical/common names

Family Leguminosae:

<i>Copaifera reticulata</i> Ducke	Oil/balsam: copaiba,
<i>C. guianensis</i> Desf.	copaiva, copahyba
<i>C. multijuga</i> Hayne	
<i>C. officinalis</i> Jacq.	
<i>C. langsdorffii</i> Desf.	

Description and distribution

Copaifera species occur in Africa and South America but the only ones which yield commercially useful oleoresin are those found in the forests of Amazonia. (As noted earlier, some African *Copaifera* were once used as sources of certain types of copal). The trees grow up to 30 m high and are widely distributed along the Amazon and its tributaries, although in very variable densities, often only thinly scattered.

C. reticulata, *C. guianensis* and *C. multijuga* are the principal Brazilian sources of copaiba. *C. reticulata* has been stated in the past as accounting for 70% of Brazilian copaiba

production. *C. langsdorffii* is a *cerrado* source of oil but is not believed to be traded in any significant amounts. *C. officinalis* is the traditional main source of copaiba in Colombia, Venezuela and the Guianas.

COLLECTION/PRIMARY PROCESSING

Copaiba oleoresin accumulates in cavities within the trunk which join and form reservoirs of clear liquid in the centre (core) of the tree. Tapping is carried out by drilling a hole into the tree about 1 m above ground. A bamboo tube provided with a simple stopcock is inserted and this enables the flow of oleoresin to be controlled. Sometimes a second hole is made some distance above the first. After the flow of oil has ceased a plug of wood or clay is used to seal the hole. The interval between visits to the tree to make a new hole is anything from 3 months to a year or more.

The only treatment of the oleoresin which is undertaken prior to any large-scale distillation is the removal of extraneous matter by filtration; this is usually carried out by traders before sale to the factory.

Yields

The yield of balsam per tree is very variable and depends on the species of *Copaifera* tapped, the age of the tree, the period of time since the previous tapping and the season. Estimates given by traders in Brazil for oleoresin yields differ widely and yields of up to 15 litres or more are quoted.

Relatively recent tapping studies (ALENCAR, 1982) have revealed high variability in yields between individual trees growing under the same conditions. A maximum mean yield of 0.25 litres of oleoresin per tree was obtained for the first tapping. The highest yield of oleoresin was almost 3 litres, but a third of the trees produced no oleoresin at all, and four further tappings over a 3½-year period yielded progressively less.

VALUE-ADDED PROCESSING

Distillation of the crude oleoresin or oil – which is only undertaken by companies with large-scale fractionation facilities – furnishes a paler, refined oil, free of any polymeric and other high-boiling material which may have been produced by natural degradation of the original.

PRODUCTS OTHER THAN RESIN

Some use is made of the wood for sawtimber. The wood is also reputed to make good charcoal.

DEVELOPMENTAL POTENTIAL

The possible use of copaiba oil as a substitute for diesel fuel has attracted some attention from researchers in the past, and in the late 1970s/early 1980s there was speculation that *Copaifera* might be grown on a plantation scale as an energy source. However, it was conceded at the time that the economics of such a venture would probably not be favourable and there is no evidence that the situation has improved since then.

The tree provides no other potentially useful product which would make it attractive as a multipurpose tree (apart, possibly, from timber), and with no firm evidence that copaiba can penetrate the international pharmaceutical market (and therefore generate increased demand) or that present supplies from traditional exploitation of the wild resource cannot be maintained, there is no strong case for assigning a priority to research on formal cultivation of copaiba.

Research into improved tapping techniques for use with wild trees is also difficult to justify. The physical form of the oleoresin does not lend itself to adapting tapping methods used for some of the more viscous or harder resins.

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Table 26. Copaiba: production and exports from Brazil, 1986-92
(tonnes)

	1986	1987	1988	1989	1990	1991	1992
Production	43	99	54	49	na	na	na
Exports	47	114	94	59	51	95	56
<i>Of which to:</i>							
France	17	26	15	na	22	na	na
Germany	14	10	13	na	14	na	na
USA	8	68	52	na	10	na	na
Mexico	4	5	3	na	-	na	na
UK	4	4	2	na	5	na	na
Spain	-	1	4	na	-	na	na
Netherlands	~	-	4	na	~	na	na

Source: National statistics (taken from COPPEN *et al.* 1994)

ELEMI

DESCRIPTION AND USES

The term "elemi" has been applied in the past to a large number of oleoresins from a variety of geographic and botanical sources (see **PLANT SOURCES** below). Nowadays, however, the term is almost always used to describe the product from the Philippines, Manila elemi, which is the only one that is traded internationally, and most of the rest of the discussion focuses on this.

Manila elemi is the soft, fragrant oleoresin obtained from the trunk of *Canarium* species, the most important of which is *C. luzonicum*. When fresh, the oleoresin is oily and pale yellow or greenish in colour, resembling crystallized honey in consistency, but on exposure to air it loses some of the volatile constituents and hardens. It has a balsamic odour and a spicy, rather bitter taste.

In the forest areas where it is collected it is rolled in leaves and used for lighting purposes, but in commerce it is used mainly by the fragrance industry after distillation of the essential oil. It still finds occasional use as an ingredient in lacquers and varnishes, where it gives toughness and elasticity to the dried film.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Exports of Manila elemi from the Philippines for the period 1988–93 are given in Table 27. Annual totals have been somewhat erratic but average almost 300 tonnes, with a peak of over 600 tonnes in 1990.

France is the largest single market, accounting for up to three quarters of the total exported from the Philippines, and it is presumed that the elemi is used principally or solely for fragrance purposes. Germany is the second biggest market, and exports to Japan have increased slowly but significantly. The United Kingdom, United States and Switzerland are other, sometimes erratic, importers.

The trend is difficult to predict but, at least, does not appear to be down, and with continued supply of elemi the market is likely to be able to sustain levels of around 200–300 tonnes annually.

Supply sources

Although the source of Manila elemi, *C. luzonicum*, occurs on other islands in the Pacific (where it may have potential for exploitation; see **DEVELOPMENTAL POTENTIAL**), the Philippines are the only source of internationally traded elemi. Export figures are as given in Table 27.

Quality and prices

Three classes of Manila elemi exist for domestic and export trade, although the designations are not always adhered to: class I (within which there are two grades), class II (two grades)

and class III (one grade). Class I represents the palest material (the two grades being clean or non-clean), class II a more yellowish material, and class III a mixture of I and II. The softer grades are the higher quality, reflecting a higher essential oil content compared with the harder grades.

In the last four years for which data are available, the FOB export value per kg for Manila elemi has been US\$ 1.74 (1990), US\$ 1.73 (1991), US\$ 1.67 (1992) and US\$ 2.08 (1993). Currently (mid-1995) there is reported to be a shortage and prices quoted by London importers are in the range US\$ 4.20–4.50/kg (cf US\$ 2.25/kg a year earlier). Prices for elemi fluctuate more than for most other resins.

PLANT SOURCES

Botanical/common names

Family Burseraceae:

<i>Canarium luzonicum</i> (Bl.) A. Gray (syn. <i>C. polyanthum</i> Perkins, <i>C. oliganthum</i> Merrill)	Pili, piling-liitan (resin: elemi, sahing, brea blanca)
<i>C. ovatum</i> Engl.	Pili nut
<i>C. indicum</i> L. (syn. <i>C. commune</i> L., <i>C. amboinense</i> Hochr.)	Java almond, kenari nut, ngali nut
<i>C. schweinfurthii</i> Engl.	

C. luzonicum is probably the only source of commercially traded Manila elemi, although *C. ovatum*, *C. indicum* and *C. schweinfurthii* are known to produce resin which is, or has been, used locally. Other species of *Canarium* undoubtedly produce resin if wounded.

Other genera which yield gums or resins which have been traded in the past as elemis include *Protium* (which produces "breu branco" or Brazilian elemi), *Amyris* (Mexican elemi) and *Dacryodes* (West Indian elemi). They are not discussed further.

