Global food security and economic growth depend on a declining number of plant species. This has raised the interest in underutilised species as they allow to improve livelihoods by generating income, supporting food security and improving nutrition. People in Mali and Benin depend on the multiple goods and services supplied by underutilised indigenous tree species, such as baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.).

The overall objective of the research presented here is to obtain insight in the structure and functioning of the markets of baobab and tamarind products in Mali and Benin. The present study first identified all chain actors involved in the markets of baobab and tamarind products in Benin and Mali, namely gatherers, traders, processors and consumers, and described their characteristics, activities, problems and linkages. Secondly, the markets of six different baobab and tamarind products traded in Mali and Benin were mapped. Then, the different market chains and their characteristics were analysed on local and national level. Finally, recommendations were formulated on how local chain development should build linkages and enhance trust between actors in the market chain. Once the major domestic limitations have been tackled, commercialisation of baobab and tamarind products on regional and international level could be developed and expanded.

Most aspects of the market chains of baobab and tamarind products in Mali and Benin studied in the present research have not yet been studied and published elsewhere. Therefore, this PhD should be considered as a pilot case study in obtaining insight in the commercialisation of baobab and tamarind products in Mali and Benin.

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ir. Emmy De Caluwé

2011

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UNIVERSITEIT GENT

FACULTEIT BIO-INGENIEURSWETENSCHAPPEN

If many people,
in many little places
do many little things,
they can change the face of the earth

African Proverb

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Market chain analysis of baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.) products in Mali and Benin

Thesis submitted in fulfilment of the requirements for the degree of
Doctor (PhD) in Applied Biological Sciences: Agronomy

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aeu	adult equivalent unit
AFTPs	Agroforestry Tree Products
APG	Angiosperm Phylogeny Group
AVRDC	Asian Vegetable Research and Development Centre (now World Vegetable Centre)
BFCS	Baobab Fruit Company Senegal
CBI	Centre for the Promotion of Imports from Developing Countries
CGIAR	Consultative Group on International Agricultural Research
CIA	Central Intelligence Agency
CIRAD	*Centre de Coorpération Internationale en Recherche Agronomique pour le Développement*
DADOBAT	Domestication And Development Of Baobab And Tamarind
DEA	Data Envelopment Analysis
EC	European Commission
ECOWAS	Economic Community of West African States
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FCFA	*Fédération des Communautés Francophones et Acadienne*

FIAS	Multi-donor Investment Climate Programme of the World Bank Group
GDP	Gross Domestic Product
GFAR	Global Forum on Agricultural Research
GFU	Global Forum for Underutilised Species
HDI	Human Development Index
ICRAF	International Centre for Research in Agroforestry (now World Agroforestry Centre)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICUC	International Centre for Underutilised Crops
IDRC	International Development Research Centre
IFC	International Finance Corporation of the World Bank Group
IIRR	International Institute of Rural Reconstruction
IMF	International Monetary Fund
INRA	*Institut National de la Recherche Agronomique*
IPGRI	International Plant Genetic Resources Institute (now Bioversity International)
IUNC	International Union for the Conservation of Nature
KIT	Royal Tropical Institute
MDGs	Millennium Development Goals
NGOs	Non-Governmental Organisations
NTFPs	Non-Timber Forest Products
NWFPs	Non-Wood Forest Products
OECD	Organisation for Economic Co-operation and Development
PMCA	Participatory Market Chain Analysis
PPP	Purchasing Power Parity

PRSP	Poverty Reduction Strategy Papers
RMA	Rapid Market Analysis
SAGORGEN	Sub-Saharan Africa Forest Genetic Resources Programme
SAFRUIT	Sahelian Fruit Trees Project
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
SUN	Tools for Management and Sustainable Use of Natural Vegetation in West Africa
SWAC	Sahel and West Africa Club
SWOT	Strengths, Weaknesses, Opportunities and Threats
UK	United Kingdom
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
WHO	World Health Organisation

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Bedankt! Thanks! Merci!

Summary - Résumé - Samenvatting

Summary

Global food security and economic growth depend on a declining number of plant species. This has placed the future supply of food and rural incomes at risk. Recently, there has been an increasing interest in underutilised species as they allow to improve the livelihoods of the rural poor by generating income, supporting food security and improving nutrition.

Mali and Benin are both characterised by high rates of rural poverty, low basic health services, problematic and unstable food security, and unsustainable use of natural resources. In addition, rural and urban people remain very dependent on the multiple goods and services supplied by indigenous trees and woody plants. Any attempt to find sustainable solutions to the problems listed for Mali and Benin should take into account locally known, used and available natural resources.

In West Africa, baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.) form part and parcel of traditional farming systems or agroforestry parklands, and both species have been identified by local people as priority species to domesticate. Notwithstanding the great agronomic, ecological, nutritional, cultural and economic importance of baobab and tamarind products, very little information is available on the basic market functioning and structures, such as stakeholders involved, trade channels and/or patterns of value adding along the market chain. The present PhD thesis thus is the first study that attempts to fill this information gap.

The overall objective of the research presented here is to obtain insight in the structure and functioning of the markets of baobab and tamarind products in Mali and Benin. To achieve this goal, the following specific

research objectives are set: (i) identify all chain actors involved in the market(s) of baobab and tamarind products in Mali and Benin, and describe their characteristics, activities and linkages; (ii) map the market(s) of baobab and tamarind products in Mali and Benin; (iii) analyse the market chain of baobab and tamarind products in Mali and Benin; and (iv) formulate possible scenarios on how to add more value to baobab and tamarind products in Mali and Benin, and how to better organise their market chains.

To formulate an answer on the objectives set for the present study, an in-depth analysis of the market chain for selected baobab and tamarind products is required. During field research, in total, 507 individual stakeholders in the market chain of baobab and tamarind products were interviewed in Mali between July and October 2007, whereas in Benin we interviewed 221 informants during the period January – April 2010.

Gatherers of baobab and tamarind products are categorised as smallholders. After harvesting, they transform fresh baobab leaves into dry baobab leaves and/or baobab leaf powder, baobab fruits are processed into baobab fruit pulp, tamarind leaves are dried, and tamarind fruit pods are stripped from their shell. In the present study, the portion of cash income obtained from baobab and tamarind products is about 4 % for the poorest and 5 % for the richer households in Mali, whereas, in Benin, a contribution of up to 11 % is reported for the poorest group of smallholders. These figures show that baobab and tamarind products fall into the gap-filling income category. The majority of surveyed gatherers in Mali and Benin reported to sell their baobab and tamarind products at the farmgate. Baobab and tamarind fruits and leaves are harvested using traditional harvesting techniques, which only require manual labour and low-cost tools. Leaf harvesting practices, in the case of baobab, may negatively impact on fruit production. Therefore, in general, sustainable harvesting practices need to be developed and proposed to promote the species' conservation and avoid overexploitation. At last, surveyed gatherers in Mali and Benin mentioned dangerous harvesting techniques, seasonality and limited availability of baobab and tamarind products, time-consuming processing practices, product quality and a lack of market information as their major problems.

Traders of baobab and tamarind products are mainly women. They fulfil different and varying functions, which points to a lack of functional specialisation. Findings in the present study revealed three possible price setting processes: (i) fair negotiation, usually when the produce is sold at the market place; (ii) traders have more bargaining power, especially when the produce is sold at the farmgate; and (iii) collecting gatherers in Benin have more influence in the price setting than traders. The latter shows the beneficial impact of collective action strategies in increasing the bargaining power of smallholders. Additionally, the present study identified distinct trade centres for baobab leaf powder, baobab fruit pulp and tamarind fruit pods in Mali and Benin. The surveyed traders reported the following principal problems: variable product quality, limited storage space, transport difficulties due to poor roads, lack of market information and no access to formal financial services.

Processors in Benin reported to make juice from baobab and tamarind fruit pulp, whereas in Mali, processors use baobab and tamarind fruits in the preparation of juice, syrup, jam and instant juice powder. Additionally, baobab fruit pulp is used in Mali for mixing with millet flour to prepare millet cream (locally called *dégué*). Processing is generally not reported as a one-man's business and processing (family) enterprises were found to transform a whole range of different products. Notwithstanding manual processing techniques and simplicity of equipment used, the portion of efficient processors identified by means of a data envelopment analysis is 63 % in Mali and 49 % in Benin. Thus, processors appear to be efficient under the given circumstances in Mali and Benin. The major cost that processors in both countries face is the cost of packaging material. Moreover, surveyed processors in Mali and Benin reported inappropriate and expensive packaging material, limited availability of adequate processing equipment, bad transport due to poor road infrastructure, lack of financial means and limited market information as main constraints.

Both rural and urban consumers buy and use baobab and tamarind products on a regular basis. Baobab fruit pulp is reported to be used in porridges and/or juices, whereas baobab leaves are used in sauce preparations. Most surveyed consumers use tamarind leaves and fruits in the preparation of juices and/or for souring meals. Substitution products for all baobab and tamarind products are reported in the present study and confirmed by literature. The main problems recorded by consumers are seasonality of supply, price fluctuations and unreliable product quality.

In total, six different baobab and tamarind products are reported in this study to be traded in Mali and Benin. Based on the market maps drawn for these products, three different market chains were identified: (i) market chain of fresh baobab leaves and tamarind leaves, characterised as locally important with a domestic potential; (ii) market chain of dry baobab leaves and baobab leaf powder, characterised as important on domestic level with a regional potential; and (iii) market chain of baobab and tamarind fruits, characterised by its domestic and regional importance with international potential.

The present study is the first that has recorded quantities bought and sold, and purchasing and selling prices for different actors involved in the commercialisation of baobab and tamarind products in Mali and Benin. Based on the quantities and prices recorded, baobab fruit pulp is traded in larger quantities in Benin than in Mali, whereas baobab leaf powder and tamarind fruit pods are marketed in larger quantities in Mali than in Benin. Prices are lower in Benin for baobab fruit pulp and baobab leaf powder than in Mali, while tamarind fruit pods are cheaper in Mali when compared to Benin. Moreover, commercialisation of baobab and tamarind products was evidenced to create a lot of employment opportunities. In addition, we calculated added values for baobab and tamarind products and showed that processors and gatherers tend to have the highest added values. This trend is found to be more pronounced in Mali than in Benin. As added value does not take into account any costs, it is impossible to prove which actor has the highest margins.

Harvesting of baobab and tamarind fruits, and baobab leaves is highly seasonal. This is further reflected in the commercialisation of baobab and tamarind products which is found to occur chiefly during the dry season in Benin. In Mali, marketing of baobab and tamarind products is observed to be less seasonal. However, no seasonal storage has been evidenced in Mali and Benin due to a lack of storage infrastructure, space and financial means. Most surveyed chain actors typically purchase a certain volume of produce, which is stored until it is sold, after which they replenish their stock. As a result, storage duration is observed to be very variable. In the present study, dry baobab and tamarind products are mainly stored in recycled rice bags which are kept in the house or in a storehouse or granary, in respectively Benin and Mali. Even though humidity and bug, mice and fungi attacks were reported as main problems during storage, the informants rated overall storage conditions as good.

None of the baobab and tamarind products were reported to be graded or standardised. Direct inspection is the only method reported by which quality is assessed. Moreover, it has been observed that different actors use different quality criteria. All chain actors in Mali and Benin attach great importance to processing and storage techniques for baobab and tamarind products, and expect a well-dried or finely ground product without impurities, which has not been exposed to humidity. Additionally, colour and taste are important quality parameters in Mali, whereas taste is only a criterion in Benin for baobab and tamarind fruits. Maturity, freshness and size, together with the absence of insects or insect lesions are important quality criteria used to assess quality of tamarind fruits and leaves in Mali. The same criteria are used in Benin to assess the quality of fresh baobab leaves.

Lack of market information is recognised by all chain actors as a major constraint in the commercialisation of baobab and tamarind products in Mali and Benin. Information is particularly lacking about harvesting and processing techniques, price, quality and demand. Chain actors in Mali particularly need more information about demand and they reported not to be satisfied with the access to information. In contrast, surveyed actors in Benin especially need information about quality and say to be rather satisfied with overall information flow.

Local chain development should build linkages and enhance trust between actors in the market chain. Recommended interventions are formulated in many fields: (i) parallel domestication and commercialisation of baobab and tamarind; (ii) training of smallholders to improve their production and management skills; (iii) supporting smallholders to associate, collaborate and coordinate to achieve economies of scale in their transactions with buyers; (iv) making channels of information and market intelligence accessible to all chain actors;(v) enabling chain actors to understand and better satisfy product, process or delivery standards required by buyers; and (vi) improving market institutions. Once the major domestic limitations have been tackled, commercialisation of baobab and tamarind products on regional and international level should be developed and expanded.

In conclusion, most aspects of the market chains of baobab and tamarind products in Mali and Benin studied in the present research have – according to the author's knowledge – not yet been studied and published elsewhere. Therefore, this research should be considered as a pilot case study in obtaining insight in the structure and functioning of the markets of baobab and tamarind products.

Résumé

La sécurité alimentaire mondiale et la croissance économique dépendent du nombre décroissant des espèces végétales. Cette situation a mis la provision future des produits alimentaires et des revenus ruraux en danger. Il ya eu récemment un intérêt croissant dans les espèces sous-utilisées qui permettent d'améliorer la subsistance de la population rurale en générant des revenus, en entretenant la sécurité alimentaire et en améliorant la nutrition.

Le Mali et le Bénin sont tous deux caractérisés par des taux élevés de pauvreté rurale, par de faibles services de la santé de base, par une scurité alimentaire problématique et instable ainsi que par une utilisation non durable des ressources naturelles. En outre, les populations rurales et urbaines demeurent très dépendantes des produits et services multiples fournis par des arbres et des plantes ligneuses indigènes. Tout effort visant à trouver des solutions durables aux problèmes énumérés pour le Mali et le Bénin devrait prendre en compte des ressources naturelles localement connues, utilisées et disponibles.

En Afrique de l'Ouest, le baobab (*Adansonia digitata* L.) et le tamarinier (*Tamarindus indica* L.) font partie des systèmes agricoles traditionnels ou des parcs agroforestiers, et les deux espèces ont été identifiées par la population locale comme une espèce prioritaire à domestiquer. Malgré la grande importance agronomique, écologique, alimentaire, culturelle et économique des produits du baobab et du tamarinier, très peu d'information est disponible sur le fonctionnement et sur les structures du marché, tels que les acteurs impliqués, les circuits de commercialisation et/ou les modèles qui ajoutent de la valeur le long de la chaîne de commercialisation. Cette thèse de doctorat est donc la première étude qui tente de combler cette lacune.

L'objectif global de la recherche présentée ici est d'obtenir un aperçu de la structure et du fonctionnement des marchés de produits du baobab et du tamarinier au Mali et au Bénin. Pour atteindre ce but, les objectifs de recherche spécifiques sont: (i) identifier tous les acteurs impliqués dans le(s) marché(s) des produits du baobab et du tamarinier au Mali et au Bénin, et de décrire leurs caractéristiques, les activités et les liens; (ii) dresser le(s) circuit(s) de commercialisation des produits du baobab et du tamarinier au Mali et au Bénin; (iii) analyser la chaîne de commercialisation des produits du baobab et du tamarinier au Mali et au

Bénin; et (iv) formuler des scénarios possibles pour augmenter la valeur des produits du baobab et du tamarinier au Mali et au Bénin, ainsi que mieux organiser leurs filières.

Afin de formuler une réponse aux objectifs de la présente étude, une analyse profonde de la filière des produits du baobab et du tamarinier est indispensable. Lors des visites sur le terrain, au total, 507 personnes impliquées dans la chaîne de commercialisation des produits du baobab et du tamarinier ont été interrogées au Mali entre juillet et octobre 2007, alors qu'au Bénin nous avons interrogé 221 informants durant la période janvier - avril 2010.

Les producteurs des produits du baobab et du tamarinier sont catégorisés comme petits exploitants agricoles. Après la récolte, ils transforment les feuilles fraîches de baobab en feuilles sèches et/ou en poudre, les fruits du baobab sont transformés en poudre, les feuilles de tamarinier sont séchées, et les fruits du tamarinier sont décortiqués. Dans la présente étude, la part de revenu obtenu par la vente des produits du baobab et du tamarinier s'élève à 4 % pour les paysans les plus pauvres et 5 % pour les paysans riches du Mali. Alors qu'au Bénin la contribution s'élève à 11 % pour les petits exploitants agricoles les plus pauvres. Ces résultats démontrent que les produits du baobab et du tamarinier entrent dans la catégorie de revenu '*gap-filling*'. La majorité des producteurs interrogés au Mali et au Bénin déclare vendre leurs produits du baobab et du tamarinier à l'exploitation agricole. Les fruits et les feuilles du baobab et du tamarinier sont récoltés en utilisant des techniques de récolte traditionnelles, qui ne nécessitent que des mains-d'uvre et des outils pas chers. Dans le cas du baobab, les pratiques pour récolter les feuilles peuvent influencer la production des fruits de façon négative. Par conséquent, les pratiques de récolte durables en général, doivent être développées et proposées pour promouvoir la conservation de l'espèce et éviter ainsi la surexploitation. Enfin, les enquêtés au Mali et au Bénin ont mentionné comme problèmes principaux, des techniques de récolte dangereuses, la saisonnalité et la disponibilité limitées des produits, les pratiques de transformations qui prennent du temps, la qualité des produits et l'information du marché insuffisante.

Les commerçants des produits du baobab et du tamarinier sont principalement des femmes. Ils remplissent des fonctions différentes et variées, ce qui dénote un manque de spécialisation fonctionnelle. Les conclusions de la présente étude ont révélé trois manières possibles pour

fixer les prix: (i) négociation équitable, principalement lorsque le produit est vendu au marché, (ii) les commerçants ont plus de pouvoir de négociation, en particulier lorsque le produit est vendu à l'exploitation agricole, et (iii) les producteurs qui récoltent au Bénin ont plus d'influence dans la fixation des prix que les commerçants. Ce dernier montre les effets bénéfiques des stratégies d'action collective dans l'augmentation du pouvoir de négociation des petits exploitants. En outre, la présente étude a identifié des centres commerciaux distincts pour la poudre de feuille de baobab, la poudre de fruit de baobab et les fruits de tamarinier au Mali et au Bénin. Les commerçants interrogés ont déclaré comme problèmes principaux: la qualité variable du produit, l'espace de stockage limité, les difficultés de transport causées par le mauvais état des routes, le manque d'information du marché et l'absence d'accès aux services financiers formels.

Les transformateurs au Bénin disent de préparer du jus à base des fruits du baobab et du tamarinier, alors qu'au Mali, les transformateurs utilisent les fruits du baobab et du tamarinier dans la préparation du jus, du sirop, de la confiture et de la poudre instantanée de jus. En outre, la poudre des fruits du baobab est utilisée au Mali pour mélanger avec de la farine du mil pour préparer la crème de mil (appelée localement *dégué*). La transformation n'est généralement pas reconnue comme une entreprise unipersonnelle et les entreprises (familiales) transforment toute une gamme des produits différents. Nonobstant des techniques de transformation manuelle et la simplicité du matériel utilisé, la part des transformateurs identifiés comme efficaces par la méthode d'enveloppe des données est de 63 % au Mali et de 49 % au Bénin. Ainsi, les transformateurs semblent efficaces malgré les circonstances au Mali et au Bénin. Le coût le plus important auquel les transformateurs dans les deux pays sont confrontés est celui des matériaux d'emballage. En outre, les transformateurs interrogés au Mali et au Bénin ont signalé comme contraintes principales les matériaux d'emballage inappropriés et coûteux, la disponibilité limitée des équipements de transformation adéquats, le transport difficile causé par une infrastructure routière faible, le manque de moyens financiers et l'information du marché limitée.

Les consommateurs ruraux et urbains achètent et utilisent très régulièrement les produits du baobab et du tamarinier. La poudre du fruit du baobab est utilisée dans les bouillies et/ou dans des jus, tandis que les feuilles de baobab sont utilisées dans la préparation des sauces.

La plupart des consommateurs interrogés utilise les feuilles et les fruits du tamarinier dans la préparation des jus et/ou pour acidifier des repas. Des produits de substitution pour tous les produits du baobab et du tamarinier ont été révélés dans la présente étude et confirmés par la littérature. Les principaux problèmes mentionnés par les consommateurs sont la saisonnalité de l'approvisionnement, les fluctuations de prix et la qualité fiable des produits.

Au total, les six différents produits du baobab et du tamarinier traités dans cette étude seront commercialisés au Mali et au Bénin. Basé sur les cartes du marché, établies pour ces produits, trois chaînes de commercialisation différentes ont été identifiées: (i) la chaîne de commercialisation des feuilles fraîches du baobab et des feuilles du tamarinier, caractérisée par son importance locale et possédant un potentiel national; (ii) la chaîne de commercialisation des feuilles sèches du baobab et de la poudre des feuilles du baobab, caractérisée par son importance nationale ayant un potentiel régional; et (iii) la chaîne de commercialisation des fruits du baobab et du tamarinier, caractérisée par son importance nationale et régionale ayant un potentiel international.

La présente étude est la première qui a enregistré les quantités achetées et vendues ainsi que les prix d'achat et de vente des différents acteurs impliqués dans la commercialisation des produits du baobab et du tamarinier au Mali et au Bénin. Basé sur ces quantités et ces prix, la poudre des fruits du baobab est commercialisée en plus grandes quantités au Bénin qu'au Mali, alors que la poudre des feuilles du baobab et les fruits du tamarinier sont commercialisés en quantités plus importantes au Mali qu'au Bénin. Les prix de la poudre des fruits du baobab et de la poudre des feuilles du baobab sont moins élevés au Bénin qu'au Mali, tandis que les fruits du tamarinier sont moins chers au Mali par rapport au Bénin. En outre, la commercialisation des produits du baobab et du tamarinier crée des opportunités d'emploi. En plus, nous avons calculé les valeurs ajoutées pour les produits du baobab et du tamarinier et nous avons montré que les transformateurs et les producteurs ont tendance à avoir les plus hautes valeurs ajoutées. Cette tendance est plus prononcée au Mali qu'au Bénin. Comme la valeur ajoutée ne prend aucuns coûts en compte, il est impossible de prouver l'acteur qui a les marges bénéficiaires les plus élevées.

La récolte des fruits du baobab et du tamarinier et des feuilles du baobab est très saisonnière. Ceci se reflète également dans la commercialisation des produits du baobab et du tamarinier qui a lieu principalement pendant la saison sèche au Bénin. Au Mali, la commercialisation des produits du baobab et du tamarinier est identifiée comme étant moins saisonnière. Cependant aucun stockage saisonnier n'a été mis en évidence au Mali et au Bénin ceci est du au manque d'infrastructures de stockage, au manque d'espace et de moyens financiers. La plupart des acteurs interrogés achète généralement une certaine quantité de produits, qui est stockée jusqu'à ce qu'elle soit vendue, après quoi ils renouvèlent leur stock. Par conséquent, la durée de stockage observée est très variable. Dans la présente étude, respectivement au Bénin et au Mali, les produits secs du baobab et du tamarinier sont principalement stockés dans des sacs de riz recyclés qui sont gardés dans la maison ou dans un entrepôt/grenier. Néanmoins l'humidité et l'assaut d' insectes, de souris et de champignons sont signalés comme principaux problèmes pendant le stockage, les informateurs considèrent les conditions générales de stockage comme étant correctes

Aucuns produits du baobab et du tamarinier ont été observés comme étant triés ou standardisés. L'inspection directe est la seule méthode utilisée pour évaluer la qualité. En outre, on remarque que les différents acteurs utilisent différents critères de qualité. Tous les acteurs de la chaîne au Mali et au Bénin prêtent attention aux techniques de transformation et de stockage pour les produits du baobab et du tamarinier. Ils s'attendent à un produit bien séché ou finement écrasé sans impuretés et qui n'a pas été exposé à l'humidité. En plus, la couleur et le goût sont d'importants paramètres de qualité au Mali, alors que le goût est seulement un critère au Bénin pour juger la qualité des fruits du baobab et du tamarinier. La maturité, la fraîcheur et la taille, ainsi que l'absence d'insectes ou de lésions d'insectes sont des critères de qualité importants utilisés pour évaluer la qualité des fruits et des feuilles du tamarinier au Mali. Les mêmes critères sont utilisés au Bénin pour apprécier la qualité des feuilles fraîches du baobab.

Le manque d'information du marché est reconnu par tous les acteurs de la chaîne comme une contrainte majeure dans la commercialisation des produits du baobab et du tamarinier au Mali et au Bénin. L'information fait défaut particulièrement au niveau des techniques de récolte et de transformation, du prix, de la qualité et de la demande. Les acteurs au Mali ont particulièrement besoin de plus d'informations sur la demande et ils ont déclaré ne pas être satisfaits de l'accès à l'information.

Contrairement, aux acteurs interrogés au Bénin qui ont essentiellement besoin d'informations sur la qualité et disent être plutôt satisfaits de la propagation de l'information.

Le développement des chaînes locales devraient établir des liens et renforcer la confiance entre les acteurs de la chaîne de commercialisation. Les interventions recommandées sont formulées dans de nombreux domaines: (i) la domestication et la commercialisation parallèle du baobab et du tamarinier; (ii) la formation des petits exploitants afin d'améliorer leur production et leurs compétences en gestion, (iii) l'appui aux petits exploitants de s'associer, de collaborer et de coordonner afin de réaliser des économies d'échelle dans leurs transactions avec les acheteurs; (iv) l'accès pour tous les acteurs de la chaîne à la propagation de l'information et d'intelligence du marché; (v) permettre aux acteurs de la chaîne de mieux comprendre et d'améliorer les normes des produits, des processus ou de la livraison exigées par les acheteurs, et (vi) l'amélioration des institutions du marché. Une fois les principales limites nationales appliquées, la commercialisation des produits du baobab et du tamarinier au niveau régional et international devrait être développée et étendue.

En conclusion, la plupart des aspects des chaînes de commercialisation des produits du baobab et du tamarinier au Mali et au Bénin, étudiés dans la présente recherche, n'ont – selon les connaissances de l'auteur – pas encore été examinés et publiés ailleurs. Par conséquent, cette recherche devrait être considérée comme une étude de cas pilote à obtenir un aperçu de la structure et du fonctionnement des marchés des produits du baobab et du tamarinier.

Samenvatting

De wereldwijde voedselzekerheid en economische groei hangen af van een afnemend aantal plantensoorten. Dit brengt, voornamelijk op het platteland, de toekomstige voedselvoorziening en inkomenszekerheid in gevaar. Recentelijk is er een toenemende interesse voor weinig gekende plantaardige nutssoorten omdat deze het mogelijk maken de bestaanszekerheid van de arme plattelandsbevolking te verbeteren door inkomsten te genereren, voedselzekerheid te ondersteunen en voeding te verbeteren.

Zowel Mali en Benin worden gekenmerkt door een hoge graad van armoede op het platteland, zwakke basisgezondheidszorg, problematische en instabiele voedselzekerheid, en niet-duurzaam gebruik van natuurlijke hulpbronnen. Bovendien blijft de plattelands- en stedelijke bevolking erg afhankelijk van de diverse goederen en diensten geleverd door inheemse bomen en houtige gewassen. Elke poging om duurzame oplossingen te vinden voor de genoemde problemen voor Mali en Benin moet rekening houden met de lokaal gekende, gebruikte en beschikbare natuurlijke hulpbronnen.

In West-Afrika vormen baobab (*Adansonia digitata* L.) en tamarinde (*Tamarindus indica* L.) een essentieel onderdeel van de traditionele landbouwsystemen of agroforestry parklandschappen en beide soorten werden door de lokale bevolking geïdentificeerd als prioritaire soorten om te domesticeren. Ondanks het grote agronomische, ecologische, nutritionele, culturele en economische belang van baobab en tamarinde producten, is zeer weinig informatie beschikbaar over de basis marktwerking en -structuren, zoals de betrokken actoren, de handelskanalen en/of manieren om toegevoegde waarde in de keten te genereren. Het huidige doctoraatsproefschrift is dan ook de eerste studie die deze informatiekloof probeert te dichten.

De algemene doelstelling van het hier voorgestelde onderzoek is, inzicht krijgen in de structuur en de werking van de markten van baobab en tamarinde producten in Mali en Benin. Om dit doel te bereiken, werden de volgende specifieke onderzoeksdoelstellingen geformuleerd: (i) alle actoren identificeren die in Mali en Benin betrokken zijn bij de markt(en) van baobab en tamarinde producten, en hun kenmerken, activiteiten en relaties beschrijven, (ii) de markt(en) van baobab en tamarinde producten in kaart brengen in Mali en Benin, (iii) de marktketen van baobab en

tamarinde producten analyseren in Mali en Benin, en (iv) mogelijke scenario's formuleren hoe baobab en tamarinde producten meer waarde kunnen krijgen in Mali en Benin, en hoe hun marktketens beter kunnen georganiseerd worden.

Om een antwoord te kunnen formuleren op de doelstellingen van de huidige studie, is een grondige analyse van de marktketen van baobab en tamarinde producten nodig. Tijdens het veldonderzoek werden in totaal 507 actoren in de marktketen van baobab en tamarinde producten geïnterviewd in Mali tussen juli en oktober 2007, terwijl we in Benin 221 informanten geïnterviewd hebben tijdens de periode januari - april 2010.

Verzamelaars van baobab en tamarinde producten worden gecategoriseerd als kleine boeren. Na de oogst verwerken ze verse baobab bladeren tot droge bladeren en/of bladpoeder, worden baobab vruchten verwerkt tot vruchtpoeder, tamarinde bladeren gedroogd, en tamarinde vruchten ontdaan van hun harde schil. In de voorliggende studie komt het gedeelte van het beschikbaar inkomen, verkregen via de verkoop van baobab en tamarinde producten, op ongeveer 4 % voor de armste en 5 % voot de rijkere ondervraagde kleine boeren in Mali, terwijl in Benin een bijdrage van om en bij de 11 % voor de armste groep kleine boeren werd gevonden. Deze cijfers tonen aan dat baobab en tamarinde producten tot de zogenaamde '*gap-filling*' inkomenscategorie behoren. De meerderheid van de ondervraagde verzamelaars in Mali en Benin blijkt hun baobab en tamarinde producten te verkopen op de boerderij. Baobab en tamarinde vruchten en bladeren worden geoogst met behulp van traditionele oogsttechnieken, die alleen handenarbeid en goedkoop gereedschap vereisen. De oogst van baobab bladeren heeft in vele gevallen een negatieve invloed op de vruchtontwikkeling. Dit toont aan dat duurzame oogsttechnieken moeten ontwikkeld en voorgesteld worden om plantensoorten te behouden en overexploitatie te vermijden. Tot slot vermeldden de ondervraagde verzamelaars in Mali en Benin gevaarlijke oogsttechnieken, seizoensgebondenheid en beperkte beschikbaarheid van baobab en tamarinde producten, tijdrovende verwerkingsmethoden, productkwaliteit en een gebrek aan marktinformatie als hun belangrijkste problemen.

Handelaars in baobab en tamarinde producten zijn voornamelijk vrouwen. Zij hebben diverse en uiteenlopende functies, wat wijst op een gebrek aan functionele specialisatie. Bevindingen in de onderhavige studie toonden het bestaan van drie mogelijke prijszettingsprocessen aan: (i) eerlijke onderhandeling, komt meestal voor wanneer het product op de markt wordt verkocht; (ii) handelaars hebben meer onderhandelingskracht, komt vooral voor wanneer het product op de boerderij wordt verkocht; en (iii) verzamelende producenten in Benin hebben meer invloed op prijsvorming dan handelaars. Het laatste geval toont aan dat collectieve actie een gunstig effect heeft op de onderhandelingsmacht van kleine boeren. Verder heeft de studie verschillende handelscentra geïdentificeerd voor de handel in baobab bladpoeder, baobab vruchtpoeder en tamarinde vruchten in Mali en Benin. De ondervraagde handelaars meldden als belangrijke problemen: variabele productkwaliteit, beperkte opslagruimte, transportmoeilijkheden als gevolg van slechte wegen, gebrek aan marktinformatie en geen toegang tot formele financiële diensten.

Baobab en tamarinde vruchten worden in Benin verwerkt tot vruchtensap, terwijl ze in Mali gebruikt worden in de bereiding van vruchtensap, siroop, confituur en instant poeder. Daarnaast wordt baobab vruchtpoeder in Mali gemengd met gierstbloem om een crème te bereiden (lokaal gekend als *dégué*). Verwerkingseenheden zijn over het algemeen geen eenmanszaken en de (familiale) verwerkingsbedrijven zijn betrokken bij de verwerking van een hele reeks verschillende producten. Niettegenstaande de handmatige verwerkingstechnieken en de eenvoud van de gebruikte apparatuur werd 63 en 49 % van de verwerkingseenheden, respectievelijk in Mali en Benin, efficiënt bevonden door middel van een *data envelopment* analyse. Dus, onder de gegeven omstandigheden in Mali en Benin blijken verwerkingsbedrijven efficiënt te werken. De grootste kost voor verwerkers in beide landen is de kost van het verpakkingsmateriaal. Daarnaast zijn de voornaamste beperkingen van ondervraagde verwerkingsbedrijven in Mali en Benin ongeschikt en duur verpakkingsmateriaal, beperkte beschikbaarheid van adequate verwerkingsapparatuur, slecht transport als gevolg van een slechte wegeninfrastructuur, tekort aan financiële middelen en beperkte toegang tot marktinformatie.

Zowel landelijke als stedelijke consumenten kopen en gebruiken regelmatig baobab en tamarinde producten. Baobab vruchtpoeder wordt gebruikt in de bereiding van pap en/of sap, terwijl baobab bladeren gebruikt worden in de bereiding van sauzen. De meerderheid van de ondervraagde consumenten gebruikt tamarinde bladeren en vruchten in de bereiding van sappen en/of om maaltijden een zure toets te geven. Substitutieproducten voor alle baobab en tamarinde producten werden in de voorliggende studie gerapporteerd en bevestigd door de literatuur. De voornaamste

problemen vermeld door consumenten zijn seizoensgebondenheid van het aanbod, prijsschommelingen en onbetrouwbare productkwaliteit.

In totaal werden zes verschillende baobab en tamarinde producten in deze studie vermeld als zijnde verhandeld in Mali en Benin. Gebaseerd op de marktketens die in kaart gebracht werden voor deze producten, kunnen drie verschillende ketens onderscheiden worden: (i) de marktketen van verse baobab en tamarinde bladeren, gekenmerkt door hun lokaal belang en nationaal potentieel; (ii) de marktketen van droge baobab bladeren en baobab bladpoeder, gekarakteriseerd door hun belang op nationaal niveau en hun regionale potentieel; en (iii) de marktketen van baobab en tamarinde vruchten, gekenmerkt door hun nationaal en regionaal belang en internationaal potentieel.

De voorliggende studie is de eerste die gekochte en verkochte hoeveelheden, en inkoop- en verkoopprijzen geregistreerd heeft voor de diverse actoren betrokken in de marktketen van baobab en tamarinde producten in Mali en Benin. Gebaseerd op deze hoeveelheden en prijzen kan afgeleid worden dat baobab vruchtpoeder in grotere hoeveelheden verhandeld wordt in Benin dan in Mali, terwijl baobab bladpoeder en tamarinde vruchten in grotere hoeveelheden verkocht worden in Mali dan in Benin. Prijzen zijn lager in Benin dan in Mali voor baobab vruchtpoeder en bladpoeder, terwijl tamarinde vruchten goedkoper zijn in Mali in vergelijking met Benin. Bovendien geeft de commercialisering van baobab en tamarinde producten de mogelijkheid om veel werkgelegenheid te creëren. Daarnaast berekenden we de toegevoegde waarde van baobab en tamarinde producten en toonde aan dat verwerkers en verzamelaars de hoogst toegevoegde waarden voor hun rekening nemen. Deze trend blijkt meer uitgesproken te zijn in Mali dan in Benin. Gezien de toegevoegde waarde echter geen rekening houdt met eventuele kosten, is het onmogelijk om uitspraken te doen over welke actor de hoogste marges heeft.

De oogst van baobab en tamarinde vruchten en baobab bladeren is sterk seizoensgebonden. Dit weerspiegelt zich verder ook in de commercialisering van baobab en tamarinde producten die vooral tijdens het droge seizoen plaats vindt in Benin. In Mali is de waargenomen handel in baobab en tamarinde producten minder seizoensgebonden. Er is echter geen seizoensgebonden opslag aangetoond in Mali noch in Benin wat te wijten is aan een gebrek aan opslaginfrastructuur, ruimte en financiële middelen. Het merendeel van de ondervraagde actoren in de keten koopt een bepaalde hoeveelheid van een product aan, die dan opgeslagen

wordt totdat alles verkocht is, waarna de voorraad opnieuw aangevuld wordt. Als gevolg hiervan is de waargenomen opslagduur zeer variabel. Gedroogde baobab en tamarinde producten worden hoofdzakelijk bewaard in gerecycleerd rijstzakken die opgeslagen worden in het huis of in een magazijn/graanschuur, in respectievelijk Benin en Mali. Hoewel vochtigheid en schade door insecten, muizen en schimmels gemeld werden als de belangrijkste problemen tijdens de opslag, scoorden de informanten de globale bewaarcondities als goed.

Geen enkel baobab en tamarinde product wordt gesorteerd of gestandaardiseerd. Directe inspectie is de enige gerapporteerde methode om productkwaliteit te beoordelen. Bovendien werd waargenomen dat verschillende actoren verschillende kwaliteitscriteria gebruiken. Alle actoren in Mali en Benin hechten groot belang aan de verwerkingstechnieken en opslagmethoden van baobab en tamarinde producten, en verwachten een goed gedroogd of fijn gemalen product zonder onzuiverheden dat niet werd blootgesteld aan vochtigheid. Daarenboven vormen kleur en smaak belangrijke kwaliteitsparameters in Mali, terwijl enkel smaak een criterium is in Benin voor de kwaliteitscontrole van baobab en tamarinde vruchten. Rijpheid, versheid en grootte, samen met de afwezigheid van insecten of beschadigingen zijn belangrijke kwaliteitscriteria bij de beoordeling van tamarinde vruchten en bladeren in Mali. Dezelfde criteria worden gebruikt in Benin om de kwaliteit van verse baobab bladeren evalueren.

Een gebrek aan marktinformatie wordt erkend door alle actoren als een belangrijke beperking in de commercialisering van baobab en tamarinde producten in Mali en Benin. Informatie ontbreekt in het bijzonder over oogstmethoden, verwerkingstechnieken, prijs, kwaliteit en vraag. Actoren in Mali hebben voornamelijk nood aan meer informatie over de vraag naar baobab en tamarinde producten en vermelden dat ze niet tevreden te zijn met de toegang tot marktinformatie. Daarentegen hebben de ondervraagde actoren in Benin nood aan informatie over kwaliteit en zeggen ze tevreden te zijn met de algemene informatievoorziening.

Lokale ketenontwikkeling moet relaties uitbouwen en vertrouwen versterken tussen de verschillende actoren in de marktketen. Aanbevolen interventies kunnen geformuleerd worden op verscheidene vlakken: (i) parallelle domesticatie en commercialisering van baobab en tamarinde; (ii) opleiding van kleine boeren om hun productieniveau en managementvaardigheden te verbeteren; (iii) ondersteuning van kleine boeren om zich te associren, samen te werken en te coördineren met het oog op het behalen van schaalvoordelen in hun transacties met kopers; (iv) informatiekanalen en marketinzichten toegankelijk maken voor alle actoren; (v) mogelijkheid bieden aan actoren om inzicht te krijgen in product, proces of leveringsnormen van kopers en hieraan tegemoet te komen; en (vi) verbetering van marktinstellingen. Zodra de grote beperkingen op nationaal vlak zijn aangepakt, kan de commercialisering van baobab en tamarinde producten op regionaal en internationaal niveau worden ontwikkeld en uitgebreid.

Tot slot kan vermeld worden dat de meeste aspecten, bestudeerd in het voorliggende onderzoek, van de marktketens van baobab en tamarinde producten in Mali en Benin – volgens de auteur – nog niet eerder onderzocht of elders gepubliceerd werden. Daarom moet dit onderzoek beschouwd worden als een pilootstudie die als doel heeft inzicht te verwerven in de marktstructuur en -werking van de markten van baobab en tamarinde producten.

1
Introduction

The present chapter presents the context, state of the art, justification and problem statement of this PhD research, together with the objectives and outline.

1.1 Context

Today, only 30 plant species are used to meet 95 % of the world's food energy needs, whereas more than half of the needs for energy and proteins are being met by only three crops, *i.e.* maize, wheat and rice (Prescott-Allen & Prescott-Allen, 1990; FAO, 1997, 2010e). These crops are widely and intensively cultivated and have been selected from a large agrobiodiversity basket containing more than 7000 food species, which is approximately one tenth of the estimated number of edible species present in nature (Prescott-Allen & Prescott-Allen, 1990; FAO, 1997; IPGRI, 2002; Williams & Haq, 2002; FAO, 2010e). In contrast, ethnobotanical surveys, particularly in the marginal environments of developing agricultural economies, have evidenced that many lesser known or underutilised species continue to be cultivated or harvested (FAO, 1996; Gebauer *et al.*, 2002a; IPGRI, 2002) (see Box 1.1 for a definition of underutilised species). Many authors (FAO, 1996; Padulosi *et al.*, 1999; Lockett & Grivetti, 2000; Gebauer *et al.*, 2002a; IPGRI, 2002; Padulosi *et al.*, 2002; Williams & Haq, 2002; Hughes & Haq, 2003; Giuliani & Padulosi, 2005; Giuliani *et al.*, 2007; Giuliani, 2007; Akinnifesi *et al.*, 2005; Kazembe-Phiri, 2005; Gruère *et al.*, 2006; Dawson *et al.*, 2007; Nevenimo *et al.*, 2007; Will, 2008) recognised that embedding these underutilised species into traditional household systems holds significant potential for:

- improving food security and achieving more balanced nutrition for the rural and urban poor (*i.e.* social benefits);
- conserving biodiversity and stabilising agro-ecosystems (*i.e.* environmental benefits); as well as
- generating income for the rural poor and creating employment along the value chain (*i.e.* economic benefits).

Agricultural biodiversity and its potential as a driver of economic growth, food security and natural resource conservation has gathered an increasing amount of interest within the scientific community (Neumann & Hirsch, 2000; Arnold & Ruiz Pérez, 2001; Marshall *et al.*, 2003; Belcher, 2005; Belcher *et al.*, 2005; Belcher & Schreckenberg, 2007) since the Convention

Box 1.1: Definition of underutilised species

Underutilised species are defined by the Strategic Framework of the International Centre of Underutilised Crops (ICUC) as those species with under-exploited potential for contributing to food security, health (nutritional/medicinal), income generation, and environmental services (Jaenicke & Höschle-Zeledon, 2006). The ICUC and the Global Forum for Underutilised Species (GFU) identified some common features of underutilised species (Jaenicke & Höschle-Zeledon, 2006; GFU, 2011), namely species that:

- represent an enormous wealth of agrobiodiversity and have great potential for contributing to improved incomes, food security and nutrition, and for combating the 'hidden hunger' caused by micronutrient (vitamin and mineral) deficiencies;
- are strongly linked to the cultural heritage of their places of origin;
- are mainly local and traditional crops (with their ecotypes and landraces) or wild species whose distribution, biology, cultivation and uses are poorly documented;
- tend to be adapted to specific agro-ecological niches and marginal land;
- have weak or no formal seed supply systems;
- are recognized to have traditional uses in localized areas;
- are collected from the wild or produced in traditional production systems with little or no external inputs;
- receive little attention from research, extension services, farmers, policy and decision makers, donors, technology providers and consumers; and
- may be highly nutritious and/or have medicinal properties or other multiple uses.

Gruère *et al.* (2006) define underutilised species as any agricultural or non-timber forest species, collected, managed, or cultivated, that have simultaneously the following three characteristics: (i) they are locally abundant (especially in developing countries) but globally rare; (ii) scientific information and knowledge about them are scant; and (iii) their current use is limited relative to their economic potential.

on Biological Diversity (Rio, 1992) and the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (FAO, 1996; Padulosi *et al.*, 2002; Belcher & Schreckenberg, 2007; Giuliani, 2007; Irungu, 2007; FAO, 2010e). The Food and Agriculture Organisation of the United Nations (FAO) was one of the first agencies to promote non-timber forest products (NTFPs) through its programme on non-wood forest products (NWFPs) (FAO, 1999b) (see Box 1.2 for a definition of NTFPs). In addition, the Consultative Group on International Agricultural Research (CGIAR) recently expanded its research agenda to include also underutilised species (CGIAR Science Council, 2005). Bioversity International, for example, recognises the need of urgent action to promote a more diverse portfolio of species to be used in agriculture (IPGRI, 2002). Over the past years, many other international agencies such as the World Bank, International Development Research Centre (IDRC) and International Union for the Conservation of Nature (IUCN), among others, have incorporated the concepts of underutilised species and/or NTFPs into their research and development programmes (Ahenkan & Boon, 2011).

Within the context of emerging new international commitments to address rural poverty, such as the Millennium Development Goals (MDGs), commercialisation of NTFPs has been promoted by researchers, conservation and development organisations, and, more recently, by governments, as a means to achieve rural livelihood improvement in an environmentally sound way (FAO, 1995a; Pimentel *et al.*, 1997; Wollenberg & Ingles, 1998; Leakey, 1999; Neumann & Hirsch, 2000; Ros-Tonen, 2000; Arnold & Ruiz Pérez, 2001; Marshall *et al.*, 2003; Angelsen & Wunder, 2003; Garrity, 2004; Sunderland & Ndoye, 2004; Belcher, 2005; Belcher *et al.*, 2005; Kruijssen *et al.*, 2009). In sub-Saharan Africa (SSA), too, there is an increased emphasis on the need to integrate local development concerns, including the extraction of NTFPs, into conservation projects (Neumann, 1996). Global harvest of NTFPs is economically very significant. An estimated 80 % of the population of the developing world uses NTFPs for its daily needs (Bennett, 2002), and the value of global trade in NTFPs has been estimated at 18.5 billion $ US (FAO, 2011b).

Research on NTFPs has mainly focused on the humid tropics (Schreckenberg, 1999). However, it is recognised that not all NTFPs originate from pure forests (see definition in Box 1.2), but also from the

Box 1.2: Definition of non-timber forest products

The term non-timber forest products (NTFPs), encompassing all biological materials other than timber extracted from forests for human use, was first coined by de Beer & McDermott (1989). With 'forest' the latter authors referred to a natural ecosystem in which trees are a significant component. However, forest products are derived not only from trees, but from all plants, fungi and animals (including fish) for which the forest ecosystem provides a habitat (Ros-Tonen, 1999; Neumann & Hirsch, 2000; Belcher, 2003; Ahenkan & Boon, 2011).

Literally, NTFPs include all products that are derived from forests with the exception of timber. In practice, and due to the fact that NTFPs are mostly defined by what they are not (Belcher, 2003), various products and production environments are included or excluded depending on the objectives of the author (Belcher, 2005; Ahenkan & Boon, 2011). Due to an overabundance of terminologies which has been used interchangeably by various authors and organisations, a lot of confusion is associated with NTFPs semantics and terminologies (Ros-Tonen, 2000; Belcher, 2003; Vantomme, 2003a; Quang & Anh, 2006; Rajchal, 2006; Belcher & Schreckenberg, 2007; Ahenkan & Boon, 2011). NTFPs have proved to be difficult to clearly define because of the blurred boundaries between timber and non-timber products and the underlying difficulty in defining a forest (Ahenkan & Boon, 2011). Consequently, the meaning of NTFPs has generated a lot of controversy and there is no universally accepted operational definition of NTFPs (Belcher, 2003; Ahenkan & Boon, 2011). However, there are five main elements to the interpretation of the NTFP concept that seem to matter most to users, namely the (i) nature of the product/service, (ii) source of the product/source, (iii) production system, (iv) scale of production, and (v) ownership and distribution of benefits (Rajchal, 2006).

The Food and Agriculture Organisation of the United Nations (FAO) has been a strong proponent of a clear and consistent definition and elected to use the term non-wood forest products (NWFPs) (Belcher, 2003). NWFPs are defined to consist of goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests (FAO, 1999b).

many other environments used by people, including intensively managed fields, fallows and savannah vegetations (Lintu, 1995; Schreckenberg, 1999, 2000). The majority of species yielding important NTFPs in West Africa are located in fields and fallows, and form an integral and often characteristic part of local and regional landscapes, also known as agroforestry parklands (Schreckenberg, 1999, 2000) (see Box 1.3 for a definition of agroforestry parklands). Therefore, an alternative term has been suggested for NTFPs from managed agroforestry systems, such as parklands, namely agroforestry tree products (AFTPs) (Simons & Leakey, 2004) (see Box 1.3). Leakey & Simons (1998) and Leakey *et al.* (2005) referred to agroforestry trees as 'Cinderella' tree species since their potential is yet to be unveiled. These traditionally important indigenous species have long been overlooked by science. However, if carefully promoted and marketed, they may alleviate rural poverty and increase the sustainability of agroecosystems (Simons, 1996; Leakey & Simons, 1998; Leakey *et al.*, 2005). Up till now, farmers typically do not plant these indigenous trees but protect specimens of interest that grow naturally for their own use (Jama *et al.*, 2008).