Description and distribution

Canarium is a genus of big shade trees in the Old World tropics, chiefly Malaysia to the Philippines, but extending to Papua New Guinea and other Pacific islands, which are often highly prized for their edible fruits and nuts. *C. luzonicum* is a large tree up to 35 m tall and 1 m in diameter. It is found in primary forests at low and medium elevations in Luzon and some other islands of the Philippines.

C. ovatum is a large, buttressed tree, reaching up to 20 m in height, and native to the Philippines.

C. indicum reaches as high as 40 m and occurs in parts of Malaysia, Indonesia, Papua New Guinea, the Solomon Islands and other islands in the Pacific.

C. schweinfurthii grows to 50 m in height and is found outside the usual *Canarium* region, in tropical West and Central Africa. In the past it has been an occasional source of "African elemi".

COLLECTION/PRIMARY PROCESSING

In a survey of tapping methods practised in the Philippines (ALONZO and ORDINARIO, 1972), tappers used a sharp "bolo" and a wooden mallet to make a series of cuts up the trunk of the tree, each cut resulting in removal of bark and exudation of the oleoresin. The diameter of the trees tapped was in the range 20–60 cm. The initial strip of bark which is removed should be 2 cm high and not more than 30 cm wide. Subsequent strips (1 cm high) are removed at approximately two-day intervals above and adjacent to the previous one, and tapping is continued as high as the person can reach. A second face may be opened close to the first, providing at least one third of the circumference of the bark of the tree is left intact.

The exuded, sticky mass is collected at two-week intervals, usually by scraping it off the tree with a blunt-tipped bolo or stick.

After transport to the towns, elemi which is destined for export is cleaned by manual removal of as much bark and other forest debris as possible. The cleaned resin is then packed in polythene-lined kerosene cans.

Yields

Yields are known to vary from tree to tree, but no reliable quantitative data are available; yields of 4–5 kg of resin per tree annually have been reported in the older literature. Tapping is usually a year-round activity, but resin flow is at its greatest during the rainy season and little, if any, may be collected in the dry months.

VALUE-ADDED PROCESSING

The crude oleoresin contains a high proportion of essential oil, around 25%, and this can be recovered by the simple process of steam distillation. The freshly distilled oil is liable to resinify and polymerize on standing, and for this reason distillation is normally carried out in the importing country, where it can be formulated soon after preparation.

A resinoid is also sometimes prepared by solvent extraction of the crude elemi.

PRODUCTS OTHER THAN RESIN

Although usually restricted to local use, many species of *Canarium* are used as sources of edible fruits and nuts, and provide valuable fat and protein in the diets of very many people in the Pacific region. The Chinese olive, from *C. album*, is exceptional in being exported to other regions of Southeast Asia and, occasionally, further afield. Recent work in the Solomon Islands on the ngali nut (from *C. indicum* var. *indicum*) has shown this, too, to have considerable promise as an export item, although it is not known whether the tree is also a potential source of resin.

It has been suggested that the essential oil of *C. luzonicum* could be blended with diesel oil and used as a motor fuel, but at the moment this application remains speculative.

DEVELOPMENTAL POTENTIAL

C. ovatum and some other resin-yielding species of *Canarium* are already grown as sources of fruits and nuts and integration with resin tapping would be a welcome development,

providing one does not adversely affect the other. The method of tapping described is not unlike that used to obtain resin from pine trees, and if the international market can absorb more elemi, there are grounds for optimism that improved methods of tapping *Canarium* could be developed which would lead to higher yields of better quality oleoresin than at present.

Research needs

Some work to develop improved varieties of *Canarium* for fruit and nut production has already been carried out, and since cultivation for this purpose is likely to remain the primary activity, research on resin production should be complementary to that on fruit and nuts. Several aspects need to be researched:

- Comparative evaluation of different *Canarium* species for dual purpose fruit/nut and oleoresin production. Although *C. luzonicum* is the present source of Manila elemi, its productivity should be compared (in terms of both fruits and oleoresin) with *C. ovatum*, *C. indicum* and, possibly, other species, to determine which might offer the best combination for maximizing economic returns. As a first step, however, a laboratory and trade assessment of the resin from each species should be made to determine whether the non-traditional elemis would be acceptable in the market-place.
- Germplasm screening for elite planting stock. As has been noted elsewhere with other gum and resin-yielding species, natural populations of *Canarium* (particularly *C. luzonicum*) should be screened to determine provenance and tree-to-tree variation in oleoresin yield and composition.
- Improved methods of tapping. This should draw on experience in the gum naval stores (pine tapping) field and include an examination of the use of cups (such as coconut shells) to collect the resin which runs down the tree in order to produce a cleaner product.

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**Table 27. Manila elemi: exports from the Philippines, and destinations, 1988-93
(tonnes)**

	1988	1989	1990	1991	1992	1993
Total	191	298	611	145	176	330
<i>Of which to:</i>						
France	149	191	442	90	103	142
Germany	7	33	63	20	31	60
Japan	8	12	12	27	23	44
UK	12	36	25	3	-	-
USA	15	8	15	2	4	3
Switzerland	-	15	4	-	3	78
China (Taiwan)	-	-	28	-	-	-
Hong Kong	-	-	17	-	-	-
Netherlands	-	3	-	-	-	-
Italy	-	-	5	-	-	-
Spain	-	-	-	3	2	3
Finland	-	-	-	-	10	-

Source: National statistics

ASAFOETIDA and GALBANUM

DESCRIPTION AND USES

Asafoetida

Asafoetida is the oleoresin exudate obtained from certain *Ferula* species, particularly *F. asafoetida*, which occur in Afghanistan, Turkey, Iran and surrounding areas. The product is one of the few examples (another one is tragacanth gum) of an exudate which is obtained by "tapping" the roots of a shrubby plant.

Asafoetida has a strong, characteristic odour (due to the presence of sulphur compounds) and extracts of "asafoetida hing" – derived from three main species (see below) – are used in spice blends and as a flavouring for meat sauces, pickles, currys and other food products. Since it is so strong in taste and odour, asafoetida is often blended with diluents such as starch and flour and sold in a compounded form.

An essential oil can be distilled from the oleoresin and finds minor use for flavouring purposes.

"Asafoetida hingra" – from two other *Ferula* species – are used in pharmaceutical preparations.

Galbanum

Galbanum is another oleoresin exudate produced from a *Ferula* species: *F. galbaniflua*. It is obtained from the cut stem. Extracts of the oleoresin and the distilled essential oil contain a number of sulphurous compounds and they are used to a limited extent as perfume fixatives.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Export data from the producing countries are not readily available and imports into, say, the European Community or Japan are not identifiable since they are not listed separately for asafoetida and galbanum. It is therefore extremely difficult to estimate international demand.

India is a large importer of asafoetida and imports for the years 1987/88–92/93 are shown in Table 28. Except for 1990/91, when 1 000 tonnes were imported, levels of imports have been around 500–700 tonnes/year.

Although India is a net importer of asafoetida it also exports significant amounts; these exports are believed to be largely re-exports of imported material rather than originating from indigenous production. Exports for the period 1987/88–93/94, and their destinations, are given in Table 29. Middle East countries are seen to be an important destination and the United Arab Emirates, Saudi Arabia, Oman, Bahrain, Qatar and Kuwait are all consistent importers; the United Arab Emirates averaged almost 50•tonnes annually.

Supply sources

Table 28 shows that Afghanistan was by far the largest supplier of asafoetida to India, averaging 525 tonnes annually outside the peak year 1990/91, when 950 tonnes were exported. Exports from both Iran and Pakistan, the only other sources of Indian imports, increased sharply in 1992/93 to about 160 tonnes and 120 tonnes respectively (compared to annual averages of about 30 tonnes and 20 tonnes, respectively, for previous years).

Iran is a source of galbanum.

Quality and prices

Asafoetida

Tears are the purest form of the resin and these are grey or dull yellow in colour, although they sometimes darken to a reddish brown colour on storage.

The more common form is where tears have agglomerated into a solid mass, usually with fragments of root, sand and other extraneous matter present. Commercial samples are often in the form of a paste and may be very variable in quality, sometimes containing added "inert" diluents.

The chief constituents of asafoetida are "resin" (40–65%), "gum" (*ca* 25%) and essential oil; reasonably fresh asafoetida usually contains around 7–9% of essential oil, although it varies with origin and may be as high as 20%.

A current (mid-1995) London spot price for asafoetida (no grade stated) is US\$ 12/kg.

Galbanum

Galbanum of commerce is usually in the form of agglutinated tears, about the size of peas and orange-brown on the outside, yellowish white or blue-green inside. Like asafoetida, it is often mixed with extraneous matter and can be very variable in quality.

The major constituents are "resin" (50–70%), "gum" (*ca* 20%) and essential oil (5–20%).

PLANT SOURCES

Botanical/common names

Family Umbelliferae:

<i>Ferula asafoetida</i> L.	}	
<i>F. alliacea</i> Boiss.	}	Asafoetida hing
<i>F. narthex</i> Boiss.	}	
<i>F. foetida</i> Regel]]	Asafoetida hingra
<i>F. rubricaulis</i> Boiss.]]	
<i>F. galbaniflua</i> Boiss. & Buhse		Galbanum

Description and distribution

Of the asafoetida-yielding *Ferula* species, the most important is *F. asafoetida*. The plants grow to a height of 1.5–3 m and the shrubby foliage grows annually from a perennial rootstock. The species are indigenous to parts of Afghanistan, Turkey, Iran and northwest India, where they are found on the arid plains and high plateaus. They also grow in some parts of North Africa.

F. galbaniflua occurs in Iran and northwest India.

COLLECTION/PRIMARY PROCESSING

Asafoetida

Just prior to the flowering stage the plants are cut above the ground and the taproot/rhizome exposed. A small quantity of "latex" exudes and this is collected every few days; exposure to the air causes the latex to form first a soft exudate and then one which is hard and discoloured. Sometimes the root is sliced every few days to produce more exudate.

Galbanum

The stem of *F. galbaniflua* is cut to produce an orange-yellow gummy fluid which, again, hardens on exposure to air.

Yields

No information is available on resin yields.

VALUE-ADDED PROCESSING

Further processing of the crude resin entails either blending (as mentioned for asafoetida, above), steam distillation to produce an essential oil, or preparation of an extract using an appropriate solvent. Extraction with a hydrocarbon solvent yields a "resinoid", while alcohol extraction gives an "absolute". Both types of extract are semi-solid and dark brown or red-brown in colour.

PRODUCTS OTHER THAN RESIN

There are no other products of commercial value obtained from the plants.

DEVELOPMENTAL POTENTIAL

In the absence of detailed knowledge on the size and trend in the markets for the two resins it is impossible to know whether the existing, wild resource is sufficient to meet demand, or whether there is scope for some production from new, cultivated sources.

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Table 28. Asafoetida: imports into India, and sources, 1987/88–1992/93^a
(tonnes)

	87/88	88/89	89/90	90/91	91/92	92/93
Total	715	630	492	1006	649	619
<i>Of which from:</i>						
Afghanistan	681	574	428	956	606	337
Iran	19	27	26	30	38	165
Pakistan	13	29	34	20	5	117

Source: National statistics

Note: *a* Year runs April-March

Table 29. Asafoetida: exports from India, and destinations, 1987/88–1993/94^a
(tonnes)

	87/88	88/89	89/90	90/91	91/92	92/93	93/94
Total	140	144	149	130	164	231	205
<i>Of which to:</i>							
United Arab Emirates	33	39	39	31	59	46	76
Thailand	10	16	22	20	18	33	19
UK	26	3	12	11	14	22	20
USA	8	13	12	11	15	22	17
Singapore	12	11	14	16	11	18	9
Malaysia	12	14	9	11	7	18	11
Saudi Arabia	14	16	6	-	17	11	13
Oman	3	2	7	3	6	3	3
Bahrain	5	3	3	2	4	4	3
Qatar	1	1	2	1	1	3	1
Kuwait	2	1	2	1	1	1	1
Kenya	1	3	3	10	-	1	8
Canada	2	2	2	2	2	4	4
Sri Lanka	2	-	1	3	-	1	2
Germany	-	7	-	-	-	20	-
Ethiopia	1	2	-	-	-	-	3
Djibouti	-	-	3	~	1	7	3
Japan	-	-	7	~	~	7	-

Source: National statistics

Note: *a* Year runs April-March

CHICLE

DESCRIPTION AND USES

Chicle is the coagulated latex obtained from *Manilkara zapota*, and is produced on a commercial scale in Mexico and certain parts of Central America. Chicle is to be distinguished from sapote gum, the hard, gummy material which forms slowly over the wound made in the tree to obtain the latex, after the latter has ceased to flow. Sapote gum was once used in Peru as a sizing agent for cloth, and as a glue, but it does not enter world trade and is not considered further here.

Although it has had miscellaneous minor uses as a gutta percha substitute, chicle's economic importance has arisen from its use in the manufacture of chewing gum, where it imparts the "chewing" properties to the product. An inferior, little-used "chicle"-type of gum is crown gum.

WORLD SUPPLY AND DEMAND TRENDS

Markets

At one time, chewing gum base consisted almost entirely of natural "gums", of which the principal one was chicle. The most important of the other natural gums was jelutong, although smaller quantities of sorva and maçaranduba have also been used. Nowadays, with the advent of cheaper, synthetic resins with suitable properties, demand for the natural gums for use in chewing gum has declined.

The United States chewing gum industry was traditionally the major consumer of chicle but as they have moved towards using a greater proportion of synthetic gums, imports of chicle have fallen, and the Far East has become the major market, particularly Japan. In 1930, at the peak of production, over 6 000 tonnes of chicle were imported into the United States. In the period 1963–66, American imports of chicle from Mexico, the leading producer, averaged just over 1 000 tonnes/year. In the three years 1988–90, exports of chicle to the United States from Mexico (Table 30) averaged 10 tonnes.

Imports of chicle, balata, gutta percha and guayule are recorded as a single group in Japanese trade statistics. However, they have been separated, here, into the component gums as judged by the country origins, and data for the period 1988–94 are given in Table 32. Total imports of chicle into Japan are estimated to have been around 800–1 000 tonnes annually in recent years.

In Europe, at least as far as Mexican exports of chicle are concerned (Table 30), Italy has been the major importer. Total annual imports into Italy may amount to 100–200 tonnes.

Supply sources

Mexico is believed to be the biggest producer of chicle, although if the disaggregation of imported chicle and gutta-type products into Japan – and shown in Table 32 – is correct,

Guatemala, which has been a significant producer in the past, may recently have surpassed Mexico: estimated imports from the two countries for the period 1988–94 averaged approximately 400 tonnes (Guatemala) and 370 tonnes (Mexico) each year. Exports of chicle from Mexico for 1988–90 are shown in Table 30.

Other, minor producers include Belize (see Table 31 for exports in 1989 and 1990), Honduras, Venezuela and Colombia.

Quality and prices

Recent quality and price information on chicle is not available. General requirements of natural masticatory substances, including chicle, are specified in the Food Chemicals Codex of the United States and these detail limits on arsenic, lead and heavy metals.

PLANT SOURCES

Botanical/common names

Family Sapotaceae:

<i>Manilkara zapota</i> van Royen (syn. <i>M. achras</i> Mill., <i>M. zapotilla</i> Gilly, <i>Achras sapota</i> L., <i>A. zapote</i> L., <i>Sapota achras</i> Mill.).	Chicle (gum), sapodilla, chico, zapote
<i>M. chicle</i> Pittier	Crown gum
<i>M. williamsii</i> Standley	Venezuelan chicle

Description and distribution

M. zapota is a tree which reaches a height of 20–25 m in the wild, with a dense rounded or conical crown and a hard timber. It is indigenous to Central America in the region extending from southern Mexico to northern Colombia, but grows best in the Yucatan peninsula, embracing the southern states of Mexico and the northern parts of Belize and Guatemala – these form the principal chicle-producing areas.