Many rural households rely on indigenous trees as sources of cash and subsistence, but until recently there has been little effort to cultivate, improve or add value to these species (Akinnifesi *et al.*, 2006). Since 1994, the International Centre for Research in Agroforestry (ICRAF, now the World Agroforestry Centre) initiated a worldwide programme to domesticate the species identified by local people as their priority for cultivation in agroforestry systems (Leakey & Simons, 1998; Leakey, 1999; Leakey *et al.*, 2005; Tchoundjeu *et al.*, 2010). The priority species for the semi-arid lowlands of West Africa are (i) *Adansonia digitata* or baobab tree, (ii) *Vitellaria paradoxa* or shea tree (*karité*), (iii) *Parkia biglobosa* or African locust bean tree (*néré*), (iv) *Tamarindus indica* or tamarind tree, and (v) *Zizyphus mauritiana* or ber tree (*jujubier*) (Franzel *et al.*, 1996). Tree domestication is conceived as a farmer-driven and market-led process (Simons & Leakey, 2004; Leakey *et al.*, 2005). It aims to significantly increase and stabilise the income, food and health situation of rural households and their extended families through improvement of AFTPs (Gebauer *et al.*, 2002b; Garrity, 2004; Simons & Leakey, 2004; Leakey *et al.*, 2005; Tchoundjeu *et al.*, 2006, 2007; Kalinganire *et al.*, 2007; Nevenimo *et al.*, 2007; Tchoundjeu *et al.*, 2010). Discussion of the role of domestication cannot, however, be divorced from that of commercialisation, since without an expanded or a new market the

Box 1.3: Definition of agroforestry, agroforestry parklands and agroforestry tree products

Agroforestry is a collective term for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit, either in a spatial mixture or a temporal sequence (Leakey & Izac, 1996).

Agroforestry parklands are characterized by well-grown scattered trees on cultivated and recently fallowed land (Verheij, 2003) and are thus mixtures of trees and shrubs that farmers select for certain functions and cultivate together with staple food crops (Kalinganire *et al.*, 2007). In the Sahel, agroforestry parklands are the principal agricultural system used by subsistence farmers (Boffa, 1999; Verheij, 2003). In Mali, for example, parklands occupy approximately 90 % of the agricultural land. As agroforestry parklands are managed to fit environmental conditions and to fulfil multiple functions (Verheij, 2003; Kalinganire *et al.*, 2007; Stoate & Jarju, 2008), they vary in species composition and density within and among countries in any region due to farmers' attitudes toward trees in cultivated fields (Verheij, 2003; Kalinganire *et al.*, 2007). In West Africa, indigenous trees species such as *Vitellaria paradoxa*, *Parkia biglobosa*, *Adansonia digitata*, *Tamarindus indica*, *Borassus aethiopium*, *Faidherbia albida*, *Balanites aegyptiaca* and *Acacia* spp. have been recorded in parklands (Boffa, 1999; Verheij, 2003).

The term **agroforestry tree products** (AFTPs) has been introduced by Simons & Leakey (2004) to refer to NTFPs that are sourced from trees in farming systems, thus from trees cultivated outside forests (Leakey *et al.*, 2005; Nevenimo *et al.*, 2007). The aim of introducing this term was to avoid some of the confusion occurring in the current NTFP literature (Belcher, 2003; Leakey *et al.*, 2005) (see Box 1.2).

incentives to domesticate intensively for self-use are insufficient (Leakey & Simons, 1998; Akinnifesi *et al.*, 2006; Tchoundjeu *et al.*, 2007). Nowadays, throughout the tropics most products of indigenous trees are marketed locally on a small scale, as a means of generating cash to supplement a subsistence lifestyle (Arnold, 1995; Lamien *et al.*, 1996). However, there is great potential for indigenous fruit tree species in regional and even world markets, and it is hoped that research and development towards better understanding and utilization of these species will be stimulated in the near future (Gruère *et al.*, 2006).

Recently, several regional and international projects in West Africa have focused on biodiversity and the sustainable use of natural resources. The SSA forest genetic resources programme (SAFORGEN) of Bioversity International (formerly known as the International Plant Genetic Resources Institute (IPGRI)) aims at enabling people and institutions in SSA to maintain and make the best use of forest biodiversity by developing an effective networking platform (Bioversity International, 2011). Other examples are the EU-funded projects SAFRUIT, SUN and DADOBAT. The Sahelian fruit trees project (SAFRUIT) has as objective the contribution to increased food security and sustainable livelihood for people living in the sorghum and millet-based production systems in Burkina Faso, Mali and Niger, through facilitating access to knowledge and germplasm of underutilised fruit tree species (*A. digitata*, *P. biglobosa*, *T. indica* and *Z. mauritiana*) (SAFRUIT, 2004). The acronym of the SUN project stands for tools for management and sustainable use of natural vegetation in West Africa. This project aims at developing new, practical management tools and concrete management actions for improved sustainable use of natural vegetation by combining scientific vegetation data, remote sensing and socio-economic information with local people's knowledge and needs (SUN, 2005). At last, the DADOBAT project stands for domestication and development of baobab and tamarind and its overall objective is to develop sustainable production systems of both baobab and tamarind in the West African countries Benin, Mali and Senegal (DADOBAT, 2006). The latter project, and in particular the sixth work package dealing with the market chain of baobab and tamarind products, forms the framework of the present doctoral study (see Box 1.4 for more details about the DADOBAT project).

Box 1.4: Domestication And Development Of Baobab And Tamarind

The INCO-CT-2006-032217-DADOBAT project, or shortly DADOBAT, was funded during the 2006-2010 period by the European Commission under the Sixth Framework Programme. The acronym DADOBAT stands for Domestication And Development Of Baobab And Tamarind. Six partners were involved: (i) Laboratory of Tropical and Subtropical Agronomy and Ethnobotany, Ghent University, Belgium (coordinator); (ii) Centre for Underutilised Crops, University of Southampton, United Kingdom; (iii) Institute of Organic Farming, University of Natural Resources and Life Sciences, Austria; (iv) Laboratory of Applied Ecology, University of Abomey-Calavi, Benin; (v) Institute of Rural Economy, Mali; and (vi) Regional Centre for Studies on the Improvement of Plant Adaptation to Drought, Senegal.

The overall strategic objective of the DADOBAT project is to develop sustainable production systems for baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.) in West Africa (more specifically in Benin, Mali and Senegal) based on characterisation, conservation and use of local genetic resources (http://www.dadobat.soton.ac.uk). This is expected to have a positive impact on food security and income generation in the south countries involved in the project. Six research-oriented work packages were defined in order to meet the objective: (i) field characterisation of plant material; (ii) eco-physiological characterisation of plant material for understanding drought stress tolerance and resistance; (iii) domestication; (iv) development of improved cropping techniques; (v) characterisation of nutritional and medicinal properties of primary and secondary products; and (vi) production and marketing chain analysis.

1.2 State of the art

Up till now, many studies have been carried out on ethnobotanical knowledge and the multiple uses of baobab and tamarind in (West) Africa (Burkill, 1985; Wickens, 1982; Sidibé & Williams, 2002; Diop *et al.*, 2005; Assogbadjo, 2006; Assogbadjo *et al.*, 2006a; El-Siddig *et al.*, 2006; Wickens & Lowe, 2008; Assogbadjo *et al.*, 2008; Kumar & Bhattacharya, 2008; Assogbadjo *et al.*, 2009b; De Caluwé *et al.*, 2009a; Buchmann *et al.*, 2010; van der Stege, 2010; van der Stege *et al.*, 2011), as well as their processing (Sidibé & Williams, 2002; El-Siddig *et al.*, 2006; Chadare *et al.*, 2008; Kumar & Bhattacharya, 2008; Chadare, 2010), and biochemical properties (Ishola *et al.*, 1990; Saka & Msonthi, 1994; Yazzie *et al.*, 1994; Siddhuraju *et al.*, 1995; Nordeide *et al.*, 1996; Sidibé *et al.*, 1996; Smith *et al.*, 1996; Glew *et al.*, 1997; Igboeli *et al.*, 1997; Barminas *et al.*, 1998; Sena *et al.*, 1998; Lockett *et al.*, 2000; Sidibé & Williams, 2002; Osman, 2004; Soloviev *et al.*, 2004; Diop *et al.*, 2005; Glew *et al.*, 2005; Assogbadjo, 2006; El-Siddig *et al.*, 2006; Chadare *et al.*, 2009; De Caluwé *et al.*, 2009b,c; Chadare, 2010; De Caluwé *et al.*, 2010a,b).

In addition, several works have focused on botanical description, distribution, ecology and ecological diversity of both species in West Africa (Fenner, 1980; Wickens, 1982; Morton, 1987; Baum *et al.*, 1998; Sidibé & Williams, 2002; Assogbadjo *et al.*, 2005a; Diop *et al.*, 2005; Assogbadjo, 2006; El-Siddig *et al.*, 2006; Wickens & Lowe, 2008; Assogbadjo *et al.*, 2009b; Bourou *et al.*, 2010; Fandohan *et al.*, 2011c), whereas other authors investigated several aspects concerning their reproductive biology, such as phenology, pollination and natural regeneration (Baum, 1995a; Sidibé & Williams, 2002; Assogbadjo *et al.*, 2005a; Diop *et al.*, 2005; Assogbadjo, 2006; El-Siddig *et al.*, 2006; Diallo *et al.*, 2008), and agronomy, including germinative and vegetative propagation, productivity, management, and pests and diseases (Danthu *et al.*, 1995; Sidibé & Williams, 2002; Dhillion & Gustad, 2004; Assogbadjo *et al.*, 2005a,b; Diop *et al.*, 2005; Assogbadjo, 2006; El-Siddig *et al.*, 2006; Diallo *et al.*, 2008; Wickens & Lowe, 2008; Assogbadjo *et al.*, 2009b; Fandohan *et al.*, 2010b; Assogbadjo *et al.*, 2011; Fandohan *et al.*, 2011c).

Recently there has been a growing interest in morphological variability of baobab and tamarind trees (Sidibé & Williams, 2002; Assogbadjo *et al.*, 2005b; Assogbadjo, 2006; Assogbadjo *et al.*, 2006b; El-Siddig *et al.*, 2006; Assogbadjo *et al.*, 2009a; Cuni Sanchez *et al.*, 2010; Diallo *et al.*, 2010; Fandohan *et al.*, 2010b; Assogbadjo *et al.*, 2011; Fandohan *et al.*, 2011a; Kouyaté *et al.*, 2011) and the implications for conservation, genetic variation and selection (Sidibé & Williams, 2002; Assogbadjo, 2006; Assogbadjo *et al.*, 2006b; El-Siddig *et al.*, 2006; Diallo *et al.*, 2007, 2008; Wickens & Lowe, 2008; Assogbadjo *et al.*, 2009a,b; Kyndt *et al.*, 2009; Assogbadjo *et al.*, 2010; Fandohan *et al.*, 2010c, 2011b).

Finally, several authors (Lamien *et al.*, 1996; Ambé, 2001; Codjia *et al.*, 2001; Eyog Matig *et al.*, 2002; Sidibé & Williams, 2002; Codjia *et al.*, 2003; Assogbadjo, 2006; El-Siddig *et al.*, 2006; Chadare *et al.*, 2008; Teklehaimanot, 2008) agreed on the socio-economic importance of baobab and tamarind in West Africa and reported on the existence of domestic – and even sub-regional – markets for both species' products.

1.3 Justification and problem statement

In 2009, 1,023 million people in the world were undernourished (FAO, 2010f), particularly people living in developing countries. The proportion of undernourished people remains highest in SSA, at about 30 % (FAO, 2010f). In addition, at least two billion people, mostly in developing countries, suffer from 'hidden hunger', *i.e.* mineral and vitamin deficiencies, especially iron and vitamin A (Micronutrient Initiative, 2004, 2009). FAO (2010a,c) reported respectively that 12 % of the total population in both Mali and Benin was undernourished in the period 2005-07 with high levels of vitamin A and iron deficiency (FAO, 1999a, 2003). Indeed, in Mali and Benin, the Micronutrient Initiative (2004) reports an estimated prevalence of iron deficiency anaemia in children under five years of age of 77 and 82 %, respectively, whereas estimated percentage of children under six with sub-clinical vitamin A deficiency is 70 and 47 %, respectively.

Although general poverty rate in developing countries dropped from 46 % in 1999 to 27 % in 2005 (United Nations, 2010), SSA is still facing extreme poverty. In 2005, 51 % of the population in SSA was estimated to live on less than 1.25 $ a day (United Nations, 2010), which is considered as the international poverty line (Ravallion *et al.*, 2009). Mali and Benin are among the poorest countries in the world (UNDP, 2010c), with, in the 2005-07 period, an estimated poverty incidence at national level of 63.8 and 39.0 %, respectively (FAO, 2010b,d). Based on the human development index (HDI), Mali and Benin occupy respectively place 160 and 134 on 169 countries (UNDP, 2010c).

In general, Mali and Benin are both characterised by high rates of rural poverty, low basic health services, problematic and unstable food security, and unsustainable use of natural resources (Ministère du Développement Social de la Solidarité et des Personnes Agées & UNDP, 2005; UNDP, 2008; UNDP & Ministère du Développement Social, de la Solidarité et des Personnes Agées, 2008). Both countries are not considered to be in protracted crisis [1] according to FAO (2010f), and rural and urban people remain very dependent on the multiple goods and services supplied by indigenous trees and woody plants (FAO, 2001).

Any attempt to find sustainable solutions to the problems listed for Mali and Benin should take into account locally known, used and available natural resources (Chadare, 2010). Governments in both countries have recognised that, for poverty reduction, small-scale farmers can profit from the sustainable utilisation and valorisation of agroforestry systems (IMF, 2008a,b), thus including AFTPs. Bioversity International expects that AFTPs have the potential to play a major role in future crop development programmes and in the development of agroforestry systems in Mali and Benin (Eyog Matig *et al.*, 2002). Within the scope of the SAFORGEN programme of Bioversity International, each country selected ten agroforestry tree species as priority species to domesticate, valorise and conserve. The species were selected by local communities based on their social, cultural, nutritional and economical importance, their processing potential, their availability on the local market, their ease of access, their present use and their risks of extinction. Among the selected species are both baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.). Not only Bioversity International (Eyog Matig *et al.*, 2002) has accorded high priority to enhance research on and development of baobab and tamarind, also the International Centre for Underutilised Crops (ICUC) (Sidibé & Williams, 2002; El-Siddig *et al.*, 2006), the World Agroforestry Centre (Franzel *et al.*, 1996; Kalinganire *et al.*, 2007; Franzel *et al.*, 2008; Jama *et al.*, 2008) and the FAO (FAO, 2001) have classified baobab and tamarind among the top agroforestry tree species to be conserved and domesticated in West Africa.

Baobab and tamarind are both multi-purpose agroforestry tree species

[1] Protracted crisis situations are characterized by recurrent natural disasters and/or conflict, longevity of food crises, breakdown of livelihoods and insufficient institutional capacity to react to the crises (FAO, 2010f).

which are daily used by local populations in West Africa (Assogbadjo *et al.*, 2006a). Research in Benin has found 38 and 26 different uses for respectively baobab and tamarind products (De Caluwé *et al.*, 2009a; Fandohan *et al.*, 2010a). Throughout West Africa, baobab and tamarind products are reported to be used by local people forming a significant part of their daily diet and pharmacopoeia (Sidibé & Williams, 2002; El-Siddig *et al.*, 2006), and to generate income via local trade (Leakey & Simons, 1998; Eyog Matig *et al.*, 2002; Diop *et al.*, 2005; Teklehaimanot, 2008; Jama *et al.*, 2008; Fandohan *et al.*, 2010a). Both baobab and tamarind products are reported to be rich in carbohydrates, proteins (including essential amino acids), several minerals such as calcium and iron, and/or vitamins A and C (Sidibé & Williams, 2002; El-Siddig *et al.*, 2006). Despite their priority to research and development, and their widely accepted potentialities and importance, both species remain underutilised (Sidibé & Williams, 2002; El-Siddig *et al.*, 2006; GFU, 2011).

As mentioned before, to be successful, tree domestication has to be linked to commercialisation and market expansion (Tchoundjeu *et al.*, 2007). However, Lombard & Leakey (2010) documented that, up till now and in general, developments in agroforestry tree domestication have not been adequately linked to commercialisation processes. In addition, on the one hand, baobab and tamarind are identified by local communities in Mali and Benin as priority species for domestication (Franzel *et al.*, 1996; FAO, 2001; Eyog Matig *et al.*, 2002), and, on the other hand, according to recent information, participative domestication programmes of baobab and tamarind are getting started in West Africa (personal communication by Ann Degrande and Antoine Kalinganire, World Agroforestry Centre). Therefore, market information of baobab and tamarind products in West Africa is needed.

Notwithstanding the great agronomic, ecological, nutritional, cultural and economic importance of baobab and tamarind products in West Africa and particularly in Mali and Benin, as demonstrated above, very little information is – to the author's knowledge – available on the basic market functioning and structures, such as stakeholders involved, trade channels and/or patterns of value adding along the market chain. This information gap has also been recognised by Walter (2001) and Jaenicke (2006). Moreover, Sidibé & Williams (2002) and El-Siddig *et al.* (2006) concluded that there is a total lack of socio-economic research at all levels along the production-to-consumption chain.

The present PhD thesis thus is the first study that attempts to fill this information gap, and aims at contributing to a better knowledge of the market chain(s) of baobab and tamarind products in Mali and Benin. Therefore, market surveys have been conducted to identify prices and quantities of baobab and tamarind products in rural and urban markets in Mali and Benin. In addition, exploratory research has been performed by applying a market chain analysis to map market chain(s) of the different products, identify stakeholders, and analyse harvesting, processing, storage and trading practices. Local market surveys are necessary to identify potential markets for various products of baobab and tamarind.

As a result, the following research questions were formulated.

- Who is participating in the production-to-consumption chain(s) of baobab and tamarind products in Mali and Benin, what are their roles and which challenges do they face?
- What are the linkages and interactions between the stakeholders in the market chain(s) of the different baobab and tamarind products in Mali and Benin?
- Which quantities of baobab and tamarind products are traded in Mali and Benin, and at which prices?
- How can harvesting, processing, storage and trading practices of baobab and tamarind products in Mali and Benin be characterised, who is involved and what are their constraints?
- What are strengths, weaknesses, opportunities and threats of production-to-consumption chain(s) of baobab and tamarind products in Mali and Benin, and which are their food security, socio-economic, economic and environmental impacts?
- How can local market chain(s) of baobab and tamarind products in Mali and Benin be developed in order to better valorise the products, and which interventions can be recommended to this end?

Answers on these questions will help on the one hand to improve the organisation of the market chain(s) of baobab and tamarind products in Mali and Benin, and on the other hand to better valorise their products.

1.4 Objectives

The overall objective of the present PhD research is to obtain insight in the structure and functioning of the markets of baobab and tamarind products in Mali and Benin. To achieve this goal, the following specific research objectives are set:

1. identify all chain actors involved in the market(s) of baobab and tamarind products in Mali and Benin, and describe their characteristics, activities and linkages;
2. map the market(s) of baobab and tamarind products in Mali and Benin;
3. analyse and compare the market chain of baobab and tamarind products in Mali and Benin; and
4. formulate possible scenarios on how to add more value to baobab and tamarind products in Mali and Benin, and how to better organise their market chains.

1.5 PhD thesis outline

The present chapter, *chapter one*, presents the context of this PhD thesis and state of the art, together with its justification and problem statement, objectives and outline.

In *chapter two*, a brief literature review about the distribution, botany, uses and nutritional value of baobab and tamarind is given. Characteristics, functions and actors of food markets in sub-Saharan Africa found in literature are described, marketing of underutilised plant species is documented,and principles and methods of market chain analysis explained.

Subsequently, the methodology of the present research is given in *chapter three* by explaining the data collection, and quantitative and qualitative analyses methods used in this study. In addition, the study area is briefly presented and a comparison between Mali and Benin is given.

In *chapter four*, the results of the baobab and tamarind market chain analysis in Mali and Benin are presented. First, the roles and interests of the different market chain actors are presented. Secondly, the market maps of different baobab and tamarind products are drawn to show the linkages between chain actors involved in transferring the products from gatherer to consumer. Finally, data on quantities, prices, added value, gathering techniques, buying and selling period, storage and processing practices, uses and consumption trends, trade centres, quality criteria, information flow and problems are presented to analyse the market chains of baobab and tamarind products in Mali and Benin.

Furthermore, in *chapter five*, the results are discussed and confronted with findings of other authors. A SWOT and impact analysis of market chains of baobab and tamarind products in Mali and Benin are presented. Additionally, possible scenarios for intervention are formulated and substantiated with references on how to add more value to baobab and tamarind products and how to improve the organisation of their market chains.

Finally, *chapter six* gives the overall conclusions of this PhD research based on the objectives and formulates directions for future research.

2
Literature review

This chapter starts with a brief literature review about the distribution, botany, uses and nutritional value of baobab and tamarind. Then, characteristics, functions and actors of food markets in sub-Saharan Africa found in literature are described and marketing of underutilised plant species is documented. Finally principles and methods of market chain analysis are explained.

2.1 Baobab (*Adansonia digitata* L.)

Based on:

De Caluwé E., Halamová K. & Van Damme P. (2010). *Adansonia digitata* L. – A review of traditional uses, phytochemistry and pharmacology. *Afrika Focus*, 23:11-51.

De Caluwé E., Halamová K. & Van Damme P. (2009). *Adansonia digitata* L. – A review of traditional uses, phytochemistry and pharmacology. In Juliani H., Simon J. and Ho C., editors, *African Natural Plant Products: Discoveries and Challenges in Quality Control*, chapter 4, pp. 51–84. American Chemical Society, Washington DC, USA.

2.1.1 Distribution

The baobabs comprise eight species in the genus *Adansonia*: six endemic to Madagascar, one to north-western Australia and one originally coming from continental Africa (Wickens, 1982; Baum *et al.*, 1998). The African baobab or *Adansonia digitata* is native to (semi-)arid sub-Saharan Africa (Wickens, 1982; Sidibé & Williams, 2002; Yazzie *et al.*, 1994), and became iconic for Sudano-Sahelian savannahs (Sidibé & Williams, 2002; Diop *et al.*, 2005) and Sahelian tropical grasslands (Diop *et al.*, 2005). Its distribution area is large and this species can be found in most of sub-Sahara Africa's semi-arid and sub-humid regions as well as in western Madagascar (Diop *et al.*, 2005). However, baobab populations in West Africa are isolated from those in East Africa by a major and not fully explained gap which includes the Central African Republic (Wickens, 1982). It has been introduced to tropical and subtropical areas outside Africa and can be grown successfully there (Sidibé & Williams, 2002; Bosch *et al.*, 2004). The baobab tree is resistant to fire, termites and drought, and prefers a high watertable, but is very sensitive to waterlogging and frost (Wickens, 1982; Baum, 1995b; Gebauer *et al.*, 2002a; Sidibé & Williams, 2002; Bosch *et al.*, 2004; ICRAF, 2007a). Quite often, and especially in western Africa, its distribution is associated with human settlements (Wickens, 1982; Wickens & Lowe, 2008), but whether it is humans who favour baobab establishment or baobab trees that attract humans is a question still under debate.

2.1.2 Botanical description

Adansonia digitata L. belongs to the Malvaceae family (APG II, 2003). The African baobab tree (Figure 2.1) is deciduous and characterised by its massive size (reaching a height of 18-25 m) round canopy, stout branches and swollen trunk (that can grow up to more than 10 m in diameter) (Wickens, 1982; Baum, 1995b; Sidibé & Williams, 2002; Bosch *et al.*, 2004; ICRAF, 2007a). Although seedlings produce a strong prominent taproot, the mature tree is anchored by an extensive lateral root system which almost never penetrates beyond a depth of 2 m (Bosch *et al.*, 2004; ICRAF, 2007a). The wood is light and spongy with a high moisture content (Wickens, 1982; Burkill, 1985). Baobab bark is smooth, reddish brown to grey, soft and fibrous (Wickens, 1982; Baum, 1995b; Sidibé & Williams, 2002). Fruits are usually globose to ovoid, 12 cm or more in length, indehiscent, with a hard, woody shell and covered with yellowish-grey velvety hairs (Wickens, 1982; Baum, 1995b; Sidibé & Williams, 2002; Bosch *et al.*, 2004; ICRAF, 2007a). The shell can be up to 1 cm thick and encloses a dry mealy, whitish pulp in which dark brown, kidney-shaped seeds with a thick seedcoat are embedded (Wickens, 1982; Baum, 1995b; Sidibé & Williams, 2002; Bosch *et al.*, 2004; ICRAF, 2007a). Leaves are digitately compound with three to nine leaflets and occur alternately at the end of branches or on short spurs on the trunk (Wickens, 1982; Baum, 1995b; Sidibé & Williams, 2002; Bosch *et al.*, 2004; ICRAF, 2007a). Flowers are waxy white, pendulous and solitary with a large number of stamens on a large central staminal tube. Flowers are bat-pollinated (Wickens, 1982; Baum, 1995a,b; Sidibé & Williams, 2002; Bosch *et al.*, 2004; ICRAF, 2007a).

2.1.3 Utilisation

Baobab is a widely-used and multi-purpose species. Practically all parts of the tree can be utilised (Wickens, 1979, 1982; Wickens & Lowe, 2008). The different plant parts have numerous food uses and medicinal properties, whereas bark fibres are also used for a variety of purposes (Nicol, 1957; Watt & Breyer-Brandwijk, 1962; Wickens, 1979, 1982; Burkill, 1985;

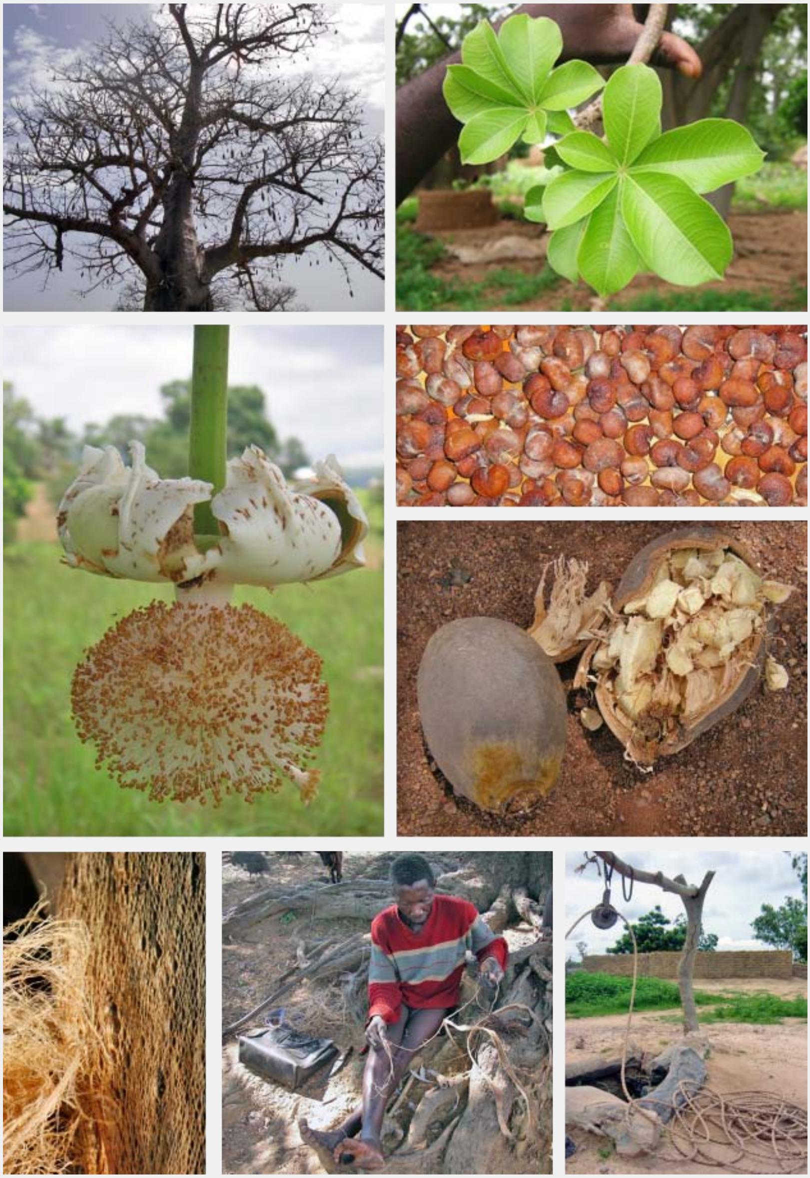


Figure 2.1: Above: baobab tree and its leaves; middle: baobab flower, seeds and fruit; and below: bark fibres of baobab twisted into ropes and use of ropes for handling water from a well

Ramadan *et al.*, 1994; Lamien *et al.*, 1996; Sidibé *et al.*, 1996; Lockett & Grivetti, 2000; Ambé, 2001; Codjia *et al.*, 2001; Shukla *et al.*, 2001; Gebauer *et al.*, 2002a; Lykke *et al.*, 2002; Sidibé & Williams, 2002; Bosch *et al.*, 2004; Gustad *et al.*, 2004; Diop *et al.*, 2005; Gruenwald & Galizia, 2005; Assogbadjo, 2006; ICRAF, 2007a; Chadare *et al.*, 2008; Wickens & Lowe, 2008; De Caluwé *et al.*, 2009a; Vogl *et al.*, 2009; Buchmann *et al.*, 2010; Fandohan *et al.*, 2010a).

Many authors recorded the daily use of baobab food products in the diet of rural communities in West Africa (Nordeide *et al.*, 1996; Lockett *et al.*, 2000; Lockett & Grivetti, 2000; Ambé, 2001; Codjia *et al.*, 2001; Walter, 2001; Sidibé & Williams, 2002; Codjia *et al.*, 2003; Diop *et al.*, 2005; Assogbadjo, 2006; Hell *et al.*, 2009; Buchmann *et al.*, 2010). In addition, several plant parts are reported to have interesting anti-oxidant (Sidibé *et al.*, 1996; Lamien-Meda *et al.*, 2008; Vertuani *et al.*, 2002; Besco *et al.*, 2007; Cisse *et al.*, 2009), anti-inflammatory (Ramadan *et al.*, 1994; Vimalanathan & Hudson, 2009), anti-pyretic (Ramadan *et al.*, 1994), antimicrobial (Anani *et al.*, 2000; Afolabi & Popoola, 2005; Masola *et al.*, 2009) and antiviral (Anani *et al.*, 2000; Hudson *et al.*, 2000; Vimalanathan & Hudson, 2009) properties. Worth mentioning is also that throughout Africa the extraordinarily shaped baobab tree is surrounded by a wealth of legends, superstitions, folk tales and anecdotal references (Watt & Breyer-Brandwijk, 1962; Wickens, 1982; Codjia *et al.*, 2001; Bosch *et al.*, 2004; Gustad *et al.*, 2004; Diop *et al.*, 2005; Assogbadjo, 2006; Wickens & Lowe, 2008; Buchmann *et al.*, 2010).

Food uses

Baobab fruit pulp is probably the most important food produced by the tree. It can be eaten fresh or dissolved in water or milk. This liquid is then used as a refreshing drink (Bosch *et al.*, 2004), a sauce for food, a fermenting agent in local beer brewing, or as a substitute for cream of tartar in baking (Wickens, 1982; Sidibé & Williams, 2002; Bosch *et al.*, 2004). When the pulp is soaked in water, it produces a milky solution, which can be consumed as a milk substitute (Becker, 1983; Ajayi *et al.*, 2003) or used to make porridge (Burkill, 1985; Obizoba & Anyika, 1994; Bosch *et al.*, 2004). Baobab fruit pulp is also important in local diets as a seasoning component and appetizer (Burkill, 1985; Ajayi *et al.*, 2003). Nowadays, the pulp has also become a popular ingredient in ice products in urban areas (Scheuring *et al.*, 1999; Sidibé *et al.*, 1998b; Bosch *et al.*, 2004; Diop *et al.*, 2005), and in different kinds of juices and jams (Figure 2.2).

Baobab seeds can be eaten fresh or roasted as snacks (Bosch *et al.*, 2004). Seeds may also be dried and ground into a flour which can either be added to soups and stews as a thickener, or roasted and ground into a paste, or boiled for a long time, and then fermented and subsequently dried for use (Sidibé & Williams, 2002). In addition, an oil can be extracted from seed kernels by boiling and distillation. Baobab seed oil is semi-fluid, golden yellow, gently scented and has a long shelf life (Figure 2.2). It is used for cooking and in the cosmetics industry (Bosch *et al.*, 2004).

The leaves of the baobab tree are an important component in the local diet of many populations in Africa, especially in the Sahel (Yazzie *et al.*, 1994). Young fresh leaves are widely used, cooked as spinach, and frequently dried or powdered and used for sauces to be added to porridges, thick cereal gruels, or boiled rice (Wickens, 1982; Burkill, 1985; Sidibé & Williams, 2002; Bosch *et al.*, 2004).

Medicinal uses

Baobab fruit pulp is used in folk medicine as an antipyretic or febrifuge to overcome fevers (Watt & Breyer-Brandwijk, 1962; Wickens, 1982; Burkill, 1985; Ramadan *et al.*, 1994; Sidibé & Williams, 2002; Bosch *et al.*, 2004), in cases of dysentery, to promote perspiration (*i.e.* a diaphoretic) and in the treatment of smallpox and measles (Wickens, 1982; Burkill, 1985; Sidibé & Williams, 2002; Bosch *et al.*, 2004). Moreover, baobab fruit pulp has been reported as anti-inflammatory, analgesic and astringent in the treatment of diarrhoea (Ramadan *et al.*, 1994).

Baobab seeds are used in cases of diarrhoea and hiccough (Sidibé & Williams, 2002). Oil extracted from the seeds is used for inflamed gums, to ease toothache (Burkill, 1985; Sidibé & Williams, 2002; Bosch *et al.*, 2004) and treat skin problems (Sidibé & Williams, 2002; Bosch *et al.*, 2004).

Baobab leaves are medicinally used as diaphoretic, expectorant, prophylactic against fever and astringent (Watt & Breyer-Brandwijk, 1962; Wickens, 1982; Burkill, 1985; Bosch *et al.*, 2004). In addition, leaves are used as anti-asthmatic, and are known to have antihistamine and anti-tension properties (Wickens, 1982; Burkill, 1985; Sidibé & Williams,

Figure 2.2: Above, from left to right: baobab nectar and two different kinds of baobab syrup; and below, from left to right: two different kinds of baobab jam and two different bottles of baobab seed oil

2002; Bosch *et al.*, 2004). Leaves are further reported to treat kidney and bladder diseases, general fatigue, diarrhoea, inflammations (Wickens, 1982; Burkill, 1985; Bosch *et al.*, 2004), insect bites and guinea worm (Wickens, 1982; Burkill, 1985).

Baobab bark is widely used in traditional medicine. The bark is mainly used as a substitute for quinine for curing fever, in particular when caused by malaria (Wickens, 1982). The activity of baobab bark as a febrifuge, however, has not (yet) been detected in experimental malaria treatments, although it is both diaphoretic and antiperiodic (Burkill, 1985). Moreover, a bark decoction is used to bathe rickety children (Wickens, 1979, 1982; Burkill, 1985; Lockett & Grivetti, 2000; Bosch *et al.*, 2004) and as a mouthwash for toothache (Wickens, 1982; Burkill, 1985; Bosch *et al.*, 2004). The bark also contains a white, semi-fluid gum that is used for cleansing sores (Wickens, 1982; Burkill, 1985). Further, Watt & Breyer-Brandwijk (1962), Wickens (1982) and Burkill (1985) reported that the bark contains an alkaloid, called ‘adansonin’, which has a strophanthus-like action. This explains the use of the bark as an antidote to strophanthus poisoning (Watt & Breyer-Brandwijk, 1962; Wickens, 1982; Burkill, 1985; Bosch *et al.*, 2004).

2.1.4 Nutritional value

Fruit pulp

The fruit pulp contains a high amount of carbohydrates, is low in proteins, and has an extremely low fat content (Nour *et al.*, 1980; Becker, 1983; Arnold *et al.*, 1985; Obizoba & Amaechi, 1993; Saka & Msonthi, 1994; Odetokun, 1996; Lockett *et al.*, 2000; Murray *et al.*, 2001; Shukla *et al.*, 2001; Osman, 2004). Moreover, the pulp is characterized by a low water content, a strong acidity and high contents of sugars (Nour *et al.*, 1980; Diop *et al.*, 2005; Cisse *et al.*, 2009), whereas it is also rich in pectin (Nour *et al.*, 1980). According to Murray *et al.* (2001), simple sugars, such as fructose, saccharose and glucose, account for about one third of total carbohydrate content in baobab pulp. This explains the noticeable sweet taste of its pulp. The pulp is also acidic, due to the presence of organic acids, *i.e.* citric, tartaric, malic, succinic and ascorbic acid (Nour *et al.*, 1980; Diop *et al.*, 2005). Baobab fruit pulp is rich in most essential amino acids and can thus be considered a good source of amino acids (Sena *et al.*, 1998). However, when compared to baobab leaves, baobab fruit pulp is inferior in terms of overall protein quality (Sena *et al.*, 1998).

Most fatty acids in the pulp do not reach detectable levels. However, Sena *et al.* (1998) point baobab fruit pulp out as a rich source of linoleic acid, which is an essential fatty acid for human nutrition.

Baobab fruit pulp is rich in minerals (Nour *et al.*, 1980; Becker, 1983; Arnold *et al.*, 1985; Obizoba & Amaechi, 1993; Prentice *et al.*, 1993; Saka & Msonthi, 1994; Smith *et al.*, 1996; Glew *et al.*, 1997; Sena *et al.*, 1998; Lockett *et al.*, 2000; Osman, 2004). In particular, it is reported to have a high calcium content (Becker, 1983; Saka & Msonthi, 1994; Sena *et al.*, 1998; Osman, 2004; Diop *et al.*, 2005), which makes baobab fruits attractive as a natural source of calcium supplementation for pregnant and lactating women, as well as for children and older people (Osman, 2004; Prentice *et al.*, 1993). Arnold *et al.* (1985) and Diop *et al.* (2005) also reported a high potassium content. Furthermore, baobab fruit pulp is rich in magnesium (Osman, 2004; Diop *et al.*, 2005), potassium (Osman, 2004) and phosphorous (Saka & Msonthi, 1994; Diop *et al.*, 2005).

Baobab fruit pulp is in particular rich in vitamin C or ascorbic acid (Carr, 1955; Nicol, 1957; Nour *et al.*, 1980; Becker, 1983; Sidibé *et al.*, 1996; Gebauer *et al.*, 2002a; Vertuani *et al.*, 2002; Diop *et al.*, 2005; Besco *et al.*, 2007; Chadare *et al.*, 2009; Cisse *et al.*, 2009). With a vitamin C content of ten times the level of vitamin C in citrus fruits (Gebauer *et al.*, 2002a), baobab fruits can be classified among the richest fruits in vitamin C, after camu-camu (*Myrciaria dubia* (H.B.K.) McVaugh), acerola (*Malpighia glabra* L.), sweet detar (*Detarium senegalense* Gmel.) and blackcurrant (*Ribes nigrum* L.) (Cisse *et al.*, 2009). Additionally, Sidibé *et al.* (1996), Sidibé *et al.* (1998a) and Scheuring *et al.* (1999) revealed a remarkable tree-to-tree variability for vitamin C content in the fruit pulp but also reported that it was quite stable from one year to the next. The exact vitamin C content of any fruit thus depends on the individual tree it comes from (Sidibé *et al.*, 1996). Noteworthy is that to assure vitamin C activity, it is important not to boil baobab fruit pulp during food preparation. It is thus recommended to add pulp to drinks while they are cold or to hot drinks after they have been removed from the heat source (Sidibé *et al.*, 1996). Next to vitamin C, baobab fruit contains detectable levels of α and β-carotene, and lutein (Sena *et al.*, 1998), whereas Becker (1983) and Arnold *et al.* (1985) reported some thiamine, riboflavin, and niacin contents.

Seeds

Baobab seeds contain relatively high amounts of protein, fat and crude fibre (Arnold *et al.*, 1985; Obizoba & Amaechi, 1993; Odetokun, 1996; Igboeli *et al.*, 1997; Proll *et al.*, 1998; Lockett *et al.*, 2000; Murray *et al.*, 2001; Shukla *et al.*, 2001; Ajayi *et al.*, 2003; Nnam & Obiakor, 2003; Osman, 2004). Baobab seeds are rich in most essential amino acids (Glew *et al.*, 1997), including lysine. Because lysine is limited in most cereal plants, it may be possible to use baobab seed proteins to improve cereal protein quality, especially in arid and semi-arid areas where the population depends heavily on sorghum for food (Proll *et al.*, 1998; Osman, 2004). Baobab seed oil contains high proportions of linoleic (Engelter & Wehmeyer, 1970; Glew *et al.*, 1997; Ezeagu *et al.*, 1998; Osman, 2004) and oleic acid (Ezeagu *et al.*, 1998; Ajayi *et al.*, 2003; Osman, 2004), as well as palmitic and α-linolenic acid (Ezeagu *et al.*, 1998; Osman, 2004). Baobab seeds are thus rich in the two essential fatty acids, namely linoleic (18:2n-6) and α-linolenic acid (18:3n-3). According to Ajayi *et al.* (2003) and Osman (2004), baobab seed oil is an excellent source of mono-and polyunsaturated fatty acids. As a result, baobab seeds have been classified as both protein- and oil-rich, whereby they thus are a rich source of energy (Igboeli *et al.*, 1997; Murray *et al.*, 2001; Osman, 2004).

The mineral content of baobab seeds has been documented by many authors (Arnold *et al.*, 1985; Obizoba & Amaechi, 1993; Glew *et al.*, 1997; Lockett *et al.*, 2000; Ajayi *et al.*, 2003; Nnam & Obiakor, 2003; Osman, 2004; Nkafamiya *et al.*, 2007). Several authors reported phosphorus (Lockett *et al.*, 2000; Diop *et al.*, 2005), calcium, magnesium (Lockett *et al.*, 2000; Osman, 2004; Diop *et al.*, 2005) and potassium (Osman, 2004; Diop *et al.*, 2005; Nkafamiya *et al.*, 2007) as the major mineral elements present in the seeds. At the same time, the seeds are a fair source of iron and zinc (Glew *et al.*, 1997; Lockett *et al.*, 2000; Osman, 2004; Nkafamiya *et al.*, 2007).

Leaves

Baobab leaves are a rich source of carbohydrate and have a low fat content (Becker, 1983; Nordeide *et al.*, 1996; Lockett *et al.*, 2000; Shukla *et al.*, 2001). Watt & Breyer-Brandwijk (1962), Gaiwe *et al.* (1989) and Diop *et al.* (2005) reported that baobab leaves contain an important amount of mucilage. In addition, Woolfe *et al.* (1977) found that the mucilage is an acidic polysaccharide with associated proteins and minerals. Baobab leaves contain fair amounts of proteins (Becker, 1983; Nordeide *et al.*, 1996; Lockett *et al.*, 2000) and significant amounts of all essential amino acids (Yazzie *et al.*, 1994; Nordeide *et al.*, 1996; Glew *et al.*, 1997; Sena *et al.*, 1998; Chadare *et al.*, 2009). Therefore, and on a qualitative and quantitative basis, baobab leaves are a good source of proteins for those populations for whom this plant material is one of the main components of their diet (Yazzie *et al.*, 1994; Nordeide *et al.*, 1996; Gebauer *et al.*, 2002a). Moreover, since part of the niacin requirement in humans can be satisfied through the conversion of tryptophan to niacin or vitamin B3 (Satyanaryana & Rao, 1983) and the fact that baobab leaves contain significant amounts of the essential amino acid tryptophan, baobab leaves may also serve as a niacin source (Yazzie *et al.*, 1994).

Many authors reported that baobab leaves are significant sources of minerals (Becker, 1983; Prentice *et al.*, 1993; Yazzie *et al.*, 1994; Nordeide *et al.*, 1996; Smith *et al.*, 1996; Glew *et al.*, 1997; Barminas *et al.*, 1998; Sena *et al.*, 1998; Lockett *et al.*, 2000; Boukari *et al.*, 2001). Several studies (Becker, 1983; Yazzie *et al.*, 1994; Glew *et al.*, 1997; Barminas *et al.*, 1998; Lockett *et al.*, 2000) recorded higher contents of iron for baobab leaves compared to numerous other wild-gathered foods. Since iron deficiency anaemia is common in regions of Africa were baobabs grow, the leaves may represent an important source of iron (Yazzie *et al.*, 1994). Moreover, baobab leaves are also a rich source of calcium (Gaiwe *et al.*, 1989; Prentice *et al.*, 1993; Yazzie *et al.*, 1994; Glew *et al.*, 1997; Barminas *et al.*, 1998; Sena *et al.*, 1998; Lockett *et al.*, 2000; Boukari *et al.*, 2001; Diop *et al.*, 2005; Maranz *et al.*, 2008; Chadare *et al.*, 2009), and contain significant amounts of zinc, phosphorous (Yazzie *et al.*, 1994; Barminas *et al.*, 1998), potassium (Yazzie *et al.*, 1994; Diop *et al.*, 2005; Maranz *et al.*, 2008) and magnesium (Yazzie *et al.*, 1994; Smith *et al.*, 1996; Glew *et al.*, 1997; Diop *et al.*, 2005; Maranz *et al.*, 2008).

Although baobab leaves contain an interesting level of vitamin A (Nordeide *et al.*, 1996; Sidibé *et al.*, 1996, 1998b), only a few authors have actually investigated their vitamin A content (Chadare *et al.*, 2009). The amount of carotenoids in baobab leaves depends on the tree and the method of leaf drying. The simple practice of drying leaves in the shade doubles the provitamin A content of the leaf powder (Sidibé *et al.*, 1996, 1998b; Scheuring *et al.*, 1999). Moreover, small leaves, which are tree-specific, further increases provitamin A by twenty percent (Sidibé *et al.*, 1996; Scheuring *et al.*, 1999). The use of leaves harvested from old or young trees does not seem to have any effect on the level of pro-vitamin A. The combination of small leaves and shade-drying allows to obtain leaves with the highest provitamin A contents (Sidibé *et al.*, 1996, 1998b; Scheuring *et al.*, 1999). In addition, Becker (1983) reported baobab leaves as sources of thiamine, riboflavin and niacin in baobab leaves. Sena *et al.* (1998) also showed a high content of lutein.

In general, baobab leaves are nutritionally superior to the fruit of the tree (Sena *et al.*, 1998). When compared to baobab fruits, leaves contain more essential amino acids, minerals and vitamin A which make them more interesting as a food source because they cover a broader range of nutritional factors. However, the ability of baobab fruits to contribute significant quantities of trace minerals and also α-linolenic acid should not be overlooked (Sena *et al.*, 1998).

2.2 Tamarind (*Tamarindus indica* L.)

Based on:

De Caluwé E., Halamová K. & Van Damme P. (2010). *Tamarindus indica* L. – A review of traditional uses, phytochemistry and pharmacology. *Afrika Focus*, 23:53-83.

De Caluwé E., Halamová K. & Van Damme P. (2009). *Tamarindus indica* L. – A review of traditional uses, phytochemistry and pharmacology. In Juliani H., Simon J. and Ho C., editors, *African Natural Plant Products: Discoveries and Challenges in Quality Control*, chapter 5, pp. 85–110. American Chemical Society, Washington DC, USA.

2.2.1 Distribution

The origin of tamarind is believed to be in western Africa, from where it spread to other parts in sub-Saharan Africa, and to Asia, and Central and South America (Burkill, 1985; Morton, 1987; Teklehaimanot, 2008). Worldwide, tamarind is now introduced, naturalized and cultivated in over 50 countries (Morton, 1987; El-Siddig *et al.*, 2006; ICRAF, 2007b; Teklehaimanot, 2008). The major production areas are in Asia, in Thailand and India in particular. In America, Mexico and Costa Rica are the biggest producers. Africa on the whole does not produce tamarind on a commercial scale, though it is widely used by local communities (El-Siddig *et al.*, 2006). The two most common varieties are a sweet and a sour variety. Sweet tamarind is produced mainly in Thailand, where it is grown on a commercial scale and is exported in fresh and processed forms (Teklehaimanot, 2008). Tamarind grows well over a wide range of soil and climatic conditions but prefers semi-arid areas and wooded grassland, and is often associated with termite hills (Burkill, 1985; El-Siddig *et al.*, 2006; ICRAF, 2007b). A long, well-marked dry season is necessary for fruiting. Thanks to an extensive root system, tamarind is resistant to drought and wind (Burkill, 1985; El-Siddig *et al.*, 2006; ICRAF, 2007b).