However, it is also widely cultivated for its fruit, both in tropical America and further afield in India, Sri Lanka, Malaysia, Thailand and the Philippines. MORTON (1987) states that in Mexico, 1500 ha are devoted to fruit production, while 4000 ha are grown primarily for chicle.

A larger member of the genus, *M. chicle*, has been exploited in Belize in a minor way as a source of crown gum, an inferior form of chicle.

COLLECTION/PRIMARY PROCESSING

Details of tapping methods used on plantation-grown trees are not known, but in the wild, methods have probably changed little from the early days of production. Contemporary descriptions given by BOLT (1961) are essentially the same as earlier ones by EGLER (1947).

Starting about 1 m from the base of the tree, the *chiclero* makes a series of diagonal cuts up the trunk (climbing to a height of up to 10 m with the aid of ropes), each cut alternating in direction to the previous one so as to form an ascending zig-zag line, down which the latex flows. A common fault in earlier days was to extend the cuts to two-thirds or more round the trunk, which eventually led to the death of the tree. A bag is attached to the tree at its base and the *chiclero* returns to collect the accumulated latex either later the same day or the following morning.

The tree can only be tapped again when the laticiferous vessels in the bark have been renewed and this may take up to five years or more. Up to three tapplings can be carried out.

The freshly collected latex is boiled in an open vessel, with constant stirring, until it reaches a concentration such that when it is poured into wooden moulds and set aside to cool it solidifies. The blocks of chicle are then transported after sale to the factory for further processing.

Yields

At the first tapping, mature wild trees yield about 1 kg (and up to 2 kg) of latex; the second tapping yields about half this quantity, and the third one less still. However, as would be expected, there is considerable tree-to-tree variation, and the older literature describes methods used by *chicleros* to test whether it would be profitable to tap individual trees. Yield data for cultivated trees are not available.

VALUE-ADDED PROCESSING

Further processing (before mixing with other ingredients to form a chewing gum base) entails drying, melting and centrifuging to remove extraneous matter.

PRODUCTS OTHER THAN LATEX

The tree is grown widely for its fruit and, where it has been cultivated as an exotic, this is its primary or sole commercial use. Sapodilla wood is strong and durable but felling of the tree is prohibited in Yucatan because of its value as a source of chicle.

DEVELOPMENTAL POTENTIAL

Methods for propagation and cultivation of *M. zapota* are well established for production of fruit, and a large number of cultivars have been developed. Unlike many of the other latex-producing trees discussed in this report there is, therefore, a firm foundation of knowledge and practical experience on cultural aspects on which to build. Furthermore, in Mexico this experience extends to commercial cultivation for chicle.

The economic viability of chicle production from cultivated sources depends on the continued market for chicle as a natural chewing gum ingredient, as well as production factors such as labour costs. If the market can be maintained and production costs can be held stable, then some increase in the area under cultivation can be justified. Providing the price of "cultivated" chicle remains attractive compared with "wild" chicle, the market always prefers to meet its requirements from renewable, sustainable resources rather than from wild trees which become increasingly less accessible.

Research needs

Efforts have been made to extract chicle from the leaves and unripe fruits of the tree, but yields have been too poor to make such production economic. Research should focus on ways of increasing yields of latex from the trunk, either by using improved planting stock or through use of better tapping methods:

- Populations of trees throughout the natural range of *M. zapota* should be screened to determine the intrinsic (genetic) variability in latex yield between and within provenances, with a view to identifying high-yielding trees.
- The development of improved tapping methods should include an investigation of the possible benefits of using chemical stimulants to increase yields of latex; such methods have been used to improve rubber yields in *Hevea*.

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Table 30. Chicle: exports from Mexico, and destinations, 1988-90
(tonnes)

	1988	1989	1990
Total	171	836	685
<i>Of which to:</i>			
Japan	118	637	510
Italy	47	184	101
USA	6	14	9
Canada	-	1	1
Korea, Rep. of	-	-	64

Source: National statistics

Table 31. Chicle: exports from Belize, and destinations, 1989-90
(tonnes)

	1989	1990
Total	79	44
<i>Of which to:</i>		
Japan	79	44

Source: National statistics

Table 32. Chicle, balata, gutta percha, and guayule^a: imports into Japan, and sources, 1988-94
(tonnes)

	1988	1989	1990	1991	1992	1993	1994
Total	1684	2258	2592	2837	2834	2286	1706
<i>Of which from:</i>							
Chicle^b							
Mexico	329	542	589	294	288	223	300
Guatemala	174	386	365	378	472	533	479
Belize	35	54	114	57	121	151	48
Honduras	3	-	-	-	-	-	-
Balata^b							
Brazil	253	235	153	359	328	214	151
Gutta percha^b							
Indonesia	577	709	1061	1304	1296	891	623
Singapore	306	331	268	362	315	213	103
Thailand	-	-	-	-	-	54	-
Hong Kong	-	-	25	-	-	-	-
Other^b							
USA	-	-	17	63	13	7	-

Source: National statistics

Notes: *a* "... and similar natural gums in plate, sheet or strip".

b Judged to be main product according to origin.

JELUTONG

DESCRIPTION AND USES

Jelutong is the coagulated gutta-like material obtained from the latex of wild trees of *Dyera* species which are indigenous to certain parts of Southeast Asia.

Before *Hevea* plantations were developed in Southeast Asia, jelutong was produced and exported for the manufacture of inferior rubber items, in which elasticity was not a prime consideration. With the advent of large-scale rubber production, exploitation of jelutong ceased almost completely. In the 1920s it regained importance as a basic ingredient in chewing gum, sometimes in admixture with chicle, and since then (at least into the 1960s, when WILLIAMS (1963) reviewed it) this has been its main use. It has a consistency comparable to that of chicle, but the additional advantage that its properties also make it suitable for "bubble" gums.

WORLD SUPPLY AND DEMAND TRENDS

Markets

The United States has traditionally been the major importer of jelutong, although it is almost all shipped via Singapore rather than direct from source. During the period of peak production in the early 1900s, consumption averaged almost 14 000 tonnes annually. For the five years 1957-61, US imports averaged approximately 1 300 tonnes, a ten-fold decrease.

Exports of jelutong from Indonesia for the six years up to 1993 (Table 33) averaged just over 3 600 tonnes/year, with a peak of 6 500 tonnes in 1990. Most, or all of it, has been exported to Singapore and it is not known how much of this has been re-exported to the United States. Some jelutong is exported directly to Japan, and in Europe, Italy is the main importer.

Unlike the other masticatory gums, therefore, there appears to have been some upturn in use of jelutong in the recent past, at least compared with thirty years ago. It remains to be seen whether the downward trend of the last four years continues.

Supply sources

In the past, Indonesia (principally Kalimantan) has been the most important supplier, followed by Malaysia (especially Sarawak). Today, Indonesia is believed to be the main source of jelutong, with the level of production indicated by the exports cited above (and Table 33).

Quality and prices

D. costulata appears to furnish an intrinsically better quality product than *D. lowii*, although in former times the method of coagulation of the latex and subsequent handling were also important factors; the moisture content of the jelutong was another important determinant. The proportion of gutta-type material is about 20% (on a moisture-free basis), most of the balance being resin.

Average FOB export values for raw, pressed and refined Indonesian jelutong were in the range US\$ 720-750/tonne in 1993, compared to US\$ 980-1 060/tonne two years earlier.

PLANT SOURCES

Botanical/common names

Family Apocynaceae:

Dyera costulata (Miq.) Hook.

Hill jelutong

D. lowii Hook.

Swamp jelutong

Description and distribution

Both species grow to be very large trees with a straight trunk, up to 50–60 m tall and 2 m in diameter in fully developed trees. They are widely distributed in the Malay Peninsula, and the islands of Sumatra and Borneo. *D. costulata* is the only species found in Malaysia and extends into the southernmost part of Thailand. Both species are found scattered throughout Sumatra and Borneo.

D. costulata is found in the flood-free lowland and upland areas (up to about 800 m), while *D. lowii* occurs in the low-lying swamplands.

The term jelutong is used to describe both the tree and the coagulated latex. Pontianak is an older term for the coagulated product.

COLLECTION/PRIMARY PROCESSING

Older, indiscriminate methods of tapping entailed making a series of cuts around the trunk and removing the bark. The trees were retapped above the first cuts approximately every 8 days until the whole of the bark had been removed from near the ground to as high as the taper could reach.

Recognizing the need to abandon such damaging practice, regulations were gradually introduced from the 1930s describing methods based on a "herring bone" system. V-shaped cuts are made in the trunk, commencing at a height of about 1.5 m, with a central, vertical channel leading to a bamboo cup or cloth bag placed at the base of the trunk, into which the latex flows. A narrow strip of bark is removed from the lower surface of the cut and repeated at 2–3 day intervals down the trunk of the tree. In Malaysia, tapping was restricted to trees of 70 cm diameter and greater, on a panel not to exceed half the trunk circumference. Size restrictions on the smaller *D. lowii* were slightly reduced. *Dyera* trees have a moderately good bark recovery, although not as rapid as rubber (*Hevea brasiliensis*) and the same panel may be retapped after a rest period of about two years.

After first straining the freshly collected latex through a fine-mesh sieve, it is coagulated in one of two ways. In the cold method, dilute phosphoric acid is added to the latex, which is then set aside to stand for 3 days; at the end of this time coagulation is usually complete. In the hot method, which usually gives better results, phosphoric acid is added to the latex and the mixture is boiled with stirring; coagulation is usually complete within 2–3 minutes.

Before shipping to the factory for further processing, the initial coagulant is subjected to some preliminary treatment. This usually entails repeated boiling in hot water to remove soluble impurities; the coagulant is then pressed into blocks in readiness for shipment. If there is

likely to be some delay before transportation the blocks are stored under water to prevent oxidation, discolouration and mould formation.

Yields

Although there can be significant tree-to-tree variation, and yields of latex also depend on the method of tapping which is used, *D. costulata* is generally regarded as being a higher latex yielder than *D. lowii*. *D. costulata* trees growing in Malaysia have been found to average about 11 litres of latex a month when tapped daily, and to yield about 3.5 kg of coagulated jelutong. Some old studies have found that upward tapping is more productive than tapping in a downward direction.

VALUE-ADDED PROCESSING

Further processing entails repeated washing (sometimes with boiling) and drying to bring it to a lower, more consistent moisture content and pressing into sheets. Recent trade statistics for Indonesian jelutong indicate that it may be exported in the raw, pressed, refined or "other" form, but the nature of modern-day refining or other treatment that it may receive is not known.

PRODUCTS OTHER THAN LATEX

Apart from minor timber use, there are no other products of commercial value.

DEVELOPMENTAL POTENTIAL

Information acquired in Sarawak shows that *D. costulata* takes nearly 60 years to attain a girth of about 1.8 m, and until it reaches this size yields of latex are such that it is not worth tapping. On this time scale, plantations established for latex production could not possibly be economic. *D. lowii* has been tested as a plantation crop in Sarawak, and although it reaches a size at which it can be tapped rather more quickly than *D. costulata*, 30–35 years of age, this is still too long for a tree in which the latex would be the principal product.

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Table 33. Jelutong: exports from Indonesia, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	2358	5373	6495	3700	2712	1182
<i>Of which:</i>						
Raw	48	612	1444	552	313	6
Pressed	932	838	1393	695	630	222
Refined	1378	2472	1958	1335	1063	516
Other	-	1451	1700	1118	706	438
<i>Of which to:</i>						
Singapore	2358	5339	6287	3039	2145	751
Japan	-	-	56	443	446	268
Italy	-	-	38	57	121	141
France	-	-	101	-	-	-
Korea, Rep. of	-	-	13	81	-	-
China (Taiwan)	-	-	-	80	-	-
Malaysia	-	34	-	-	-	-
Hong Kong	-	-	-	-	-	22

Source: National statistics

SORVA

DESCRIPTION AND USES

Sorva is collected as a milky white latex from the trunks of certain Amazonian *Couma* species.

Sorva is traded in the form of large balls or blocks, produced by the tapper from the latex by a process of boiling and coagulation. Further processing may take place either before or after export, although final processing is undertaken by the ultimate consumer industries.

Processed sorva has traditionally been used as a natural base for chewing gum. It competes in this application with other natural masticatory gums such as chicle and with synthetic gums.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Sorva has now largely been replaced by synthetic gums in chewing gum manufacture and this has led to a drastic decline in demand. The United States used to be the major importer of sorva but the main international market now is the Far East, with some limited interest in Europe.

Brazil is currently the only supplier of sorva to the market and the decline in international demand is indicated by the downturn in Brazil's exports from 3 500 tonnes in 1978 to an estimated 500 tonnes in 1992 (see Table 34).

In 1978, sorva exports were valued at almost US\$ 10 million (Table 34) and for Amazonas State it was the most important export product (and marginally more valuable than Brazil nuts). The most recent value of sorva exports from Brazil is probably of the order of US\$ 1.5-2 million.

Brazil has a large chewing gum industry but this, too, is based principally on synthetic gums and there is, therefore, effectively no domestic market for sorva.

Supply sources

Brazil is the sole world exporter of sorva. National statistics (Table 34) show a five-fold reduction in Brazilian sorva production over a 12-year period, from something of the order of 5 500 tonnes in 1978 to just over 700 tonnes in 1990. Peak production occurred in 1976 (just over 6 000 tonnes), having risen steadily from about 1 500 tonnes in 1960.

Amazonas State has been the centre of Brazilian production, accounting for 90% or more of the total throughout the period 1978-89. Roraima has been the only other source of sorva of any significance and in recent years has accounted for all of the balance.

Quality and prices

There are no international specifications for sorva and no formal grading system appears to exist for material which is exported.

Recent price data are not available but some FOB export values are included in Table 34. In 1988, the average value of exported sorva was US\$ 3 315/tonne.

PLANT SOURCES

Botanical/common names

Family Apocynaceae:

<i>Couma macrocarpa</i> Barb. Rodr.	Sorva, sorveira, sorva grande, cumã-açu, leche-caspi
<i>C. utilis</i> (Mart.) Muell. Arg.	Sorvinha
<i>C. guianensis</i> Aubl.	

Description and distribution

C. macrocarpa is a tree up to 30 m high. It is the most widely distributed of the species – found in Peru, Venezuela, Ecuador, Colombia and the Brazilian Amazon, particularly Amazonas – and is the main source of sorva. The smaller *C. utilis* (Amazonas and the upper Orinoco basin, Venezuela) and *C. guianensis* (eastern Amazonia and the Guianas) are other species that yield a sorva-type latex. Some hold the view that *C. guianensis* is a synonym of *C. utilis*.

COLLECTION/PRIMARY PROCESSING

Sorva processing and export in Brazil is based in Manaus, a major town on the Amazon. The raw material is collected from intermediary traders based in medium-sized river towns, who in turn commission collection by groups of *sorveiros*; these make trips of up to three months to find and extract the gum. The trader finances both the expedition and the extractors' families whilst they are away.

All parts of the tree exude a white latex when cut. Until relatively recently the usual practice for collecting the latex was destructive: a single, oblique channel was cut in the trunk to a height of about 1 m and after draining the liquid into a cup the tree was felled. A series of further cuts was then made the entire length of the tree, sometimes including the branches, to obtain additional quantities of latex. This form of sorva harvesting, undertaken by commissioned groups of *sorveiros*, is not "extractivism" in the sense applied to the non-destructive collection of rubber or Brazil nuts. Instead, the destructive felling of the natural resource parallels that of *Aniba rosaeodora*, which is felled for rosewood oil production.

During a recent study of selected non-wood forest products in Brazil (COPPEN *et al.*, 1994), traders stated that *Couma* is now tapped, although much less frequently than rubber; three times a year was claimed by one trader. It was reported that the recommended tapping interval is between 6 months and 2 years in Rondônia.