2.2.2 Botanical description

Tamarind or *Tamarindus indica* L. of the Fabaceae, subfamily Caesalpinioideae (Figure 2.3), is an evergreen tree up to 30 m tall with a short bole (usually 1-2 m), a dense, widely spreading and rounded crown and drooping branches. The bark is brownish-grey, rough and scaly. Tamarind produces a deep tap root and an extensive lateral root system (Morton, 1987; El-Siddig *et al.*, 1999, 2006; ICRAF, 2007b; Teklehaimanot, 2008). In addition, tamarind produces valuable timber (Burkill, 1985; Kalinganire *et al.*, 2007). Fruits are curved or straight oblong pods, measuring 5-10 x 2 cm. Fruit pods are constricted and indehiscent. The shell is light grey, or pale brown and brittle. The seeds are embedded in a firm, sticky and blackish brown pulp. Each pod contains one to twelve seeds which are flattened or rhomboid, irregularly shaped, glossy and smooth. Seeds are joined to each other with tough fibres running through the pulp. Seed coats are hard and red to purple brown in colour (Morton, 1987; El-Siddig *et al.*, 1999, 2006; ICRAF, 2007b). Leaves are alternate 7-15 cm long and pinnate with 10-20 pairs of opposite leaflets. These leaflets are narrowly oblong, 12-32 x 3-11 mm with a rounded to almost square and slightly notched apex (Morton, 1987; El-Siddig *et al.*, 1999, 2006; ICRAF, 2007b). Inflorescences are small terminal drooping racemes containing up to 18 flowers. Flowers are zygomorphic and pale yellow-, gold- or pinkish-coloured with red veins. Flowers are probably insect-pollinated (Morton, 1987; El-Siddig *et al.*, 1999, 2006; ICRAF, 2007b).

2.2.3 Utilisation

Tamarind is a multi-purpose species with numerous food and non-food uses (Morton, 1987; Lamien *et al.*, 1996; Nordeide *et al.*, 1996; El-Siddig *et al.*, 1999; Lockett & Grivetti, 2000; Lykke *et al.*, 2002; Codjia *et al.*,

Figure 2.3: Above: tamarind leaves and flowers, middle: tamarind tree, and below: tamarind fruits and seeds

2003; El-Siddig *et al.*, 2006; ICRAF, 2007b; Kumar & Bhattacharya, 2008; Vogl *et al.*, 2009; Havinga *et al.*, 2010; van der Stege *et al.*, 2011). Moreover, several plant parts are reported to have interesting anti-oxidant (Tsuda *et al.*, 1994; Komutarin *et al.*, 2004; Soong & Barlow, 2004; Sudjaroen *et al.*, 2005; Martinello *et al.*, 2006; Al-Fatimi *et al.*, 2007; Siddhuraju, 2007; Lamien-Meda *et al.*, 2008), anti-inflammatory (Rimbau *et al.*, 1999; Fook *et al.*, 2005), antibacterial (Meléndez & Capriles, 2006; Al-Fatimi *et al.*, 2007), antiviral and anti-fungal (El-Siddig *et al.*, 2006) activities. Morton (1987) reported also several superstitions around the tamarind tree.

Food uses

Fruit pulp Tamarind is highly valued for its fruits, especially the pulp which is used for a wide variety of domestic and industrial purposes (El-Siddig *et al.*, 2006). Tamarind pulp forms the raw material for manufacturing several industrial products, such as tamarind juice concentrate and pulp powder, tartaric acid and pectin (El-Siddig *et al.*, 2006). In addition, Zablocki & Pecore (1996) reported tamarind extract as a replacement for phosphoric and citric acid, and other acids that are added to soft drinks. The latter authors claim that beverages containing tamarind extract have an improved shelf life, as a result of a lower pH, and a flavour profile equivalent to or better than beverages sweetened with aspartame. Tamarind pulp can be eaten fresh as a snack and is often used to prepare juice, syrup, jam and candies (Figure 2.4) (El-Siddig *et al.*, 1999, 2006; ICRAF, 2007b). The juice is an ingredient of Worcestershire sauce (ICRAF, 2007b). Moreover, tamarind pulp is used for seasoning and as an ingredient in curries, chutneys, sauces and ice cream (El-Siddig *et al.*, 1999, 2006; ICRAF, 2007b). Although there are many uses for tamarind fruit pulp (Kalinganire *et al.*, 2007), few are known or practised in the Sahel. In the Sahel, fruit pulp is used primarily for sauces, porridge and juice. Additionally, it should be noted that local tamarind varieties have generally a strong acidic taste compared to the sweet cultivars in Thailand (Kalinganire *et al.*, 2007).

Although tamarind seeds are considered a by-product of the tamarind fruit pulp industry, the seeds have several uses (El-Siddig *et al.*, 2006; Kumar & Bhattacharya, 2008). The presence of tannins and other dyeing compounds in the testa makes the whole seed unsuitable for direct consumption (Kumar & Bhattacharya, 2008). However, the seeds become

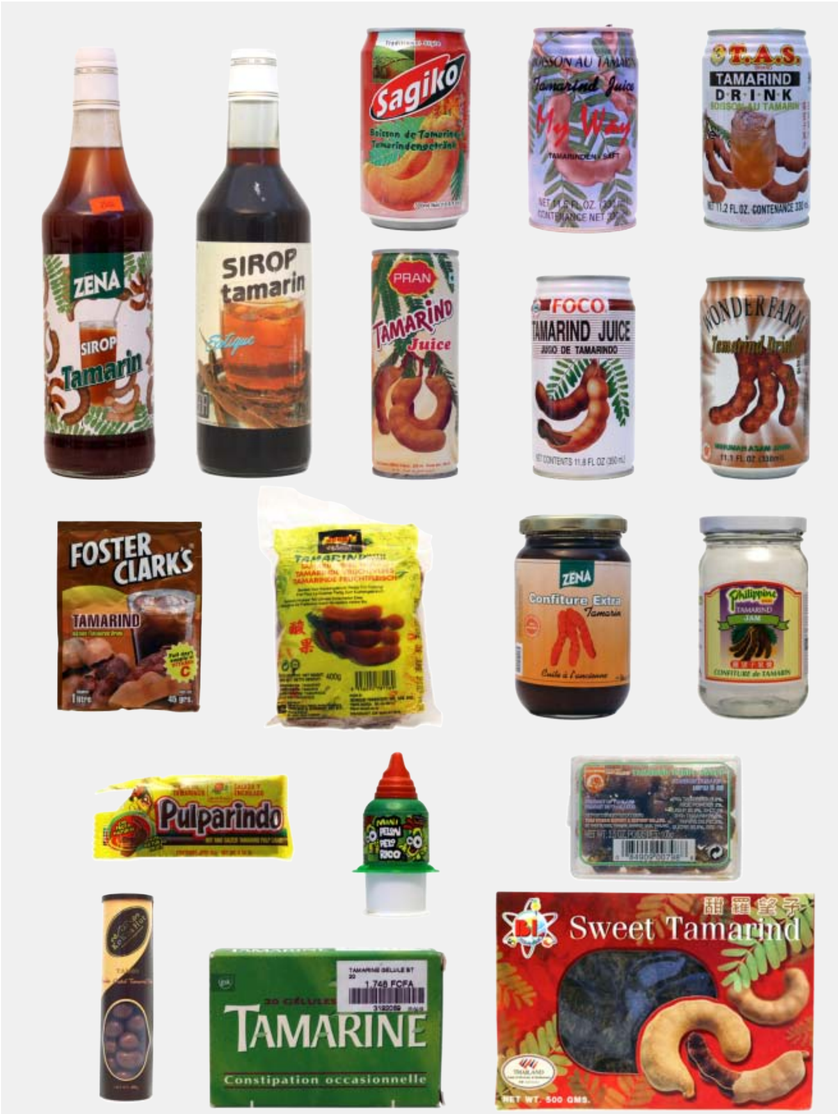


Figure 2.4: Above, from left to right: two kinds of tamarind syrup and different cans of tamarind juice; middle, from left to right: instant flavoured tamarind drink, tamarind fruit pulp to be used in different preparations, two kinds of tamarind jam and different kinds of tamarind sweets; and under, from left to right: another kind of tamarind sweets, tamarind used as laxative in medicine and sweet tamarind from Thailand

edible after soaking and boiling in water, which removes the seed coat (El-Siddig *et al.*, 2006). Locally, seeds have been reported as soup thickener (Ajayi *et al.*, 2006) and seed flour may be made into cake and bread (ICRAF, 2007b). Roasted seeds are claimed to be superior in flavour to groundnuts (ICRAF, 2007b). In India, the major industrial product of tamarind seed is the tamarind kernel powder which is an important sizing material used in the textile, paper, and jute industries (Burkill, 1985; Kumar & Bhattacharya, 2008). Tamarind seed is also a raw material used in the manufacture of polysaccharides, adhesives and tannins. This polysaccharide (pectin) with carbohydrate character and gelly-forming properties, named 'jellose' (Rao, 1948; El-Siddig *et al.*, 2006), has been recommended for use as a stabiliser in ice cream, mayonnaise and cheese, and as an ingredient or agent in a number of pharmaceutical products (Morton, 1987; El-Siddig *et al.*, 2006).

Tamarind leaves are mainly used as vegetable or souring component in soups, sauces and cereal porridge (Burkill, 1985; Lamien *et al.*, 1996; Nordeide *et al.*, 1996; Vogl *et al.*, 2009). Also, tamarind flowers can be eaten as vegetables and – together with leaves – prepared in a variety of dishes (Burkill, 1985; ICRAF, 2007b), such as curries, salads, stews and soups (Burkill, 1985; El-Siddig *et al.*, 2006).

Medicinal uses

Tamarind fruit is regarded as a digestive, carminative, laxative, expectorant and blood tonic (Burkill, 1985; Morton, 1987; El-Siddig *et al.*, 2006; Komutarin *et al.*, 2004). In addition, pulp is recognised as refrigerant for fevers and considered to be effective as a remedy for biliousness and bile disorders, and an antiscorbutic (Burkill, 1985; Morton, 1987; El-Siddig *et al.*, 1999, 2006). In traditional practice, the pulp is also applied on inflammations, used in a gargle for sore throat and, mixed with salt, as a cream for rheumatism (Burkill, 1985; Morton, 1987; El-Siddig *et al.*, 2006). It is, further, administered to alleviate sunstroke, *Datura* poisoning, and alcoholic intoxication (Morton, 1987; El-Siddig *et al.*, 2006). The laxative properties of tamarind pulp have been confirmed by modern medical science (El-Siddig *et al.*, 2006) (Figure 2.4). The pharmaceutical industry uses the pulp also as an ingredient in cardiac and blood sugar-reducing medicines (Teklehaimanot, 2008).

Powdered tamarind seeds are made into a paste to treat furuncles and prescribed for chronic diarrhoea and dysentery. Burkill (1985), Morton

(1987) and El-Siddig *et al.* (2006) also reported the use of tamarind seeds to cure eye diseases, ulcers, bladder stones and to prevent the formation of pimples. In addition, Morton (1987) recorded the use of the seed coat as astringent.

Tamarind leaves and flowers are used as poultices for swollen joints, sprains and boils. Lotions and extracts made from leaves and flowers are used to treat conjunctivitis, dysentery, jaundice, erysipelas and haemorrhoids, and as antiseptics and vermifuges (Burkill, 1985; Morton, 1987). Additionally, the leaves are used to treat throat infections, coughs, fevers, intestinal worms, urinary troubles, liver ailments, in cardiac and blood sugar reducing medicines, and applied to boils to prevent suppuration and inflammatory swellings, ulcers, eye infections, sprains, wounds and conjunctivitis (Burkill, 1985; Morton, 1987; El-Siddig *et al.*, 2006). Moreover, leaves can act as a laxative and are often used in treating liver congestion, constipation and haemorrhoids (Burkill, 1985; Morton, 1987; El-Siddig *et al.*, 2006).

The bark of the tamarind tree is regarded as an effective astringent, tonic and febrifuge (Burkill, 1985; Morton, 1987; El-Siddig *et al.*, 2006). It is also used in lotions or poultices to relieve sores, ulcers, boils and rashes (Burkill, 1985; Morton, 1987; El-Siddig *et al.*, 2006). A decoction is used in cases of gingivitis, asthma and eye inflammations (Burkill, 1985; Morton, 1987).

2.2.4 Nutritional value

Fruit pulp

Tamarind pulp is rich in carbohydrates, low in proteins and has an extremely low fat content (Ishola *et al.*, 1990; Saka & Msonthi, 1994; Nordeide *et al.*, 1996). Tamarind is reported to be the richest natural source of tartaric acid, which is found in leaves as well as in fruits (Daniel & Dudhade, 2007). Tartaric acid is synthesised in tamarind leaves in the light and subsequently translocated to flowers and fruits. It is an unusual plant acid formed from the primary carbohydrate products of photosynthesis, and once formed, it is not metabolically used by the plant (El-Siddig *et al.*, 2006). Thus, the content of tartaric acid does not decrease during fruit ripening (Daniel & Dudhade, 2007). In contrast, at the time of fruit maturing, reducing sugar levels increase and give the sour fruit a sweeter taste (El-Siddig *et al.*, 2006). As a result, tamarind is known to be simultaneously the most acidic and sweetest fruit (El-Siddig *et al.*, 2006; ICRAF, 2007b). Additionally, as mentioned earlier, sweet and sour varieties of tamarind exist. Sweet tamarind is grown on a commercial scale in Thailand and exported in fresh and processed forms (Teklehaimanot, 2008) (Figure 2.4). Although tamarind fruit pulp is relatively poor in protein, the pulp contains significant amounts of most essential amino acids (Glew *et al.*, 2005). Tamarind fruit pulp is poor in fat and contains only very little amounts of linoleic acid and even lower amounts of α-linolenic acid (Glew *et al.*, 2005).

Tamarind fruit pulp is a rich source of minerals (Ishola *et al.*, 1990; Saka & Msonthi, 1994; Nordeide *et al.*, 1996; Glew *et al.*, 2005; Almeida *et al.*, 2009). In particular, tamarind pulp is reported to be rich in magnesium, potassium (Saka & Msonthi, 1994; Glew *et al.*, 2005; Almeida *et al.*, 2009) and copper (Glew *et al.*, 2005; Almeida *et al.*, 2009). In addition, it is also a good source of calcium (Ishola *et al.*, 1990; Glew *et al.*, 2005; Almeida *et al.*, 2009), phosphorous, iron (Almeida *et al.*, 2009) and selenium (Glew *et al.*, 2005; Almeida *et al.*, 2009).

The ascorbic acid content in tamarind fruit pulp is very low (El-Siddig *et al.*, 2006). On the one hand, tamarind pulp was reported to have a high content of vitamin B (thiamine, riboflavin and niacin) as well as a small amount of carotene (El-Siddig *et al.*, 1999; ICRAF, 2007b). On the other hand, Nordeide *et al.* (1996) did not detect α or β-carotene.

Seeds

In general, tamarind seeds are rich sources of protein, lipid, crude fibre and carbohydrate (Ishola *et al.*, 1990; Siddhuraju *et al.*, 1995; Lockett *et al.*, 2000; Ajayi *et al.*, 2006). According to Ishola *et al.* (1990) and Glew *et al.* (1997), tamarind seeds are a good source of protein. Amino acid profiles of tamarind seeds, reported by Siddhuraju *et al.* (1995) and Glew *et al.* (1997), reveal that the proteins contain fairly balanced essential amino acid levels. Tamarind seeds could, therefore, be used as a cheap alternative protein source to help alleviate protein malnutrition in developing countries (Siddhuraju *et al.*, 1995). Tamarind seed kernels contain polysaccharides. When mixed with water, these polysaccharides form mucilaginous dispersions and possess the property of forming gels with sugar concentrates, like fruit pectins. However, unlike other fruit pectins, tamarind polysaccharides can form gels over a wide pH range, including neutral and basic conditions, and are not affected by boiling in neutral aqueous solutions, even if boiled for long periods of time. Therefore, tamarind polysaccharides can be useful as a gel formation agent and as a substitute for fruit pectins (El-Siddig *et al.*, 2006). However, tamarind polysaccharides do not contain galacturonic acid nor methyluronate, and are therefore not regarded as a true pectin, thus called 'jellose' (Rao, 1948). Tamarind seeds are a good source of fatty acids (Siddhuraju *et al.*, 1995; Glew *et al.*, 1997; Ajayi *et al.*, 2006). Tamarind seeds have a higher percentage of unsaturated fatty acids than of saturated fatty acids (Ajayi *et al.*, 2006). The dominant fatty acids are oleic and linoleic acid (Glew *et al.*, 1997; Siddhuraju *et al.*, 1995; Ajayi *et al.*, 2006). The presence of one essential fatty acid in seed oil makes it nutritionally valuable (Ajayi *et al.*, 2006).

Tamarind seeds appear to be a good source of different mineral elements (Ishola *et al.*, 1990; Siddhuraju *et al.*, 1995; Smith *et al.*, 1996; Glew *et al.*, 1997; Lockett *et al.*, 2000; Ajayi *et al.*, 2006). A high content of potassium (Ishola *et al.*, 1990; Siddhuraju *et al.*, 1995; Ajayi *et al.*, 2006) and magnesium (Ishola *et al.*, 1990; Smith *et al.*, 1996; Glew *et al.*, 1997; Ajayi *et al.*, 2006) is reported in tamarind seeds, together with significant concentrations of iron (Smith *et al.*, 1996; Glew *et al.*, 1997; Siddhuraju *et al.*, 1995; Ajayi *et al.*, 2006) and zinc (Smith *et al.*, 1996; Glew *et al.*, 1997; Lockett *et al.*, 2000). Ishola *et al.* (1990) and Siddhuraju *et al.* (1995) also reported that tamarind seeds are rich in calcium and phosphorous.

Leaves

To our knowledge, only one group of authors, *i.e.* Nordeide *et al.* (1996), reported on the nutritional composition of tamarind leaves. Based on the amino acid profile of tamarind leaves, they suggested that the leaves are potentially acceptable protein sources that could improve protein quality of local diets. Compared to tamarind fruit pulp, tamarind leaves score better for the minerals calcium, iron and zinc (Nordeide *et al.*, 1996).

2.3 Food markets in sub-Saharan Africa

A market is created whenever potential sellers of a good or service are brought into contact with potential buyers, and means of exchange and communication are available (FAO, 1995b; Veeman, 2002). In sub-Saharan Africa (SSA), the medium of exchange may be money (through markets) or barter (via gift exchange) (FAO, 1995b; Fafchamps, 1999, 2004). Although gift exchange continues to play a major role in the (re)distribution of subsistence goods among individuals and households in much of SSA, markets are the primary allocation mechanism. These markets, however, are different from those portrayed in most economic textbooks as they involve individuals who form relationships and networks to economize on transaction costs. In the words of Granovetter (1985), markets in SSA are embedded in webs of social relationships that help to shape them.

Getting a product from producer to final consumer requires many more individual transactions in Africa than in more developed countries – except where the product is consumed in subsistence farming – because the number of intermediaries is larger and the size of each transaction smaller. Moreover, an overwhelming proportion of Africans are basically (small-scale) entrepreneurs, and the fraction of Africans who are self-employed and head their own economic activity is much larger than in developed countries. These two characteristics classify SSA countries as more market-oriented than many advanced countries (Fafchamps, 1997, 2004) (Box 2.1). The latter author argues that, unlike in the West where much of the allocation of resources takes place within large firms and public entities, market transactions remain the dominant allocation mechanism in SSA. Additionally, markets in SSA offer the primary means through which poor people can participate in economic activity. They can do so as producers (farmers, business owners), as employees (*i.e.* providers of labour) and/or as consumers (of goods and services) (Ferrand *et al.*, 2004).

Up till now, little is known about how markets in SSA operate in practice (Fafchamps, 1997, 2004). This can partially be explained by the fact that African traders operate in both the formal and informal economy, and switch between the two at will (Fafchamps, 1999; KIT & IIRR, 2008). The informal economy is defined as all currently unregistered economic activities which contribute to the officially calculated (or observed) gross domestic product (Schneider, 2002). The informal sector is a pervasive and persistent economic feature of most developing economies, contributing significantly to employment creation, production, and income generation (Ferrand *et al.*, 2004; World Bank, 2010). The informal economy refers to activities and income that are partially or fully outside government regulation, taxation, and observation. The main attraction

Box 2.1: African food markets are efficient but poor

Food markets in Africa are probably the most vibrant in the world. Nowhere else you find more small-scale entrepreneurs and micro-businesses making their incomes from buying and selling of foodstuffs. As a consequence, markets in SSA are strongly fragmented. Food products are traded in small quantities, and many steps are needed in the value chain to take the product from the producer to the consumer. Millions of smallholder farmers produce small surplus amounts of fruits and vegetables, cereals and tubers, dairy and meat. These farmers live scattered, often separated by long distances from the major consumption centres. Thousands of small-scale itinerant traders travel there weekly to buy products to transport to and supply the urban markets. In the cities, tens of thousands of micro-retailers buy regularly small quantities of produce, which they sell over a couple of days, after which they buy more produce to resell. Finally, millions of consumers buy, often daily, small quantities of food products. Urban markets in Africa are generally characterised by inadequate marketing infrastructure leading to congestion and overflow of traders onto streets and pavements, inefficient storage, handling and packaging of produce resulting in excessive waste through spoilage, poor produce quality and rather high distribution costs.

Based on Tollens (1997), Gabre-Madhin (2001) and KIT & IIRR (2008) of the undeclared economy is financial as this type of activity allows employers, paid employees, and the self-employed to increase their take-home earnings or reduce their costs by evading taxation and social contributions (World Bank, 2010). Informal markets are, in addition, characterised by offering low value added products, and having loose procedures and limited networks (Ferrand *et al.*, 2004). Of late, the informal economy in many African countries has been growing (KIT & IIRR, 2008). According to the World Bank (Schneider, 2002), in 1999/2000, the informal economy in Africa represented 42 % of the continent's gross domestic product. In addition, the average size of the informal economy labour force was 48.2 % of the official labour force in Africa for the 1999/2000 period (Schneider, 2002). The informal economy is usually perceived as a problem, because it takes place outside the reach of state law and creates a vicious circle characterised by a lack of business organisation, limited access to formal finance, unreliable labeling and quality standards, etc. (KIT & IIRR, 2008). As a result, the informal economy can be seen as a basis of the future growth of poor African economies as it is the sector that is most likely to absorb the growing numbers of people entering job markets (Ferrand *et al.*, 2004; KIT & IIRR, 2008).

In large parts of SSA, women play a key role in food production and trade. However, a large proportion of women traders are found in the informal economy as it is relatively easy to operate in the latter since there are only few entry requirements such as skills or capital. Trading thus becomes the best option for many women who have not acquired the education needed to enter the formal economy. Informal trading also enables women to combine their unpaid care work in the household with income-earning activities (KIT & IIRR, 2008). Compared to the roles of men, the position of women in the food market chain tends to be more vulnerable and less remunerative. When men and women are engaged in the trading of the same commodity, women will tend to do the retailing while men will do the wholesaling. Men tend to be engaged in capital-intensive business while women engage in labour-intensive activities which require less capital, such as transport and petty trading in the marketplace (KIT & IIRR, 2008).

2.3.1 Market types

Markets can be described as being centralised or decentralised. The latter is typically the case in rural areas where many small local markets may be found within any regional area (Veeman, 2002). Besides, different types of markets have been identified (Tracey-White, 1999, 2005; Ferris *et al.*, 2006).

On-farm sales On-farm or farmgate sales occur when consumers and collectors purchase produce directly from farmers. The latter then arrange transport to processors, wholesale outlets, packhouses or directly to retailers.

Rural primary markets In rural markets, trade is characterized by direct sales of small quantities of produce by producers to village traders and by retail sales to rural consumers. Rural markets normally form part of a local trade network and are usually arranged on a periodic basis, on specific weekdays. They are commonly organised at a central place in a village or district centre, or beside a village's access road.

Assembly markets Larger rural markets occur where greater quantities of produce are traded, either by the producers themselves or by small local traders. These assembly markets, which are often combined with local rural or town markets, are normally situated on major highways, near local transport interchange points. Traders, collectors and commission agents, acting on behalf of urban wholesalers are the main buyers of produce at these markets.

Wholesale markets Wholesale and semi-wholesale markets are located within or near major cities. These centres may be supplied by purchasing/assembly centres in the rural areas or directly from farms, particularly those in peri-urban areas. The supply is either from agents, traders or by farmers themselves. Main buyers are retailers and businesses.

Retail markets Retail markets are markets where consumers and small businesses, such as restaurants and street food vendors, buy their supplies. Retail markets can be found in rural as well as urban areas. Although their primary function is retail, they may have a semi-wholesale function, particularly when they allow farmers to trade in them. In the latter case, they are often called farmers' markets, which is a typical feature for developing countries. Small retail shops, often termed corner shops or roadside stands provide produce close to consumers' homes.