On returning from the forest, the collector strains the latex to remove any forest debris and then boils it over a fire for a short time to induce coagulation. Alternatively, the latex is first mixed with water, salt added and the mixture left to stand overnight; this initial coagulum is then boiled in water.

The crude sorva is removed from the water and formed into large balls or blocks. These are usually brown on the outside where they are exposed to the air. The sorva is then wrapped in banana or palm leaves and placed in baskets for transportation and sale to the trader or further processor.

Yields

Yields of latex obtained by destructive means have been stated to be up to 6 litres from an adult tree of *C. macrocarpa*. Average production per man-day has been reported to be 15 litres of latex from three trees. More recently, it has been claimed that a *C. macrocarpa* tree of 50 cm diameter could yield up to 20 litres of latex after felling.

In Rondônia, an average of 2.5 litres of latex per tree can be obtained from sorvinha [*C. utilis*] and the *sorveiro* can tap up to 14 trees in a day. For "sorva mole" [*C. macrocarpa*], where the trees are more widely scattered, four trees per day are said to be tapped, producing an average of 20 kg per tree. LESCURE (1990) has stated that 1.5–2.0 litres of latex are obtained on average from one *C. utilis* tree by tapping and that a skilled man can collect 50–60 kg per day; the frequency of tapping is not stated.

VALUE-ADDED PROCESSING

Further processing (in Manaus) entails digestion of the crude sorva in water, blending of the various lots to produce a more consistent product, and drying to a moisture content of less than 1%; a little wax is added as a preservative. Although plans were made in the early 1970s to produce refined sorva, resin and *trans* polyisoprene ("gutta") at Manaus from a feedstock of sorva, balata and maçaranduba, the plant for doing this is not believed to have been built.

PRODUCTS OTHER THAN LATEX

C. utilis is amenable to cultivation for fruit production and it is grown for this purpose in parts of Amazonas. Some research has been undertaken on this aspect and one Brazilian institution (FCAP, Faculdade de Ciências Agrárias do Para, in Belém) has a 16-year old trial plot at one of its field stations. However, no research appears to have been carried out on tapping and its effects on fruit production.

DEVELOPMENTAL POTENTIAL

The earlier study cited (COPPEN *et al.*, 1994) concluded that although the recent trend was one of marked decline in world markets for sorva, it seemed unlikely that this would continue. Trade sources in Brazil were cautiously optimistic that energetic marketing would lead to a small increase in demand, perhaps to around 800 tonnes/year (but not to historical levels of 3 000 tonnes and more).

However, any foreseeable increase in the volume of demand for sorva could be met by harvesting of the wild resource. A network of collectors, intermediate market buyers and exporters is in place and there appears to be no immediate pressure on the wild tree resource. Research and development work on sorva production by cultivation in an agroforestry context, either solely for the latex or in combination with fruit production, is therefore difficult to justify. Moreover, the indications are that the economics of production would not be attractive or competitive with the present form of extractivism.

Research needs

There appears to have been little or no recent systematic research carried out into ways of improving sorva production on a sustainable basis. In the early 1960s, WILLIAMS (1962) carried out tapping trials on *C. macrocarpa* over a 5-month period. He concluded on the basis of his own work and that of others that it was not economic to recover sorva from this species in a manner analogous to rubber tapping. Furthermore, unlike the rubber tree, bark renewal is very slow and even after several years the channels have not healed sufficiently to allow re-tapping of the original surface.

However, if future demand for sorva is judged to warrant the investment in research, technological improvements to the present tapping methods are desirable. Such improvements should be possible by drawing on more recent experience with other latex and resin-yielding species (such as rubber and pine trees), and should be aimed at improving yields and reducing the risk of permanently damaging the trees.

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Table 34. Sorva: production and exports from Brazil, 1978 and 1986-92
(tonnes; US\$/tonne)

	1978	1986	1987	1988	1989	1990	1991	1992
Production	5555	3002	1524	1059	1106	736	na	na
Exports	3481	1570	991	931	na	na	na	500
FOB unit value	2760	3255	3175	3315	na	na	na	na

Source: National statistics (taken from COPPEN *et al.*, 1994, and LESCURE, 1995)

GUTTA PERCHA

DESCRIPTION AND USES

Gutta percha is the coagulum produced from the latex of certain trees of the Sapotaceae family indigenous to Southeast Asia, particularly those found in the Malay and Indonesian archipelagos.

In contrast to rubber, which is an elastic material, gutta percha is non-elastic; it becomes plastic when heated but retains its shape when cooled. The differences between the two materials arise from their different chemical compositions: rubber and gutta percha both contain a large proportion of the polymeric hydrocarbon polyisoprene, but in the former it is the *cis* isomer while in the latter it is the *trans* isomer. The presence of *trans* polyisoprene in balata-like materials originating from tropical America is referred to elsewhere (BALATA and MAÇARANDUBA), and confers on them their non-elastic properties.

Towards the middle of the last century it was discovered that gutta percha had excellent insulating properties which were retained under water, and its most important use was in providing the insulating material for submarine and underground cables. It was also used (as was balata) for the manufacture of golf ball covers and other moulded products. However, the advent of synthetic resins and other, petroleum-based polymeric materials led to the rapid decline in use of the natural material.

WORLD SUPPLY AND DEMAND TRENDS

Markets

Average annual world consumption of gutta percha in the early part of the century (40 years up to 1936) has been stated to be approximately 850 tonnes, of which about 450 tonnes were used for submarine cables, 300–400 tonnes for the manufacture of golf balls, and the remainder for miscellaneous industries such as machine belting (READER, 1953). LOCKHART-SMITH (1972), on the other hand, states that exports of gutta percha and inferior guttas from Singapore averaged nearly 14 000 tonnes annually between 1900 and 1920. By the 1960s/1970s, golf ball manufacture was the only significant end use for gutta percha (and balata).

In the 1960s, the United States was by far the largest importer of gutta percha; average annual imports from Indonesia over the 10 years 1963–72 were 1 140 tonnes (LOCKHART-SMITH, 1972). Recent US data are not available.

It is not easy to draw conclusions about present day consumption of gutta percha on the basis of trade statistics alone. Gutta percha is not always disaggregated from other non-elastic gums, and although an attempt has been made to do this in the case of recent imports into Japan of "chicle, balata, gutta percha and guayule" (Table 32), the average annual figure of about 970 tonnes for assumed gutta percha imported from Indonesia is much greater than total recorded exports of gutta percha out of Indonesia for the same period (Table 35, annual average 190 tonnes). Furthermore, of these total exports, only 6 tonnes (in 1993) went directly to Japan.

Supply sources

In past years, Indonesia and Malaysia have been the dominant producers of gutta percha, with minor quantities coming from Thailand and a few other countries in the region. Singapore is often the first destination for exports, which are then re-exported to end-user countries.

Indonesia is believed to be the largest producer and exporter of gutta percha today, although it is not clear whether the quantities given in Table 35 are a true reflection of the size of this trade.

Quality and prices

The quality of gutta percha, both in its crude and processed form, depends largely on its hydrocarbon (gutta) content, since it is this that confers on gutta percha its thermo-plastic properties. Most of the remaining material is "resin". Gutta percha which has been extracted from leaves by non-solvent methods (see **VALUE-ADDED PROCESSING** below) contains around 70–75% hydrocarbon and 6–10% resin; the balance is moisture and a few per cent of solid impurities. Fully refined, solvent-extracted gutta percha ("white gutta") contains less than 1% resin.

FOB export values for gutta percha of Indonesian origin have been quite steady for the last three years of data (1991–93): approximately US\$ 1 200/tonne. In 1990 it was about US\$ 1 900/tonne.

PLANT SOURCES

Botanical names

Family Sapotaceae:

Palaquium gutta (Hk. f.) Baillon

Other *Palaquium* spp., including *P. obovatum* (Griffith) Engler, *P. oblongifolium*, *P. oxleyanum* Pierre and *P. treubii*.

Payena leerii (Teys. et Binn.) Kurz

Description and distribution

Palaquium species are medium to very tall trees. *P. gutta* is a medium tree, up to 25 m in height and 1.5 m in girth, with small buttresses. *Payena leerii* grows up to 40 m high.

The main gutta percha-yielding trees are found in Indonesia and Malaysia, particularly the islands of Sumatra and Borneo and smaller surrounding ones. However, they occur as far north as the Philippines and mainland Southeast Asia, and as far east as Papua New Guinea.

Palaquium species are amenable to cultivation and plantations were established in Java for gutta percha production as early as the 1890s. Commercial plantations were also being worked in Malaysia in the 1950s, but the last of these ceased operation in 1967. LOCKHART-SMITH (1972) reported that the plantation at Cipetir, West Java, was the only active one in the early 1970s; its status today is not known. Although *P. gutta* produces the highest quality gutta percha, *P. oblongifolium* is the species most suited to planting.

COLLECTION/PRIMARY PROCESSING

In the early 1900s, when demand for gutta percha was at its greatest, collection of the latex from wild trees was entirely by destructive means, so as to obtain as much as possible: the tree was felled, the branches lopped off, and a number of wide cuts made through the bark at intervals along the trunk. When it became clear that this was leading to significant losses of forest, such methods were banned and techniques for tapping the living tree were developed.

Usually these methods entailed making a series of V-shaped cuts in the bark of the tree about 20–30 cm apart, with a central, vertical channel. Most of the latex coagulated in the cuts and was collected by rolling it into small balls along the cuts; the remainder flowed into small cups fixed to the tree. A rest period of at least two years was said to be necessary between successive tappings to keep the tree economically productive. Unlike rubber trees, which contain laticiferous tubes in the bark, *Palaquium* spp contain irregular cavities which are not connected, and tapping cannot be done in a manner similar to that for rubber.

In plantations, extraction of gutta percha from the leaves of the trees is more productive than collection of latex by tapping. Harvesting is done partly by plucking (about four times a year) and partly by collecting prunings (which comprise leaves, twigs and small branches).

Primary processing of the latex entails pressing the partially formed coagulum into blocks after first softening it in hot water and removing larger pieces of foreign matter. The blocks are then transported to the factory for further processing; if they need to be stored for any length of time before transportation they are best kept under water to avoid spoilage by aerial oxidation.

Extraction of the gutta percha from leaves is briefly described under **VALUE-ADDED PROCESSING**, since some aspects of it are similar to methods used for further processing of the crude gutta percha blocks.

Yields

Tapping yields of latex depend on both genetic and environmental factors, as well as the part of the tree which is tapped. In *P. oblingifolium*, for example, the latex hardens after a few minutes of exposure to the air, and the yield is considerably lower than that from *P. obovatum*. Cloudy, moist conditions allow the latex to flow more easily than during hot, sunny periods, when there is some loss of water by evaporation. Higher yields are also obtained from the upper portion of the trunk and branches than from the lower part. Yields of gutta percha per tree are also very variable, but about 1.5 kg has been stated to be a good average.

The gutta percha content of leaves increases with the age of the leaf: results reported in the older literature state about 3% (dry basis) in young leaves, 8% in medium-aged leaves and 10% in old leaves.

VALUE-ADDED PROCESSING

Preparation of purified gutta percha involves chopping the blocks of crude material into small pieces, removing the resinous ("non-gutta") fraction by dissolution in cold petroleum spirit, and then dissolving the remaining, separated gutta fraction in hot petroleum spirit. This hot

extract is drained from any insoluble foreign matter and then allowed to cool, whereupon the purified gutta percha separates out. After separation and distillation of residual solvent the hot, plasticized gutta is rolled into sheets and stored, either in the dark in well sealed tins, or in water.

Solvent extraction of gutta from harvested leaves follows the same principles as above, but involves pulverized leaf material instead of chopped crude gutta percha. Bleaching earth is added to the hot mixture to remove unwanted leaf pigments.

An alternative method of processing the leaves involves digesting the leaf pulp in hot water, and collecting and pressing the coagulated latex which separates out into blocks.

PRODUCTS OTHER THAN LATEX

No other products of economic value are believed to come from the gutta-yielding species.

DEVELOPMENTAL POTENTIAL

Although recent Indonesian export data show a modest upward trend, there is insufficient information, here, to be able to make an informed judgement as to the developmental potential of *Palaquium* and gutta percha production. In particular, it is not known whether the gutta percha produced in Indonesia (or elsewhere) comes from plantation or wild sources.

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Table 35. Gutta percha: exports from Indonesia, and destinations, 1988-93
(tonnes)

	1988	1989	1990	1991	1992	1993
Total	3	75	156	316	366	241
<i>Of which to:</i>						
Singapore	-	72	119	316	363	234
USA	2	3	36	~	3	-
Belgium/Luxembourg	1	-	1	-	-	-
Japan	-	-	-	-	-	6

Source: National statistics

BALATA

DESCRIPTION AND USES

Genuine balata is obtained as a latex from trees of certain South American *Manilkara* species, in particular *M. bidentata*. Like sorva, balata latex is coagulated by boiling and turned into blocks, the form in which it is traded.

Balata is sometimes described as the South American gutta percha. Its non-elastic, insulating properties made it, in the past, a valuable export commodity, used for covering submarine and telephone cables, and in the manufacture of machine belting. Its most well-known use was in providing the outer covering for golf balls. Today, its use in Brazil, once the major world source of balata, is limited to a number of small applications such as the manufacture of souvenir figures and surgical implants.

WORLD SUPPLY AND DEMAND TRENDS

Markets

An international market for balata no longer exists. During the 1960s, when Brazil was the main supplier, the United States was the dominant importer. During this period, Brazil exported around 500 tonnes/year to a world market of approximately 800 tonnes.

In the 1970s, synthetic substitutes were developed which immediately displaced balata's role in world markets, and this remains the case today. Table 36 indicates that only small or nil amounts of balata have been exported from Brazil in recent years.

The Brazilian domestic market remains a very small one. Balata finds some use in dentistry and for surgical implants. Its most visible application is its use in the cottage crafts industry for making model animals and other figures, mostly for sale to tourists.

Neither domestic nor international markets offer any prospect for substantially increased use of balata.

Supply sources

The extent of balata production today in countries other than Brazil is not known, but it is unlikely to be substantial given the collapse in world markets. Peru, like Brazil, was a significant producer in the 1950s, and in the 1960s and early 1970s Venezuela and Suriname appeared in United States' import statistics as exporting countries for balata.

Brazilian data indicate a steady and severe decline in production over the last 30 years, consistent with world market trends. Production in Pará state, the main source of balata, was almost 1 500 tonnes in 1961. By 1978 (Table 36), total Brazilian production was down to 400 tonnes and by the latter half of the 1980s recorded production was only around 20 tonnes annually; it was 18 tonnes in 1990.

Quality and prices

When balata was a significant item of international trade, its quality depended on its "gutta" (*trans* polyisoprene) content. Commercial balata was said, typically, to contain about 40–50% gutta, most of the balance being resinous material. Genuine balata of Brazilian origin (from *M. bidentata*) was claimed to be of superior quality, with a gutta content of up to 80%.

No price information is available on balata.

PLANT SOURCES

Botanical/common names

Family Sapotaceae:

<i>Manilkara bidentata</i> (DC.) A. Chev.	Balata,
(syn. <i>Mimusops bidentata</i> DC.,	balata verdadeira
<i>Mimusops balata</i> Gaertn.)	bulletwood tree

Genuine balata comes from *M. bidentata* although the term balata is sometimes used in a wider sense to include other non-elastic gums such as maçaranduba (from *M. huberi*) and coquirana (from *Ecclinusa balata*).

Description and distribution

M. bidentata is a tall tree, reaching 30 m or more, and is found mostly in northern Amazonia and the Guianas.

COLLECTION/PRIMARY PROCESSING

Traditional methods of collecting the latex have entailed felling the tree and girdling the entire trunk so as to recover as much latex as possible at one time. Such methods are still claimed to be favoured by many *balateiros* today.