Supermarkets In Latin America and Asia, supermarkets dominate the trade in fresh produce (estimated to represent between 40 and 70 % of total retail sales), but this is less evident in SSA (10-25 %), where supplies from traditional markets continue to be very important (Reardon, 2006). The rapid growth of supermarkets in developing countries is having a significant impact on shopping habits and is increasingly controlling downstream segments of the chain through contracts, private standards and sourcing networks (Reardon, 2006; Abrahams, 2010).

Most major African cities lack specialised and efficient wholesale markets (Tollens, 1997). In SSA, it is often difficult to distinguish between wholesale and retail operations. Food wholesalers usually trade in a wide range of items, only rarely specializing, and often combine wholesale and retail functions. Retailing is, especially in cities, characterized by an inordinately large number of micro-retailers competing for sales to low-income consumers (Tollens, 1997). However, wholesale markets play a crucial role in the vertical coordination of food markets, equilibrating supply with demand and facilitating price formation (Tollens, 1997).

Moreover, in SSA, the different types of markets are often not easily distinguished. A trader can be collector, transporter and distributor at the same time and thus simultaneously operate in assembly, wholesale and retail markets (Ndoye *et al.*, 1998). Other traders may have retailing functions for some products, while acting as wholesaler for other products. In addition, traders can perform different market functions depending on the season. Therefore, many authors (Poulton & Poole, 2001; Lintu, 1995; Ahmad & Ahmad, 2007; Narrod *et al.*, 2007) distinguish only local (rural), national (urban) and international (export) markets. Poulton & Poole (2001) and Jaenicke & Lengkeek (2008) add a fourth category, namely the regional markets. These markets differ in several organisational aspects but, most importantly, in their demand for food safety (Narrod *et al.*, 2007). Local markets are supply-driven and characterised by small-scale actors, short market chains and high seasonality. Besides, transactions are often informal, margins are generally low and there is little emphasis on quality. In contrast, demand-driven export markets are characterised by more complex value chains, high added value, and a high food safety awareness. Consequently, quality, flexibility and innovation determine competitiveness. National (and regional) markets show intermediate characteristics (Poulton & Poole, 2001; Narrod *et al.*, 2007; Jaenicke & Lengkeek, 2008). Similarly, Ruiz Pérez *et al.* (2000) identified four types of NTFP markets on the basis of their size and degree of self-sufficiency (as a percentage of supply from the same area). Type I markets consist of small, local markets with a high level of self-sufficiency that act as local exchange places as well as suppliers of the regional and national markets. Products are gathered and/or produced by sellers, while buyers are directly the products' consumers. Type II markets consist of a group of medium-sized markets of regional importance, with a medium level of self-sufficiency, acting as secondary nodes for the small local markets and as intermediate assembly points for the larger urban markets. Type III markets are large urban markets whose size and spread of linkages give them a national projection and which are characterized by a weak degree of self-sufficiency, having to rely on more distant supply areas. Finally, type IV are frontier markets with small to medium value of transactions and very high dependency for their supply on other areas due to the specialisation for only a few products.

2.3.2 Marketing and marketing functions

Marketing can be defined as the performance of all activities necessary to transform a raw product from its point of production, harvest, gathering or collection, to the point of final consumption, whether as food, medicinal or household item (Veeman, 2002). Besides, Crawford (1997) adds that marketing is about establishing and maintaining long-term relationships with customers. In other words, the goal of marketing is to attract new customers by promising superior value, and to keep current customers by providing satisfaction (Kotler *et al.*, 2005). The basic components of marketing are referred to as marketing variables, marketing mix or the four P's, *i.e.* product, price, place and promotion (FAO, 1995b; Kotler *et al.*, 2005; Ferris *et al.*, 2006).

Recently, more and more importance has been attached to social marketing. Social marketing identifies human needs in non-competitive economies and/or sectors of society, and defines the means of delivering products and services to meet these needs (Crawford, 1997). The marketing mix of social marketing strategies is evaluated using quite different criteria from those employed in assessing purely commercial marketing strategies. Criteria such as percentage of target population reached with the technology, products, processes or services, quantities produced and distributed, and uptake of the product, service or technology are used to evaluate performance. Benefits are measured in terms of development goals, such as improved nutritional status or higher rural incomes (Crawford, 1997). Criteria used to evaluate commercial marketing strategies should, however, not be dismissed, because these improve the efficiency of some aspects of social marketing without preventing the attainment of social objectives (Crawford, 1997).

Three alternative approaches have been shown to be useful in studying agricultural marketing (van der Laan, 1999): (i) the commodity approach which takes individual crops or groups of crops as its starting point; (ii) the institutional approach which concentrates on institutions and actors; and (iii) the functional approach which focuses on the activities of the actors.

A marketing system has three sets of marketing functions. These are physical functions required for distribution (transportation, storage and processing), the functions that are directly associated with exchange (buying, selling and price establishment), and the facilitating functions which enable the exchange process to take place (market intelligence, financing, risk-bearing, grading and standardisation, good governance) (Whetham, 1972; Crawford, 1997; van der Laan, 1999; Veeman, 2002; Ferris *et al.*, 2006). All marketing functions are individually detailed below.

- Transportation: making a product available where it is needed or, in other words, adding utility of place to the product.
- Storage: balancing supply and demand or, in other words, adding utility of time to the product.
- Processing: physical transformation whereby the product is converted into forms more suitable for the next stage in the distribution process or for the final buyer.
- Buying: obtaining a product or service in exchange for money or goods.
- Selling: offering a product or service for people to buy or exchange.
- Price establishment: price levels reflect the nature of supply and demand, in which supply is the quantity of products offered for sale and demand is the quantity of products that consumers can buy.

- Market intelligence: process of collecting, interpreting and disseminating information relevant to taking marketing decisions.
- Financing: related firstly to the value of the product, secondly to the time and distance between its first and final sale, and thirdly to the degree of risk involved.
- Risk-bearing: risk of physical deterioration or loss, and risk of unexpected changes in prices and costs.
- Grading and standardisation: can be achieved if the product has readily measurable characteristics that are relevant to users or consumers, and if the distribution of these characteristics is such that products can be categorised into well-defined groupings of fairly homogeneous products, based on relevant characteristics (*e.g.* variety, size, colour, shape, degree of impurity and ripeness). Standardisation has three dimensions: quality, weight and packaging.
- Good governance: provision of a social environment that leads to enforceable contracts and the absence of theft.

Specific characteristics of agricultural and their effect on marketing activities where documented by van der Laan (1999). Specific location calls for collection followed by distribution, while small-scale activity needs assembling, collecting and bulking. Seasonality implies seasonal storage, perishability asks for on-farm or nearby off-farm preservation whereas natural variation calls for product sorting and standardisation.

2.3.3 Intermediaries or traders

There are many kinds of traders, who operate in different segments of the food market chain. Each of these traders has specific functions, *e.g.* collection, transport and distribution. Normally, several types of traders are involved in getting a product from farm to consumer. The different traders all have a specific role in the value chain (Dijkstra, 1997; KIT & IIRR, 2008). However, not all value chains involve all kinds of traders (KIT & IIRR, 2008).

Several types of intermediaries or traders have been distinguished and described by a number of authors (Dijkstra, 1997; Tracey-White, 2005; Ferris *et al.*, 2006; KIT & IIRR, 2008).

Collectors and commission agents Collectors operate over short distances and trade small volumes at a time, using limited amounts of money and simple means of transport. They take possession of produce from an individual or group of farmers and then sell the produce to a wholesaler, market trader or other middleman. For providing these services, the collector or commission agent normally charges a percentage of the final sales price.

Assemblers Assemblers buy from collectors or farmers, at the farmgate or local market, for selling to other traders, wholesalers and retailers. Their main function is to gather produce for sale to large traders who do not have the time to carry out small purchases from scattered producers and collectors. They may own or rent small, motorised transport vehicles and small storage facilities.

Wholesalers Wholesalers sometimes buy produce from farmers and collectors, but tend to rely on assembly traders and other wholesalers as their main sources of supplies. They vary in size, but deal with larger volumes than collectors and assemblers, and often store goods. They normally own or rent medium to large vehicles for transporting agricultural products which they may also grade and store for a while. Wholesalers cater for the needs of larger urban markets and sell in bulk to other wholesalers, processors, industries, institutional buyers and retailers.

Processors Processors can be small household enterprises or fairly large formal firms.

Retailers Retailers buy either directly from farmers, traders or wholesale markets. The larger retailers buy in wholesale units from established wholesalers. Small-scale retailers often buy in smaller amounts from these larger retailers. Retailers are thus very diverse in size: from small kiosks and hawkers or roadside sellers, who sell small volumes of a limited number of goods to shops, and supermarket chains that deal with a vast range of agricultural products. Retailers have as main role the distribution of products to consumers. Their function is to obtain supplies and display them in forms and at times convenient to consumers.

Intermediaries or traders are undoubtedly the most criticised actors in the value chain since they are often accused of exploiting farmers

(Schreckenberg, 2003). Nevertheless, some studies suggest that the role of middlemen has been underestimated (Padoch, 1992) and that it is a mistake to try to ignore or bypass them (Corry, 1993). Consequently, there is a need to recognize that traders carry out many useful marketing functions and that they bear substantial risks from thin and uncertain markets, while carrying out costly distribution functions (Ndoye *et al.*, 1998; KIT & IIRR, 2008).

2.3.4 Marketing costs

Traders perform their collecting, travelling and distributive function(s) in the food chain in return for a certain share of the consumer price. Agricultural trading in SSA is in general a high-risk business, because there is no support from formal institutions such as those providing quality standards, market information and mechanisms for contract enforcement. All in all, the marketing margins of traders should thus be interpreted in relation to the costs and risks they face (KIT & IIRR, 2008). The major marketing costs faced by traders are listed below (Fafchamps & Gabre-Madhin, 2001; Gabre-Madhin, 2001; Fafchamps, 2004; Shepherd, 2007; KIT & IIRR, 2008).

- Transport: physical transport of produce depends on the distance and the state of the roads, and can account for 40-60 % of the marketing margin.
- Handling: handling costs include the costs of loading the produce at the time of purchase and off-loading at the time of sale, the costs of packing the produce, and of the packaging material. These costs can represent 20-30 % of the marketing margin.
- Search: in SSA there is often no public market information available, so traders may spend a long time looking for goods to buy. These costs vary significantly from one situation to another, but they can represent up to 15-20 % of the marketing margin.
- (In)formal taxes: these include taxes from the government, tolls for market stalls, fees, and tips at road blockades. These costs can account for 10-15 % of the marketing margin.
- Product losses: traders inevitably lose some of the produce they buy. Among the many causes are delays in transport, theft, improper handling, lack of storage space and refrigeration, post-harvest pest and disease attacks (for stored produce), selection and grading, inadequate packaging, and unsold produce.

- Processing: processing costs depend on the efficiency of the processing unit, the available infrastructure, the capacity and the frequency of operation. Besides, there are two other important aspects of processing costs. Firstly, one kilogram of product purchased from the farmer cannot be compared to one kilogram of processed product sold to the consumer. Secondly, processing may yield a by-product which can often be sold.

African traders have few capital costs, as they make little use of loans from banks and have few capital assets such as vehicles or warehouses. They also have low storage costs, which implies that they tend to sell the produce as quickly as possible and thus achieve high capital turnover, rather than to store the produce and speculate on price increases. Finally, traders have few personnel costs as most are self-employed entrepreneurs with nobody assisting them (KIT & IIRR, 2008).

Marketing costs are the total costs for bringing produce from the farm to the ultimate consumer. Margins are the costs that are added by transporters and traders to cover their expenses and to provide a profit for their services (Tracey-White, 2005). In other words, a marketing margin is the percentage of the final weighted average selling price taken by each stage of the market chain (Shepherd, 2007). Total margins will depend on the length of the market chain, the extent to which the product is stored or processed, and the level of post-harvest losses. thus, to know whether margins are reasonable you need to understand the costs (Shepherd, 2007).

2.4 Marketing underutilised plant species

Gruère *et al.* (2006) present a conceptual framework to support the effective commercialisation of underutilised plant species. The authors first identify the economic factors that cause these plants to be 'underutilised'. Based on this analysis, they propose a classification of underutilised plant species based on the relationship of the observed to the potential economic value of the species, and the presence or absence of and constraints to output markets. Finally, focusing on a subset of underutilized plant species with market potential, Gruère *et al.* (2006) identify three necessary conditions for the successful commercialisation of underutilized plant species for the benefit of the poor. Hereafter, the framework of Gruère *et al.* (2006) is briefly presented.

Underutilised plant species are referred to as agricultural or non-timber forest species, collected, managed, or cultivated, that have simultaneously the following three characteristics:

- they are locally abundant but globally rare;
- scientific information and knowledge about them is lacking; and
- their current use is limited relative to their economic potential.

'Underutilisation' translates thus into undervaluation in economic terms. This means that these crops have a lower observed (or expressed) value relative to their economic potential. In other words, their current public and/or private value is below its potential. The private value of an underutilised crop is its propensity to generate an income, ability to absorb production shocks and nutritional, medicinal or food diversifying potential as a livelihood strategy. The public value is its contribution to agricultural biodiversity (*e.g.* ecosystem services), opportunity for future generations to generate an income or proper nutrition, and the maintenance of tradition and culture. The latter value is generated by positive externalities or by the mere existence of the species.

Underutilised plant species are also characterised by the temporal dimension of their potential economic value and three basic cases can be identified:

1. the observed value of a plant species was equal to its potential value in the past, but its observed value declined;
2. very limited past value (observed and potential) but recent knowledge has increased its economic potential; and
3. underutilised plant species that have always been undervalued despite the knowledge of its potential.

Differences among these three cases are important because they may help define the appropriate policy response to support underutilised plant species. The multi-purpose baobab tree is an example of the third case. Despite its wide distribution in semi-arid Africa, the commercial potential for its numerous products has never been realized because of the lack of planting material, management techniques, processing technologies, and organized market chains (ICUC, 2004).

Additionally, underutilised plant species may be characterised by the spatial distribution of their potential economic value. There are two possibilities. First, the observed value may be limited to a certain area where the species is produced and consumed. Secondly, the observed value may be dispersed among multiple areas, and either the plant species is underutilised in each of these areas, or it is only underutilised in certain areas and not others.

In a perfectly competitive market, no species would be considered underutilised. Thus, plant species are underutilised as a consequence of market imperfections. Perfect competition and full appropriation of the product value in a commercial market implies that all economic actors have complete information, and both private and public sources of values are reflected in market price. There are three major economic factors explaining why these market conditions, *i.e.* full information and full appropriation, are not met for underutilised plant species.

Missing output market When primary producers do not or cannot access a market for underutilised plant species, the output market is 'missing'. This may be due to exogenous and endogenous constraints, *e.g.* capers (*Capparis spinosa*) are underutilised in Syria due to high transactions costs caused by a lack of information and trust among market chain actors (Giuliani *et al.*, 2007), whereas African garden egg (*Solanum aethiopicum*) is underutilised in Ghana due to its short shelf life (Horna *et al.*, 2007).

Suboptimal market equilibrium In a market economy, the situation of underutilised plant species with a potential value that is not fully realized can be interpreted as a suboptimal market equilibrium. The latter is the direct consequence of one or more market imperfections. The market price does not reveal the full value of the product or consumer willingness-to-pay and the quantity produced does not represent the optimal scale of production or production capacity. There are three possible explanations, namely weak market demand, inefficient supply and a combination of the two. An example of a market imperfection is the need for processing infrastructure and organisation causing a lack of caper supply in Syrian consumer markets (Giuliani *et al.*, 2007).

Market failures Some underutilised species are not only underutilised from a market perspective but their limited use also fails to reflect their public value. The lack of economic information and the lack of product knowledge can contribute to market failures. For example, local populations may be ignorant of the nutritional benefits of consuming products from underutilised species. This lack of knowledge can be a market constraint, resulting in a lower demand than what it would be under full information.

Based on the above-mentioned, underutilised plant species can be classified according to four economic criteria: (i) observed and potential value characterization, (ii) output market, (iii) market imperfections, and (iv) market failures. This classification scheme forms in turn the basis for the formulation of three necessary conditions for the successful commercialisation of underutilised plant species:

1. expansion of demand;
2. improved efficiency of production and marketing channels; and
3. supply control mechanism or capacity to differentiate from products that are close substitutes.

2.5 Market chains

2.5.1 Definition, principles and evolution

In SSA, marketing channels are mostly characterised as conventional marketing channels instead of vertical channels (Dijkstra, 1997). A conventional marketing channel consists of isolated and autonomous units or stages of which each performs a defined set of marketing functions. Coordination among channel members is primarily achieved through bargaining and negotiation at spot markets (Dijkstra, 1997; Kotler *et al.*, 2005). Moreover, no channel member has much control over the other members and no formal means exist for assigning roles and resolving channel conflicts (Kotler *et al.*, 2005). In contrast, a vertical marketing system consists of stakeholders as a unified system. one channel member owns the others, has contracts with them, or has so much power that they must all cooperate (Kotler *et al.*, 2005).

The use of the term channel or chain suggests a focus on relationships between buyers and suppliers, and the movement of a good or service from producer to consumer (Gibbon & Ponte, 2005). This entails an analysis centred on flows of material resources, finance, knowledge, and information between buyers and suppliers (Gibbon & Ponte, 2005).

A market chain describes the numerous links that connect all actors and transactions involved in the movement of a product from the field to the end user or consumer (Lundy *et al.*, 2004b; Ferris *et al.*, 2006; Lundy *et al.*, 2007). The term 'market chain' is often used interchangeably with the terms production chain, supply chain, market channel, marketing chain or value chain (Ferris *et al.*, 2006; Lundy *et al.*, 2004a, 2007) and will be used by the author in the present study.

Value chain analysis is emerging as a useful tool that has already led to new practical insights in the markets for textiles and clothing (Gereffi, 1999), fresh fruits and vegetables (Dolan *et al.*, 1999), commodities such as tea and coffee, and wooden furniture in the case of the forestry sector (Kaplinsky *et al.*, 2003). Moreover, value chain analysis has also been added to the research agenda for NTFPs (Jensen, 2009). Box 2.2 shows briefly the history of the value chain concept.

A value chain describes the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services) and delivery, to end consumers, and final disposal after use (Kaplinsky & Morris, 2001). This definition has been widely accepted by researchers and scientists (Roduner, 2005). Value chains are as strong as their weakest link. In other words, when *e.g.* the midstream segment of the chain (trading) does not work properly, it has negative repercussions upstream in the chain (production) as well as downstream (consumers) (KIT & IIRR, 2008).

Value chains aim at optimising the chain, are demand-driven and characterised by differentiated products, interdependent actors, extensive information flows, and a focus on quality and value (Hobbs *et al.*, 2000). In contrast, production or traditional chains strive for self optimisation, are supply-driven and characterised by basic (primary and secondary) products, independent actors, little or no information flow, and a focus on price and costs (Hobbs *et al.*, 2000). Based on the findings in the present study, the chain of baobab and tamarind products can be characterised as a traditional chain rather than a value chain. Therefore, the author prefers to use the term market chain instead of value chain.

2.5.2 Market chain analysis

At the most basic level, value chain analysis can be seen as a methodological tool to plot the flow of goods and services up and down the chain, and between different chains (Kaplinsky & Morris, 2001), thus

Box 2.2: History of the value chain concept

The value chain concept has evolved through time across various disciplinary fields, areas of application and levels of analytical aggregation. Three main research streams in the value chain literature are distinguished: (i) the *filière* approach; (ii) the conceptual framework elaborated by Porter; and (iii) the global approach. The evolution time line and content change in the concept value chain is given below (Porter, 1998; Gereffi, 1999; Raikes *et al.*, 2000; Kaplinsky & Morris, 2001; Stamm, 2004; Roduner, 2005; da Silva & de Souza Filho, 2007; van den Berg *et al.*, 2007).

’50s The first realization of the importance of a vertical dimension in the analysis of agrifood sectors has been attributed to two researchers from Harvard University, Davis and Goldberg, who coined the term agribusiness to represent the aggregate of operations that take place between farm and consumer.

’60s and ’70s Agricultural economists in the United States developed the general framework that became known as the commodity systems approach, which offered a logical structure to perform agrifood sector analysis, taking into account both horizontal and vertical dimensions. A parallel development with a similar focus was the *filière* (chain) approach developed by a number of French researchers. The French *filière* concept, developed by researchers at the *Institute National de la Recherche Agronomique* (INRA) and the *Centre de Coopération Internationale en Recherche Agronomique pour le Développement* (CIRAD), encompasses a static model with non-changing actors and national boundaries, describing the linear flow of physical inputs and services in the production of a final product. Initially, the approach was used as a tool to analyse the ways in which agricultural production systems were organised in developing countries under the French colonial system.

Box 2.2: History of the value chain concept (Continued)

'80s Porter proposed the chain concept to relate the activities performed by an organisation with its competitive position (system thinking). Porter's value chain is an instrument for identifying the value created at each step in the production, and how a firm should position itself in the market and in relationship with suppliers, buyers and competitors. Firms can be organized according to their primary activities that include inbound and outbound logistics, operations, marketing and sales, and service. Support activities, also performed by firms, include procurement, technology development, human resource management and infrastructure. It is the systematic arrangement of these activities that creates value and influences the competitive position of the firm. Systems principles are also present in supply chain management, which is primarily concerned with the way firms organize the flow of inputs and production resources from procurement through product manufacturing and distribution.

'90s Other uses of the chain concept were promoted by researchers interested in globalisation and international trade issues. Global commodity chains, introduced into literature by Gereffi, cover a concept that is mainly focusing on the power relations in the coordination of dispersed, but linked, production systems. This concept is used to examine the ways in which firms and countries are globally integrated and to assess the determinants of global income distribution.

to describe markets (te Velde *et al.*, 2006). By focusing on the whole range of activities and relations, the value chain approach is simultaneously a descriptive tool and an analytical instrument (Kaplinsky & Morris, 2001; Jensen, 2009).

Because each value chain is different and has particular characteristics, Kaplinsky & Morris (2001) stress that there is no unique correct way to conduct a value chain analysis. Therefore, it is the research question that fundamentally determines the followed approach (van den Berg *et al.*, 2007). A methodology for undertaking value chain research may contain, among others, following issues: point of entry for value chain analysis, mapping value chains, product segments and critical success factors in final markets, benchmarking production efficiency, governance of value chains and upgrading in value chains (Kaplinsky & Morris, 2001). Hereby, governance in a value chain refers the structure of relationships and coordination mechanisms that exist between actors in the chain, whereas upgrading can involve improvements in quality (*i.e.* process upgrading) and product design (*i.e.* product upgrading) that enable actors to gain higher value or through diversification in the product lines served (*i.e.* functional upgrading) (Kaplinsky & Morris, 2001; van den Berg *et al.*, 2007).

The objectives of value chain analysis are according to Marshall *et al.* (2006a):

- identify the main actors or organisations in the commercialisation chain from the input provider to the collector right through to the final consumer, and identify their specific activities;
- identify the different routes to commercialise the product, which could be what currently exists and what potentially is available or could be developed; and
- assess how well the market chain is working.

How to carry out a value chain analysis is split into three sections (Marshall *et al.*, 2006a): (i) description of the value chain; (ii) identification of important routes and actors in the chain; and (iii) assessing the profitability, power and institutional environment of the key actors. A value chain analysis typically includes the following key elements or steps (Roduner, 2005; FIAS, 2007; Will, 2008):

- choose the sub-sector(s) [1] to assess;
- analyse the market;
- map the value chain;
- measure the performance of the chain and establish benchmarks (*i.e.* comparing similar value chains in different regions or countries);
- analyse performance gaps (*e.g.* market failures); and
- establish recommendations and develop an upgrading strategy.

Once the sector(s) to assess has been chosen, a point of entry into the chain needs to be selected prior to the start of the analysis, in order to ensure an effective and targeted study (Kaplinsky & Morris, 2001). Due to the high degree of complexity of most chains and their overlap with other chains, the selection of the point of entry is critical to the study as it often determines the actual chain (or chains) that will be investigated (Kaplinsky & Morris, 2001). The focus of this study and point of entry was the small-scale rural producer (hereafter referred to as gatherer) of baobab and tamarind products in Mali and Benin. Further links and functions were then investigated by departing from the smallholder's respective position, moving up or down the chain as necessary. A value chain analysis should be carried out with the following groups (Marshall *et al.*, 2006a):

- the initial stages of the analysis take place in the community to identify the important traders and markets and develop an understanding of how familiar the community is with the chain beyond this initial market point of contact;
- subsequent stages of the analysis should be undertaken with the traders and at markets identified with the community to determine what happens to the product next and who is involved. The research should then move to the next actor along the chain, continuing until the end consumer is reached;
- once a chain has been developed from producer to consumer, data gaps should be identified and filled with either primary or secondary data. The latter will involve contacting people and organisations

[1] A sub-sector refers to all the actors and services that are financially and socially linked as products, information and finances flow from producers through intermediaries to consumers for a particular commodity. Usually a sub-sector analysis is undertaken at national level (Best *et al.*, 2005). A market chain has a similar definition, but may be undertaken at more local level and provide a partial view of the total commodity sub-sector (Best *et al.*, 2005).

who have previously collected and documented important data and information; and

- the initial value chain analysis should be presented and discussed with the community, and where necessary modified. The final results should be retained within the community. Where appropriate, the results from the value chain analysis should be disseminated to local authorities and policy decision makers.