Tapping methods that are now used for balata involve making a series of circular incisions round the trunk of the tree, eventually extending to the lower branches, which the *balateiro* reaches by climbing. Each circular incision meets a vertical channel, down which the latex flows to a receiver fixed to the tree.

The frequency with which trees can be tapped appears to be very low and dependent on renewal of the bark which has been removed during the first tapping; different sources state this to be only about once every 3–5 years or every 8–10 years. LOPES (1970), citing views expressed by the "patrons" of several commercial operations in Brazil, says that a 15–20 year rest period is necessary. Furthermore, this is only possible for those trees that survive the first tapping – survival rates were reported to be anything between 80% and 25%.

In a similar manner to sorva, the collected latex is boiled in a large galvanized vessel and the resulting coagulated material then removed, washed with cold water and placed in wooden boxes to form blocks. After removal from the boxes, the gum is left for 2–3 days to harden.

Yields

As might be expected, latex yields per tree are very variable and not easily predicted, although there appears to be some correlation with bark thickness. Felled trees have been claimed to yield up to 40 litres of latex or 5–8 times as much as a standing tree. Trees which are tapped a second time have been found to produce only a third the quantity of latex obtained from the first tapping.

Average yields of 18–20 litres of latex per tree have been reported for tapped trees, and in Brazil, in a 6-month period, one person is said to be able to tap 200–300 trees, producing a total of 800–2000 kg of balata (i.e., of the order of 4–7 kg of balata per tree). Reports of balata production in Guyana in the 1930s describe yields of 5 litres of latex (producing 2.5 kg of balata) per tree as being good, although up to five times these yields can be obtained in exceptional cases.

VALUE-ADDED PROCESSING

Separation of the gutta and resinous fractions of balata is, as far as is known, always carried out in the end-user country and there are few opportunities for value-added processing at source.

PRODUCTS OTHER THAN LATEX

Apart from occasional timber use, there has been no other significant exploitation of the balata tree.

DEVELOPMENTAL POTENTIAL

The practical difficulties in cultivating and tapping *M. bidentata* are, if anything, even greater than for *Couma* spp., the source of sorva. In the absence of any significant market for balata, and the fact that there appear to be no problems in meeting local demand from existing supply sources, at least in Brazil, there is little incentive to undertake research on silvicultural aspects or improved tapping methodologies, and the developmental prospects must be considered negligible.

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**Table 36. Balata: production and exports from Brazil, 1978 and 1986-92
(tonnes)**

	1978	1986	1987	1988	1989	1990	1991	1992
Production	407	22	19	21	21	18	na	na
Exports	na	5	-	-	15	-	-	na

Source: National statistics (taken from COPPEN *et al.*, 1994, and LESCURE, 1995)

MAÇARANDUBA

DESCRIPTION AND USES

Sometimes described as an inferior balata, maçaranduba is collected as a latex from trees of the same genus as genuine balata (*Manilkara*).

Maçaranduba, like sorva, has been used mainly for chewing gum manufacture, though in slightly different formulations.

WORLD SUPPLY AND DEMAND TRENDS

Markets

With the development of synthetic gums for making chewing gum, the international market for maçaranduba has declined sharply.

In the 1950s, recorded exports from Brazil, the major producer, were around 300–400 tonnes/year; most of it went to the United States. More recent data (from the early 1980s onwards, including that shown in Table 37) are somewhat incomplete but indicate exports of less than 10 tonnes/year for most years. Unofficial, trade sources indicate that the level of exports in the early 1990s has been around 20–30 tonnes annually.

Levels of exports from other countries in the region, if any, are not known.

Use of natural gums by the Brazilian chewing gum industry is believed to be very small, and no significant shift in this direction is anticipated which would offer prospects for substantial increases in domestic consumption of maçaranduba.

Supply sources

Table 37 indicates a general decline in Brazilian production over the last decade or so, and by 1990 it was only just over 100 tonnes. Data from earlier years suggest that production peaked in 1965, at around 1 000 tonnes. Since 1982, all recorded production of maçaranduba in Brazil, like balata, has come from Pará state.

Production in other countries is not known but it is likely to be small.

Quality and prices

Maçaranduba has a lower *trans* polyisoprene (gutta) content than genuine balata, about 25%, and this accounts for its description as inferior balata. Its value (and price) is therefore assumed to be lower than that of balata and this is borne out by Brazilian export values for consignments shipped in the early 1980s: the unit value of balata was approximately 1.5–2.0 times that of maçaranduba.

PLANT SOURCES

Botanical/common names

Family Sapotaceae:

Manilkara huberi (Ducke) Stand./Chev. Maçaranduba

MORS and RIZZINI (1966) regard *M. huberi* as a synonym of *M. elata* (Fr. All.) Monac.

Description and distribution

M. huberi, which is generally considered to be the source of maçaranduba, is a tall Amazonian tree, up to 40 m or more in height.

COLLECTION/PRIMARY PROCESSING

Methods of collection of maçaranduba are the same as those described earlier for balata, and primary processing is performed in the same way as for sorva and balata, with the latex being turned into balls and blocks.

In Brazil, traders' perceptions of how the latex is collected in the forest differ (COPPEN *et al.*, 1994). Some believe that earlier, destructive methods of obtaining the latex have given way to those involving tapping, while others explain that, unlike sorva and balata, which can be tapped, maçaranduba is always obtained by first felling the tree. This may be related, however, to the fact that the wood of *M. huberi* is very resistant to fungal attack and so highly valued as a source of timber.

In Brazil, the final processing and export of maçaranduba, like sorva, is concentrated in the hands of one or two Manaus-based companies. These companies notify traders based in small river towns of their need for certain products. Such traders, in turn, finance extractivists for a period of up to several months to search for the commodity in question. The costs of this search, and of looking after the families whilst the men are away, are met by the middleman as a partial advance payment for the commodity.

Yields

There is very little published information on yields from *M. huberi*. OLIVEIRA *et al.* (1992) state that tapping is carried out at intervals of two years, yielding an annual equivalent of 1 kg of maçaranduba per tree.

VALUE-ADDED PROCESSING

As was indicated for balata, no value-added processing is believed to have ever been carried out at source on maçaranduba.

PRODUCTS OTHER THAN LATEX

The fruits of *M. huberi* are edible and are sometimes found in local markets (in Belém, in Brazil, for example).

As noted above, the timber is also highly valued. Maçaranduba wood is very dense and resistant to biodeterioration, and is used for making railway sleepers.

DEVELOPMENTAL POTENTIAL

The poor market prospects for maçaranduba and the low yields of latex obtained (at infrequent intervals in its native state), mean that *M. huberi* has very little potential in developmental terms. It is unlikely that any investment in research would lead to a more favourable conclusion.

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**Table 37. Maçaranduba: production and exports from Brazil, 1978 and 1986-92
(tonnes)**

	1978	1986	1987	1988	1989	1990	1991	1992
Production	451	376	298	192	127	116	na	na
Exports	na	3	-	-	-	-	na	na

Source: National statistics (taken from COPPEN *et al.*, 1994, and LESCURE, 1995)

APPENDIX 1

BIBLIOGRAPHY OF GENERAL ARTICLES OR BOOKS ON GUMS, RESINS AND LATEXES

The following references provide details of books on gums and resins, and some articles covering a number of gums, resins and latexes not cited earlier in this report. Some of the older books, which are often a valuable source of information, are likely to be out of print but should be accessible through libraries.

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Gums, resins and latexes are among the most widely used and traded non-wood forest products. Applications of gums embrace food, pharmaceutical and miscellaneous technical purposes. Resins have an equally diverse range of applications, in paints, varnishes and lacquers and in flavours and fragrances. Latexes have specialized applications in, for example, insulating materials and the manufacture of golf balls and chewing gum. The use of some of these products has declined because of competition from synthetic products. This document reviews the production, markets and development potential of a number of gums, resins and latexes.

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