Mapping the market

The term market map has been developed by Practical Action based on the believe that markets matter to the rural poor. Factors that influence how markets operate, including access to information, market institutions, linkages and trade rules, have a powerful influence on the earnings of smallholders (Albu & Griffith, 2005, 2006). Failure to address these factors can mean that the benefits of economic growth, innovative technologies and better infrastructure, simply by-pass the poor (Albu & Griffith, 2005, 2006). Therefore, Albu & Griffith (2005, 2006) are convinced that efforts to secure and improve the income of poor rural smallholders are best pursued through concentrating on the improved overall performance of specific economic channels or market chains. Market chains comprise the economic actors who produce and transact a particular product as it moves from primary producer to final consumer, such as smallholders, processors, transporters, wholesalers and retailers (Albu & Griffith, 2005, 2006).

The market map is a framework that describes the overall market system for any given market chain (Albu & Griffith, 2005, 2006). The market map serves two purposes: (i) it is a framework for conceptualizing the entire commercial and institutional environment in which rural producers operate, and (ii) it is a practical tool for market facilitators to develop, visually represent and briefly communicate this knowledge among different stakeholders (Albu & Griffith, 2005; Hellin *et al.*, 2005; Albu & Griffith, 2006). Therefore, the market map plays an important role in encouraging market literacy. The latter is defined as a better understanding of the institutions, competencies and relationships necessary for specific market systems to work for poor producers (Albu & Griffith, 2005; Hellin *et al.*, 2005; Albu & Griffith, 2006).

The market map as shown in Figure 2.5 is made up of three interlinked elements (Ferrand *et al.*, 2004; Albu & Griffith, 2005, 2006; Hellin &

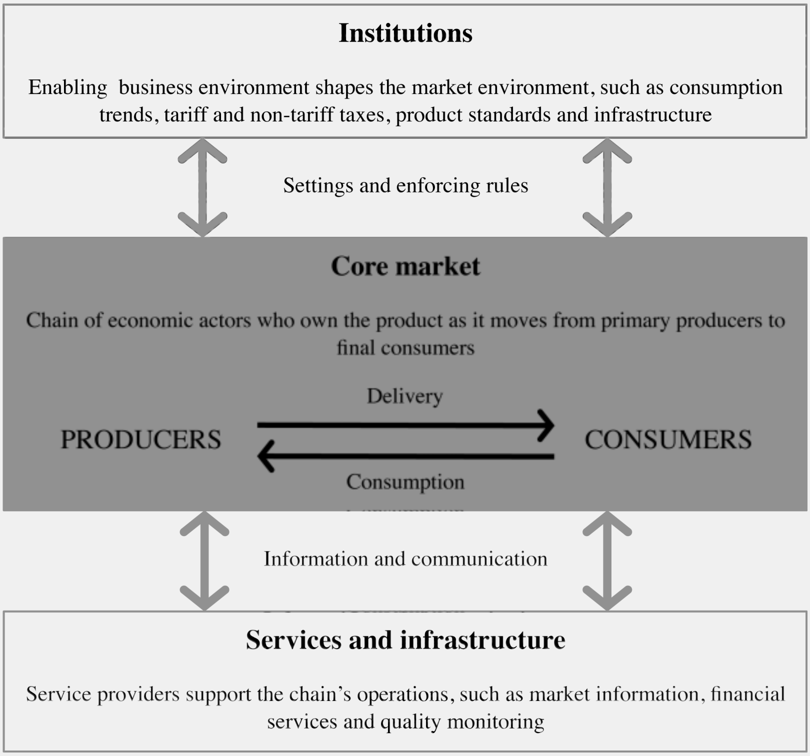


Figure 2.5: Market map (adapted from Ferrand *et al.* (2004) and Albu & Griffith (2005))

Meijer, 2006).

1. Market chain actors and their linkages: the central component maps the economic actors (the 'players') who actually own and transact a particular product as it moves through the market chain from primary producer to final consumer.
2. Enabling business environment factors: the top component maps the critical factors and trends that are shaping the market chain environment and operating conditions, but may be amendable to change. These enabling environment factors are generated by structures (national and local authorities, research agencies,

etc.) and institutions (policies, regulations and practices) (the 'influencers'), that are beyond the direct control of economic actors in the market chain.

3. Business and extension service providers: the bottom component maps the services that support (the 'supporters'), or could potentially support, the market chain's overall efficiency.

The players operate at micro-level, whereas the supporters and influences or enablers intervene respectively at meso- and macro-level (Will, 2008). Additionally, these three interlinked components and structures are all embedded into a fourth category, namely the attitudes, which encompass the socio-economic and socio-cultural conditions at meta-level (Will, 2008).

The process of mapping the market, if conducted in participation with the market chain actors themselves, can be a powerful way to build understanding and trust between stakeholders (Albu & Griffith, 2005; Hellin *et al.*, 2005; Albu & Griffith, 2006). There is, however, no single blueprint for this participatory approach (Albu & Griffith, 2005, 2006). While Practical Action was evolving the market map, the International Potato Centre (CIP) in Peru has been developing a similar participatory market chain analysis (PMCA) (Bernet *et al.*, 2005). These two sets of ideas came together initially at a seminar in February 2005 (Almond & Hainsworth, 2005) and PMCA was identified as a key approach to put the market map into practice (Albu & Griffith, 2005, 2006).

Participatory market chain analysis

Participatory market chain analysis (PMCA) is an instrument for facilitating change in market chains that lack coordination, so creating an environment that fosters interaction among market chain actors, promotes mutual learning and trust and stimulates shared innovations (Bernet *et al.*, 2006). In other words, PMCA is a participatory process that gradually stimulates interest, trust and collaboration among members of the market chain (Bernet *et al.*, 2005).

PMCA is a flexible method to be applied in different marketing chain contexts. The only fixed element of this approach are its three phases (Bernet *et al.*, 2005, 2006): (i) get to know the different market chain actors with their activities, interests, ideas and problems; (ii) analyse in a participatory manner potential joint business opportunities; and (iii) implement joint market innovations (new products, new technologies, new institutions). For more details the reader is referred to the manuals developed for participatory market chain analysis by Lundy *et al.* (2004b,a, 2007) and Bernet *et al.* (2006).

Rapid market analysis

Rapid market analysis (RMA), used in the present study, is often the first step in the first phase of a PMCA. RMA is a method that relies on semi-structured informal interviews with key informants and a minimum number participants at different stages of the market chain or sub-sector (Ferris *et al.*, 2006). Hereby, a minimum of three to five interviews of actors conducted at each stage in the market chain is used as a rule of thumb (Ferris *et al.*, 2006). The RMA is a way of: (i) getting to know the various key actors in the chain; (ii) understanding the circumstances and practices of the actors involved in the market; (iii) identifying bottlenecks and opportunities associated with the various links in the chain, *i.e.* production, commercialisation, processing, use and consumption; and (iv) prescribing interventions in the organisation, technology and management of the chain (Bernet *et al.*, 2006; Ferris *et al.*, 2006).

3
Methodology

This chapter starts with a brief overview of the study area and continues by explaining the data collection, and quantitative and qualitative analysis methods used in the present PhD study.

3.1 Study area

This study was conducted in two west African countries, namely Mali and Benin, to obtain a holistic picture of the market chain of baobab and tamarind products. Hereafter, the geographic situation is given, and population data and development indicators of both countries are listed. To conclude, a comparison is presented between Mali and Benin.

3.1.1 Mali

The Sudanese Republic and Senegal became independent of France on 22 September 1960 forming the Mali Federation. When Senegal withdrew after only a few months, what formerly made up the Sudanese Republic was renamed as the Republic of Mali (CIA, 2011c).

Geographical situation

Mali is a landlocked country situated between Mauritania and Senegal in the west, Guinea and Ivory Coast in the south, Burkina Faso and Niger in the east, and Algeria in the north (Figure 3.1). The capital is Bamako. In total, Mali has an area of 1,240,192 km^2 of which 1,220,190 km^2 is land; about two thirds is desert or semi-desert (CIA, 2011c). Mali is subdivided in eight regions: Kayes, Koulikoro, Sikasso, Ségou, Mopti, Gao, Kidal and Tombouctou, and one capital district Bamako.

Population data

Total population is estimated at approximately 13,800,000 in 2010 (CIA, 2011c). About 47.50 % of the population are under 14 years, 49.50 % are between 15-64 years of age whereas only three percent are above the age of 65. Life expectancy at birth is 52.17 years according to the Central Intelligence Agency (CIA, 2011c), while the United Nations Development Programme (UNDP, 2010c) reports 49.20 years. Annual population growth rate is currently estimated at 2.61 %. CIA (2011c) reports a literacy rate of 46.40 %, whereas UNDP (2010c) estimates the rate of literacy at 26.20 %. Albeit the official language is French, many

Figure 3.1: Map of Mali (adapted from Perry-Castañeda library map collection) with indication of the location of Mali in Africa and the vegetation zones important for the present study, namely (I) the Sahel regional transition zone, (II) the Sudanian region, and (III) the Guinea-Congolia/Sudania regional transition zone (White, 1983)

tribal languages are spoken, of which Bambara is the most commonly used (CIA, 2011c).

Development and economic indicators

Mali is among the poorest countries in the world with a highly unequal income distribution or Gini coefficient of 0.39 (UNDP, 2010c) or 0.40 (CIA, 2011c). About 36.10 % of the population lives below the national poverty line [1] in a country where annual gross domestic product (GDP) is estimated at 16.74 $ billion (CIA, 2011c). GDP per capita (purchasing power parity or PPP) amounts to 1,171 $ according to UNDP (2010c), whereas CIA (2011c) reports 1,200 $. The informal economy in Mali is estimated at 41.0 % of GDP in the 1999-2000 period (Schneider, 2002). In the 2005-07 period, poverty incidence [2] at national level was estimated to be 63.8 %, with 75.9 % in rural areas and 30.1 % for urban areas. The level of poverty in Mali is thus a marked rural phenomenon (FAO, 2010d). In addition, 12 % of Mali's population was undernourished in the period 2005-07 (FAO, 2010c) with high levels of vitamin A and iron deficiency (FAO, 1999a).

Economic activity is largely confined to the riverine area irrigated by the Niger. About 80 % of the labour force is engaged in farming and fishing. Industrial activity is concentrated on processing farm commodities. Annual growth in real output was estimated at 2.70 % in 2009. Inflation was 2.50 % in 2007 (CIA, 2011c). Since 1 January 1999, the West African CFA franc or FCFA (XOF) has been pegged to the Euro at a fixed rate of 655.957 FCFA per Euro.

Main agricultural commodities are rice, millet, groundnut, cotton, sorghum, maize, tomato, watermelon, sweet potato, shea nut, banana,

[1] National estimates of the percentage of the population falling below the poverty line are based on surveys of sub-groups, with the results weighted by the number of people in each group (CIA, 2011a). Definitions of poverty vary considerably among nations and are not comparable among countries.

[2] Poverty incidence is expressed in poverty headcount (FAO, 2011a), which is the proportion of the population who are multidimensionally poor (UNDP, 2010c). The multidimensional poverty index (MPI) identifies multiple deprivations at the individual level in health, education and standard of living. The MPI value is the product of two measures: the multidimensional headcount ratio and the intensity (or breadth) of poverty (UNDP, 2010c). The MPI complements income poverty measures (FAO, 2011a). In practice, although there is a clear overall relationship between MPI and 1.25 $ / day poverty, the estimates do differ for many countries which can be explained by the fact that they measure different conceptions of poverty (FAO, 2011a).

yam and cowpea; main export commodities are cotton, groundnut oil and groundnut, mango and livestock products (FAO Stat, 2010).

Mali is heavily dependent on foreign aid. The government implements a recommended structural adjustment program of the International Monetary Fund (IMF) that is helping the economy to grow, diversify, and attract foreign investment (CIA, 2011c). National poverty reduction strategy papers (PRSPs) are one of the main tools by which individual countries first define, and then articulate and monitor their plans to address the millennium development goals (MDGs) (Garrity, 2004). The PRSP of Mali (IMF, 2008b) mentions three strategic orientations: development of infrastructures and the productive sector, pursuance and consolidation of structural reforms, and strengthening of the social sector.

3.1.2 Benin

Present-day Benin once was the site of Dahomey, a prominent West African kingdom that was founded in the 15th century. The territory became a French colony in 1872 and achieved independence on 1 August 1960, as the Republic of Benin (CIA, 2011b).

Geographic situation

Benin is located between Togo and Nigeria, and is bordered by Burkina Faso and Niger in the north, and the Bight of Benin in the south (Figure 3.2). Although and *de facto* the administrative capital is Porto Novo, Cotonou is the economic capital. Benin has a total area of 112,622 km^2 of which 110,622 km^2 is land. Benin is subdivided in 12 departments: Alibori, Atacora, Atlantique, Borgou, Collines, Kouffo, Donga, Littoral, Mono, Oueme, Plateau and Zou.

Population data

Total population is estimated at approximately 9,100,000 in 2010 (CIA, 2011b). About 45.30 % of all Beninese are under 14 years, 52.10 % are between 15-64 years of age and only 2.60 % are above the age of 65. Life expectancy at birth is 59.42 years according to CIA (2011b), while UNDP (2010c) reports 62.3 years. Annual population growth rate is estimated at 2.94 %. CIA (2011b) reports a literacy rate of 34.70 %, whereas UNDP (2010c) estimates the rate of literacy at 43.00 %. Even though the official language is French, many tribal languages exist, among which Fon and

Figure 3.2: Map of Benin (adapted from Perry-Castañeda library map collection) with indication of the location of Benin in Africa and the vegetation zones important for the present study, namely (II) the Sudanian region, and (III) the Guinea-Congolia/Sudania regional transition zone (White, 1983)

Yoruba are the most commonly used (CIA, 2011b). Each ethnic group has its own language.

Development and economic indicators

Benin is a poor country with a highly unequal income distribution or Gini coefficient of 0.39 (UNDP, 2010c) or 0.37 (CIA, 2011c). About 37.40 % of the population lives below the national poverty line in a country where annual GDP is estimated to be 14.20 $ billion (CIA, 2011b). GDP per capita (PPP) amounts to 1,499 $ according to UNDP (2010c) and 1,500 $ according to CIA (2011b). The informal economy is estimated to be 45.2 % of GDP in the 1999-2000 period (Schneider, 2002). In the 2005-07 period, the incidence of poverty (poverty headcount) at national level was estimated to be 39.0 %, with 46.0 % in rural areas and 29.0 % for urban areas. The level of poverty in Benin is thus basically a rural phenomenon (FAO, 2010b). According to FAO (2010a), 12 % of Benin's population was undernourished in the period 2005-07 with high levels of vitamin A and iron deficiency (FAO, 2003).

The economy of Benin remains underdeveloped and dependent on subsistence agriculture, cotton production, and regional trade in agricultural commodities. Annual growth in real output has averaged around four percent over the past three years, but rapid population growth has offset much of this increase. Inflation has dropped over the past years, from 7.90 % in 2008 to 1.60 % in 2010 (CIA, 2011b). Since 1 January 1999, the West African CFA franc or FCFA (XOF) has a fixed exchange rate to the Euro, namely 1 Euro = 655.957 FCFA.

Main agricultural commodities in terms of production are yam, cassava, cotton, maize, bean, groundnut, cashew nut, pineapple, tomato, chilli and pepper; main export commodities are cotton lint, cashew nut, palm oil and pineapple (FAO Stat, 2010). CIA (2011b) reports also shea butter as export product.

In order to raise growth, Benin plans to attract more foreign investment, place more emphasis on tourism, facilitate the development of new food processing infrastructure and agricultural products, and encourage new information and communication technology (CIA, 2011b). The PRSP of Benin (Anonymous, 2007; IMF, 2008a) states four priority areas of intervention to raise growth: stabilisation of the macroeconomic framework, stimulation of the private sector, diversification of the economy, and promotion of regional integration. In addition, other interventions concern development of infrastructures (including energy and water), reinforcement of human capital (including education, health services and social security), promotion of good governance and sustainable use of natural resources (Anonymous, 2007).

3.1.3 Comparison of Mali and Benin

Based on the country profiles described above and the figures presented in Table 3.1, the first obvious difference between Mali and Benin is the geographical situation: Mali is a landlocked country, whereas Benin has a coastline. Therefore, Mali has no maritime harbour. The port of Cotonou is, however, an important – and at the same time potential – gateway to landlocked West African countries, such as Niger, Burkina Faso and Mali. Till now, high shipping costs, low efficiency, and poor logistical facilities have kept it from becoming a key trade route (IFC, 2009). Besides the port of Cotonou, there are also other ports in the Gulf of Guinea which are suitably linked to the Sahelian capitals Bamako, Ouagadougou and Niamey. These north-south axes are facing growing competition from east-west corridors, notably from Dakar, Nouakchott, Banjul and Conakry (ECOWAS-SWAC/OECD, 2006).

In Mali, the navigable Niger river has an important transport function. The Niger river, the principal river of western Africa, has its source in south-eastern Guinea, runs in a crescent through Mali, Niger – on the border with Benin – and then through Nigeria, discharging through a massive delta, known as the Niger Delta, into the Gulf of Guinea in the Atlantic Ocean.

The road network in both Mali and Benin depends largely on development aid which finances several projects per year, and has been doing so for several decades. These investment efforts have led to the current regional system, which, while imperfect, shows considerable improvements. However, the quality of the network varies significantly because of a lack of maintenance. If railways had continued to develop after independence, today they could have eased the road from the heavy loads carried over long distances by trucks (ECOWAS-SWAC/OECD, 2006).

Mali is more than ten times the area of Benin, but Benin has a higher percentage of arable land. Arable land includes land defined by the FAO

Table 3.1: Country profiles of Mali (CIA, 2011c) and Benin (CIA, 2011b)

	Mali	Benin
Geography		
Total area (km^2)	1,240,192	112,622
Coastline (km)	landlocked	121
Arable land (%)	3.76	23.53
People		
Population	13,796,354	9,056,010
0 - 14 years (%)	47.50	45.30
15 - 64 years (%)	49.50	52.10
65 years and over (%)	3.00	2.60
Median age (years)	15.80	17.20
Male (years)	15.50	16.80
Female (years)	16.20	17.70
Population growth rate (%)	2.61	2.94
Birth rate (births / 1,000 population)	46.09	38.67
Death rate (deaths / 1,000 population)	14.64	9.23
Infant mortality rate (deaths / 1,000 live births)	113.66	63.13
HIV / AIDS adult prevalent rate (%)	1.50	1.20
Urban population (% of total population)	32.00	41.00
Rate of urbanisation (% annual rate of change)	4.80	4.00
Total fertility rate (children born / woman)	6.54	5.40
Life expectancy at birth (years)	52.17	59.42
Male (years)	50.59	58.21
Female (years)	53.80	60.68
Religions		
Christian (%)	1.00	42.80
Muslim (%)	90.00	24.40
Vodoun or indigenous beliefs (%)	9.00	17.30
Other religions (%)	0.00	15.50
Literacy: age 15 and over can read and write (%)	46.40	34.70
Male (%)	53.50	47.90
Female (%)	39.60	23.30

Table 3.1: Country profiles of Mali (CIA, 2011c) and Benin (CIA, 2011b) (Continued)

	Mali	Benin
Economy		
Gross domestic product (GDP)		
Purchasing power parity (PPP) ($)	16.74 billion	14.20 billion
Real growth rate (%)	5.20	3.00
Per capita (PPP) ($)	1,200	1,600
GDP: composition by sector		
Agriculture (%)	45.00	33.20
Industry (%)	17.00	14.50
Services (%)	38.00	52.30
Population below national poverty line (%)	36.10	37.40
Distribution of family income (Gini index)	40.10	36.50
Unemployment rate (%)	30.00	NA
Labour force	3,241,000	3,662,000
Agriculture (%)	80.00	NA
Industry and services (%)	20.00	NA
Inflation rate (consumer price) (%)	2.50	1.60
Communications		
Main telephone lines in use	81,000	127,100
Mobile cellular phones	3,742,000	5,073,000
Internet hosts	524	1,286
Internet users	249,800	200,100
Transportations		
Airports	20	5
With paved runways	8	1
With unpaved runways	12	4
Railways (km)	593	578
Roadways (km) of which	18,709	16,000
Paved (km)	3,368	1,400
Unpaved (km)	15,341	14,600
Waterways (km)	1,800	150
Ports and terminals	Koulikoro	Cotonou

NA: figures not available

as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land under temporarily fallow. Land abandoned as a result of shifting cultivation is excluded (World Bank, 2011).

Population data of both countries are roughly speaking comparable. *E.g.* population growth rates in Mali and Benin are at first sight comparable. However, in Benin the growth rate decreased over the past years, whereas in Mali it has increased. Moreover, median age and life expectancy are higher in Benin than in Mali, and can be linked to a lower death rate in Benin compared to that in Mali. The majority of the population in Mali is Muslim, whereas in Benin there is a mix of Christian, Muslim, indigenous beliefs and other religions. Literacy rate is evaluated better in Mali than in Benin. A similar urbanisation rate has been reported for both countries.

With a human development index (HDI) of 0.309 Mali occupies place 160 on 169 countries, whereas Benin with a HDI of 0.435 is ranked as number 134 (UNDP, 2010c). The HDI provides a composite measure of three basic dimensions of human development: living a long and healthy life (measured by life expectancy), being educated (measured by adult literacy and gross enrolment in education) and having a decent standard of living (measured by PPP) (UNDP, 2010c). Between 1980 and 2010, Mali's HDI rose by 2.10 % annually from 0.165 to 0.309 today (UNDP, 2010b). In comparison, during the same period, Benin's HDI rose by 1.70 % annually from 0.264 to 0.435 today (UNDP, 2010a).

Furthermore, Table 3.1 reports a similar percentage of population below the national poverty line in Mali and Benin. The common international poverty line has in the past been roughly 1.00 $ a day as proposed in the 1990 World Development Report 'Poverty for measuring absolute poverty by the standards of the world's poorest countries'. In 2009, the World Bank revised the international poverty line and proposed 1.25 $/ day (PPP) as new poverty line at (Ravallion *et al.*, 2009). Thus, population below 1.25 $ a day is the percentage of the population living on less than 1.25 $ a day at 2005 international prices (World Bank, 2011). In Mali, the population below the international poverty line is 51.40 %, whereas in Benin 47,30 % of the population lives below 1.25 $ a day (UNDP, 2010c). Also the Gini indices in both countries studied are similar and evidence a highly unequal income distribution. The Gini coefficient is a measure of the inequality of income distribution: a value of 0 expresses total equality and a value of 1 (or 100) maximal inequality.

To conclude, the agricultural sector in Mali contributes the most to GDP, which is the value of all final goods and services produced within a nation in a given year, when compared to services and the industrial sector (CIA, 2011a). In Benin, the tertiary sector or services are the main contributor to GDP, followed by the agricultural and industry sector.

3.1.4 Study sites

The present field research was conducted in three different vegetation zones, namely the Sahel regional transition zone, the Sudanian region and the Guinea-Congolia/Sudania regional transition zone (White, 1983). The occurrence of these different bio-climatic zones in Mali and Benin is shown in Figures 3.1 and 3.2. Only the Sudanian region occurs in both countries and can be found in southern Mali and northern Benin. The Sahel regional transition zone occurs within the central part of Mali, while the Guinea-Congolia/Sudania regional transition zone is located in southern Benin.

In the Sahel regional transition zone, rainfall is unimodal and ranges between 300 and 650 mm per year, whereas the rainy season has a maximal duration of 60 days. In the Sudanian region, annual rainfall is also unimodal and varies between 650 and 1000 mm, whereas rainfall is bimodal with a mean annual of 1200 mm in the Guinea-Congolia/Sudania regional transition zone.

In the scope of the DADOBAT project, field research areas in Mali and Benin were defined to coincide with the agro-ecological zones defined by White (1983). Within these zones, and based on previous surveys by the project's local partner institutes, *i.e.* University of Abomey-Calavi in Benin and Institute of Rural Economy in Mali, sites with abundant baobab and tamarind tree populations were chosen and respondents were identified there. Figure 3.3 shows that in the Sahel regional transition zone of Mali, the region of Mopti was selected. In the Sudanian region of Mali regions Ségou, Sikasso and Kayes were selected together with the capital district Bamako. For Benin, Figure 3.4 shows that in the Sudanian region places in departments Alibori, Atacora, Borgou, Donga and Collines were sampled, whereas in the Guinea-Congolia/Sudania regional transition zone departments Mono, Littoral, Atlantique and Ouémé were selected. The research sites within each region or department in respectively Mali and Benin are shown in Figures 3.3 and 3.4. As the objective of the present study was not to identify regional differences in market chains, data gathered in each site were bulked per country. However, the author does not exclude that there might be significant regional differences.

3.2 Material and methods

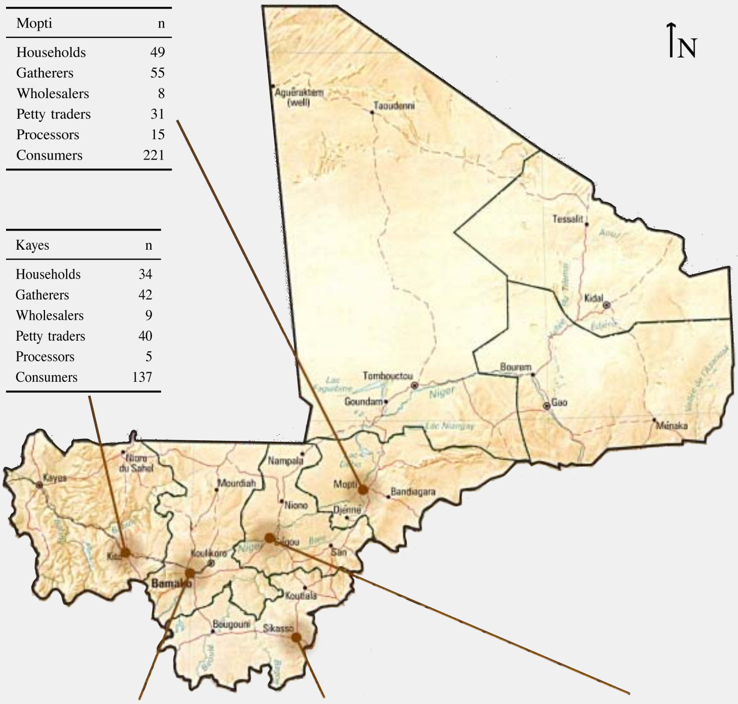
To be able to formulate an answer on the objectives set for this study, an in-depth analysis of the market chain for selected baobab and tamarind products is required, through which specific actors are identified and characterised, relationships among actors are understood, bottlenecks are identified and actions proposed for overcoming them. Data for market analysis can be divided into, on the one hand, primary data collected by the investigator during field research, and, on the other hand, secondary data that have been documented by other people and organisations, and gathered during desk research (Marshall *et al.*, 2006a).

As already mentioned in the literature review, value chains (hereafter called market chains) can be mapped and analysed using value chain analysis (hereafter referred to as market chain analysis). Tools to map the market are participatory market chain analysis (PMCA) and rapid market analysis (RMA). The present study followed the principles of RMA as a first step of PMCA. Both qualitative and quantitative tools can be used for market chain research (Hellin & Meijer, 2006). There are no fixed rules on which research approach is better but there are strong grounds for recommending that a qualitative approach is used first, followed by a quantitative study (Hellin & Meijer, 2006). Tools to be used during a participatory market chain analysis include (Hellin & Meijer, 2006; Bammann, 2007):

- participant observation is fundamental to much qualitative research and leads to a better understanding of the characteristics of the situation being studied;
- semi-structured interviews are guided conversations in which topics are predetermined and during which new questions and insights arise as a result of the discussion; and
- questionnaires are essential to obtain quantitative data which are needed to permit a more objective assessment and facilitate an assessment of trends and relationships among different value chain actors.

Mopti	n
Households	49
Gatherers	55
Wholesalers	8
Petty traders	31
Processors	15
Consumers	221

Kayes	n
Households	34
Gatherers	42
Wholesalers	9
Petty traders	40
Processors	5
Consumers	137



Bamako	n
Households	-
Gatherers	-
Wholesalers	22
Petty traders	33
Processors	22
Consumers	-

Sikasso	n
Households	-
Gatherers	-
Wholesalers	2
Petty traders	-
Processors	-
Consumers	-

Ségou	n
Households	51
Gatherers	57
Wholesalers	12
Petty traders	26
Processors	5
Consumers	249

Figure 3.3: Research sites in Mali and number of respondents per region (map adapted from Perry-Castañeda library map collection)

Atacor	n
Households	13
Gatherers	19
Wholesalers	1
Petty traders	10
Processors	1
Consumers	14

Alibori	n
Households	27
Gatherers	39
Wholesalers	2
Petty traders	24
Processors	6
Consumers	27

Donga	n
Households	13
Gatherers	18
Wholesalers	-
Petty traders	10
Processors	-
Consumers	11

Borgou	n
Households	-
Gatherers	-
Wholesalers	-
Petty traders	9
Processors	5
Consumers	9

Collines	n
Households	10
Gatherers	10
Wholesalers	-
Petty traders	6
Processors	4
Consumers	12

Ouémé	n
Households	-
Gatherers	-
Wholesalers	-
Petty traders	4
Processors	8
Consumers	11

Mono	n
Households	10
Gatherers	10
Wholesalers	-
Petty traders	-
Processors	3
Consumers	4

Atlantique	n
Households	-
Gatherers	-
Wholesalers	-
Petty traders	-
Processors	5
Consumers	5

Littoral	n
Households	-
Gatherers	-
Wholesalers	5
Petty traders	10
Processors	5
Consumers	13

Figure 3.4: Research sites in Benin and number of respondents per department (map adapted from Perry-Castañeda library map collection)

Hereby, questionnaires focus on what market chain actors are doing, whereas qualitative research tools not only provide a means to check the reliability of data from questionnaires, but also give more insight into why actors are doing what they do and how they formulate their decisions (Hellin & Meijer, 2006).

The present research is set out as a case study, following an embedded multiple-case design according to Yin (2003). The term multiple-case refers to four cases: the leaf and fruit products of both baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.). For each case, two – so-called – embedded units of research can be identified, namely the different market chains in Benin and Mali, and their analysis.

3.2.1 Data collection

During field research, in total, 507 individual stakeholders in the market chain of baobab and tamarind products were interviewed in Mali between July and October 2007, whereas in Benin we interviewed 221 informants during the period January – April 2010. Table 3.2 shows both the number of individual respondents and the number of respondents for each market chain actor of baobab and tamarind products in Mali and Benin. Additionally, Figures 3.3 and 3.4 not only show the research sites in both countries (as discussed above), but also the number of respondents interviewed per chain actor of baobab and tamarind products in the different study sites. To increase the likelihood that heterogeneity of viewpoints is properly captured in the interviews, da Silva & de Souza Filho (2007) suggested as a rule of thumb to consider at least five informants per chain segment and keep adding to this number if essential divergence becomes apparent.

By stakeholders the author means all actors that are involved in the market chain of baobab and tamarind products, such as gatherers, traders, processors and consumers who harvest, buy, sell, process and/or use baobab and/or tamarind products. Different baobab and tamarind products should be understood as fresh baobab leaves, dry baobab leaves, baobab leaf powder, baobab fruit pulp, tamarind leaves and/or tamarind fruit pods. Because there are several baobab and tamarind products, an individual actor may be considered as a respondent for up to six different baobab and tamarind products. Consequently, depending on the number of different baobab and tamarind products mentioned, one individual

Table 3.2: Number of interviewed (individual) respondents for each market chain actor of baobab and tamarind products in Mali and Benin

	Mali		Benin	
	Individual respondents	Respondents	Individual respondents	Respondents
Households	64	134	44	73
Gatherers	83	154	44	96
Wholesalers	40	53	6	8
Petty traders	102	130	29	73
Processors	21	47	32	37
Consumers	197	607	66	106
Rural	113	365	13	19
Urban	84	242	53	87
Total	507	1,125	221	393

Due to several baobab and tamarind products, an individual actor is considered as a respondent for different products. Therefore, depending on the number of different baobab and tamarind products, one individual actor may be counted as several respondents for data analysis purposes.

actor may be counted as different respondents in the data set. *E.g.* an individual processor of baobab fruit pulp and tamarind fruit pods will be treated as two different respondents for certain (statistical) analyses (as will be further explained), *i.e.* a processor of baobab fruit pulp and a processor of tamarind fruit pods. To avoid confusions, when individual respondents or chain actors are considered, the word 'individual' will always be mentioned in the text, whereas in the other case, the word respondent or chain actor will not be accompanied by the adjective individual. Applied to the example given, this means that one individual respondent will be counted as two respondents in certain data sets.

In Mali, the author worked together with an agricultural economist and three technicians, all four staff of the Institute of Rural Economy in Mali and involved in the DADOBAT project. During field work, four research couples were formed between researchers from Ghent University and the Institute of Rural Economy. In Benin, data collection was monitored by the author and field-executed by a master of agricultural science within the scope of the DADOBAT project. In both countries, field work was carefully prepared, organised, co-executed and supervised by the author herself. During the preparation phase, all different questionnaires were first pre-tested and corrected or revised when necessary. Secondly, as several researchers were involved in the field research, a meeting was organised to make sure that all questions were understood well and asked in the same way by all researchers. Additionally, it was made sure that all local researchers translated the questions in the same way in Bambara and Fon, the main local languages in Mali and Benin, respectively. Also in Benin, a preparatory meeting was held during which the research objectives and all questions were clearly explained. During the execution phase, we had regular follow-up meetings – in the beginning daily and at the end at least weekly – to discuss any observations or problems encountered during data collection.

Hereafter, the sampling methods used to describe the characteristics and activities of, and linkages between all chain actors involved in the market chain of baobab and tamarind products are explained. In this context, in total, five sets of semi-structured questionnaires were developed, all with the same basic structure and containing questions related to gathering, buying, selling, storage practices, price setting, quality assessment and information flow. Table 3.3 gives an overview of the topics covered by the different semi-structured questionnaires designed for each chain actor. Each questionnaire was further tailored to match each of the five main chain actors, *i.e.* gatherers, wholesalers, petty traders, processors and consumers. Moreover, questionnaires were adapted to the particularities of each country, while at the same time maintaining the same structure and format across the two countries in order to allow for comparisons.
Each of the following sections – about the sampling methods used per chain actor(s) – starts with the author's definition of the chain actor(s) printed in italics. Definitions given are in accordance with the definitions documented previously in the literature review.

Gatherers

Gatherers of baobab and tamarind products are rural smallholders who are mainly engaged in production and gathering activities, both for their own subsistence needs and for sale.

In each study site, field research started at the supply level of the marketing chain, *i.e.* the gatherers in rural areas. In each village were we collected data, as recommended by Marshall *et al.* (2006a), an introductory meeting was first arranged to obtain permission for field research by the local leaders or authorities. This meeting was used to

Table 3.3: Overview of topics covered by the different semi-structured questionnaires designed for each chain actor involved in the market chain of baobab and tamarind products

	Gatherers	Wholesalers	Petty traders	Processors	Consumers
Socio-economic data	x	x	x	x	x
Business specifications	–	x	–	x	–
Quantities and prices	x	x	x	x	x
Buying and selling period	x	x	x	x	x
Price determination	x	x	x	–	–
Origin / destination	x	x	–	x	x
Who buys from whom	x	x	–	x	–
Quality criteria	x	x	x	–	x
Storage practices	x	x	x	x	x
Transport	–	x	–	x	–
Processing practices	x	–	–	x	–
Uses	–	–	–	–	x
Consumption trends	–	–	–	–	x
Information flow	x	x	–	x	–
Problems encountered	x	x	x	x	x

x: covered by questionnaire; –: not covered by questionnaire introduce the project to the local community and to get to know the village. In total, ten introductory meetings were held, three in Mali and seven in Benin. In particular, the villages Mandoli, Sorobougou and Kolna were chosen in Mali situated within a radius of 50 km to the urban centres of Mopti, Ségou and Kita, respectively (Figure 3.3). In Benin, introductory meetings were held in the villages of Koffaïssa, Banité, Kpabiegou, Banité, Tchanka, Sodo and Hounontin, and situated respectively within a radius of 50 km to the urban centre of Kandi, Malanville, Natitingou, Djougou, Dassa, Lokossa and Lokossa (Figure 3.4).

Another purpose of the introductory meetings was to identify adequate respondents, in this case gatherers of baobab and tamarind products. As the present research is about the market chain of baobab and tamarind products, a prerequisite for a gatherer to participate in this study was to harvest the products of at least one of the two species. In addition, gatherers had – of course – to be willing to participate in the research. The gatherers appointed during the introductory meetings as knowledgeable would then lead the researchers further to other gatherers they considered knowledgeable and so on. This method is known as snowball sampling (Barry, 2007).

Because individual gatherers are all part of a family or household, we also incorporated the household as a unit of analysis in the present study. A household is hereby defined as a group of persons living together who make common provision for food or other essentials for living (United Nations, 2007). Once a gatherer – and thus a household – was chosen, two semi-structured questionnaires were presented during the interviews, one evaluating the household assets and different cash income sources, the second dealing with aspects related to the gathering practices of baobab and/or tamarind products. The purpose of the household questionnaire was to provide a more holistic and complete understanding of the household's composition, activities and cash incomes. The topics covered by the questionnaire about gathering practices of baobab and tamarind products are presented in Table 3.3.

The interviews with gatherers usually lasted for about one hour and took place at the respondents' homes, which made it possible to observe daily life and to ask questions about actions or situations observed.

Traders

Collectors and assemblers buy baobab and tamarind products from gatherers at the farmgate and resell the products to other traders on a marketplace. Wholesalers sometimes buy produce from gatherers, but tend to rely on collectors and assemblers as their main source of supplies. Wholesalers often cater for the needs of larger urban markets and sell to other wholesalers, processors and retailers. Retailers are very diverse in size. The larger retailers buy either directly from gatherers or wholesalers, while the smaller retailers or petty traders often buy in small amounts from the larger retailers. Retailers have as main role the distribution of baobab and tamarind products to consumers.

Due to a lack of functional specialisation, it is difficult to categorise traders or intermediaries by their function(s) in the market chain of baobab and tamarind products. Therefore, during field research, an arbitrary distinction was made between on the one hand 'large' traders, including collectors and assemblers, wholesalers and large retailers, and on the other hand 'small' traders, regrouping only small-scale retailers. The composition of the arbitrary category 'large' traders, hereafter called **wholesalers**, is shown in Table 3.4. The other category of small-scale retailers is hereafter referred as **petty traders**. If both wholesalers and petty traders are considered, traders will be used as a grouping name.

Table 3.4: Composition of arbitrary category 'large' traders (%)

	Mali	Benin
Collector / Assembler	4	37
Wholesaler	26	63
Large retailer	70	0

At each urban and rural market in the study sites (Figures 3.3 and 3.4), wholesalers and petty traders of baobab and tamarind products were interviewed. Traders were selected by an informal random approach and only included in the sample if they met the following criteria: handling in baobab and/or tamarind products, regular presence in the market, in business for at least one year, and willing to work with us.

The topics covered by the semi-structured questionnaires about trading practices of baobab and tamarind products for wholesalers and petty traders are presented in Table 3.3.

As one can derive from the table, the questionnaire for petty traders was much shorter than the questionnaire for wholesalers. This is due to several factors. The first reason has a practical nature. Most petty traders have limited space on the often crowded marketplace. As a result there is almost no space for the researcher(s) to sit or stand next to the petty trader in order to perform the interview. Moreover, due to narrow corridors between market stands and a lot of passage, the researcher(s) risk(s) to stand in the way of passer-bys. The second reason is that petty traders often do not have much time to answer questions as there are almost constantly customers buying things. This means that the interview is interrupted each time a new customer arrives. As a consequence, the petty trader loses his/her concentration and either forgets the question or will not answer to the question. The final reason is that petty traders become impatient and unwilling to answer when an interview takes too long. Therefore, the petty trade questionnaire was restricted to 15 minutes.

For the interviews with wholesalers, an appointment was made prior to the interview in order to be sure about the availability of the respondents during the whole duration of the interview which was approximately one hour.

A special type of retailers, hereafter called **caterers** and encompassing bar, restaurant and/or hotel holders, has frequently been observed during field research in Mali and Benin. Caterers in particular offer locally produced juices to their clients, the consumers. In the present study, no interviews have been performed with caterers, which implies that all results – and thus their implication in market chain – are solely based on observations and informal conversations.

Processors

Processors are either small household enterprises or groupings of processors. Their task is to process primary and/or secondary products into tertiary aiming to increase the value of a product or to make it more convenient for the end user.

A product is defined by Ferris *et al.* (2006) as a basic unit being traded and the same authors make a distinction between primary, secondary and tertiary products. Primary products are the basic units harvested or gathered, secondary products are sub-products derived from primary products, whereas tertiary products are a further differentiation or processing of secondary products. When a primary product is turned into a secondary, this is called primary processing, whereas secondary processing transforms a secondary product into a tertiary product.

Figures 3.3 and 3.4 show the study areas where processors have been interviewed. Similar selection criteria as for traders were adopted to withhold processors, namely processing of baobab and/or tamarind products, in business for at least one year, and willing to work with us. The topics covered by the semi-structured questionnaires about processing practices of baobab and tamarind products are presented in Table 3.3. In accordance with the interviews with wholesalers, an appointment was also made prior to an interview with a processor in order to make sure that he/she was available during the whole duration of the interview which was approximately one hour.

Consumers

Consumers are the end users of baobab and tamarind products.

The sites where consumers of baobab and tamarind products have been sampled are shown in Figures 3.3 and 3.4. Selection criteria for the choice of consumers were their use of baobab and/or tamarind products and their willingness to participate in the study. In rural areas, consumers of baobab and tamarind products were selected by an informal random approach by going from door to door, whereas in urban areas, consumers of baobab and tamarind products were selected at random by accosting them on the marketplace. The interviews with rural consumers usually lasted for about one hour as they took place at the respondents' homes, which made it possible to observe daily life and to ask questions about observed actions or situations. An interview with a consumer in urban areas lasted for about half an hour.

Topics covered by the semi-structured questionnaires for consumers are presented in Table 3.3. One of the questions included in the consumer questionnaire is about the existence of substitution products of respectively baobab and tamarind products. The reader should hereby know that according to Will (2008), a product is called a substitute for another product when it can be either used or consumed instead of the other without major differences in the degree of satisfaction obtained by the user or consumer.

3.2.2 Data analysis

Quantitative data analysis

Household income The calculation of total household income is complex and consists according to Cavendish (2002) of four major subcategories: (i) the value of cash income; (ii) the (net) value of gifts; (iii) the value of the use of own-produced/subsistence goods; and (iv) the value of environmental resource uses. In short, this means that:

$$\text{total income} \quad = \quad \text{cash income} \quad + \quad \begin{array}{l}\text{value of all non-purchased}\\ \text{goods and services}\end{array}$$

The importance of subsistence consumption, gifts and environmental resource use becomes obvious when individual households may not be able to produce more than they can use, resulting in no surplus production to be sold in the marketplace. When surpluses occur, these are often bartered rather than sold (Boxall & Beckley, 2002). In the present study, only a rough estimate was made of the household's income whereby only cash income was taken into account.

According to Cavendish (2002) cash income can be derived from different household activities such as crop and livestock production, off-farm activities (*e.g.* casual wages, formal employment and small-scale industries) and activities based on selling of agroforestry tree products (AFTPs) (*e.g.* foods and medicines). In this study, cash income was calculated as the sum of revenues from crop production, off-farm and ATFP gathering. It should be noted however that revenue from livestock production was not taken into account due to missing data.

Calculating total cash income involves summing up the cost of all inputs used in an income-generating activity and deducting these from the value of cash income gained in that activity. In order to be more specific, KIT & IIRR (2008) made a distinction between

$$\text{gross income} \quad = \quad \text{revenues} \quad - \quad \text{variable costs}$$

and

$$\text{net income} = \text{revenues} - \text{variable costs} - \text{fixed costs},$$

whereby revenue is defined as the selling price of the produce (KIT & IIRR, 2008) and calculated as price times quantity. In this study, an attempt was made to calculate gross income. However, several authors (Cavendish, 2002; KIT & IIRR, 2008) report some problems which are common when calculating costs and revenues. In this respect, it should be mentioned that costs of agricultural products and services vary widely from place to place, from season to season, from day to day, and even within a single day. Moreover, due to the multi-field and/or multi-crop nature of most crop production activities and the sometimes low levels of commercialisation, local respondents are not always able to assign (correct) input values to individual crops. In the present study, it should be noted that low variable costs were recorded as informants reported only limited use of inputs, such as artificial fertilisers and pesticides. As a consequence, gross income is mainly determined by revenues.

In the present study a 'snapshot' was made to gather information to calculate the gross income. This implies that, on the one hand, data were collected during a single field research (thus without repetitions in time) and, on the other hand, that mean quantities and prices were used in the calculations. In addition, it should be noted that, although most households used their own (unpaid) labour in household production (*e.g.* harvesting), the input 'labour' was not taken into account in this study due to limited data.

According to Cavendish (2002), inter-household adjustments need to be made by using an equivalence scale, which converts households of different sizes and compositions to a common scale, in order to be able to calculate average annual cash income per household member. A simple method, described by Cavendish (2002), was used to adjust for age/gender of household members, economies of scale based on total household size, and length of residence or different household members. Based on these three coefficients, average annual cash income per household member was calculated in the present study as household income per adjusted adult equivalent unit (aeu).

Calculations As observed during field research, gatherers harvest fresh (*i.e.* primary) products, but mostly sell secondary products to traders, processors and/or directly to consumers. This means that, in general, gatherers are responsible for primary processing which is often coupled with weight losses. Weight loss from fresh baobab leaves to dry baobab leaves was found to be 73.70 %, and increased even to 84.20 % for baobab leaf powder. Comparable losses of 83.00 % from baobab fresh biomass to dry leaves were reported by Dhillion & Gustad (2004). Based on Assogbadjo (2006), weight loss from whole baobab fruits to baobab fruit pulp was calculated as 82.20 %. These conversion factors were used to convert the quantity of a primary product into the corresponding quantity of a secondary product. By doing so, the quantity harvested can be compared to the quantity sold because it are both quantities of a same product. *E.g.* when a gatherer harvests 100 kg fresh baobab leaves and sells it as baobab leaf powder, the quantity of fresh leaves is converted into the corresponding quantity of leaf powder, *i.e.* 15.80 kg. According to Burkill (1985), tamarind fruit pods contain about 55 % pulp, 35 % seeds, and 10 % shell (pod) and fibres. As gatherers only remove shells and fibres, total weight loss only amounts to 10 %. For tamarind leaves, no conversion factor was needed as all gatherers reported quantities in dry matter.

Field observation learned that only a few traders, particularly wholesalers, have proper weighing equipment, and that most trade of baobab and tamarind products takes place by volume in Mali and Benin. This has also been observed by Fafchamps & Gabre-Madhin (2001) and Shackleton *et al.* (2002). Therefore, local units – mostly units of volume – were as much as possible expressed in kilogramme after weighing or measuring the dimensions.

Based on buying and selling prices, the added value or spread can be calculated. KIT & IIRR (2008) define added value for a particular actor as the price received by the actor minus the price paid by the actor. Thus,

$$\text{added value} \quad = \quad \text{selling price} \quad - \quad \text{buying price.}$$

In the results, on the one hand, percentages, quantities and prices in Euro are rounded off to the nearest whole number. However, an exception is made when numbers are very small, *e.g.* 0.08 % is maintained as 0.08 % instead of becoming 0 %. On the other hand, prices expressed in FCFA are rounded off to the nearest whole number, which is divisible by five. The reason for the latter calculation is that the smallest currency unit in FCFA is 5 FCFA.

Statistical data analysis After editing and codifying, data were statistically analysed using the Statistical Package for Social sciences (SPSS 15.0) following the principles and procedures described in Janssens *et al.* (2008). For all analyses, a 95 % level of confidence ($p < 0.05$) was used as threshold for significance. Frequency and multiple response tables were used as means for the descriptive statistics. As all data were not normally distributed, non-parametric Wilcoxon-Mann-Whitney and Kruskal-Wallis tests were used to compare, respectively, two or k independent samples (comparison of means). The Wilcoxon-Mann-Whitney test may be used with ordinal, interval and ratio variables to decide whether two independent groups have been drawn from the same population. This is one of the most powerful non-parametric tests and is therefore a very useful alternative to the parametric t-test (Siegel & Castellan, 1988). Kruskal-Wallis one-way analysis of variance by ranks requires at least ordinal measurement of the studied variables and is an extremely useful test for deciding whether k independent samples come from different populations (Siegel & Castellan, 1988).

Data envelopment analysis The objective of using data envelopment analysis (DEA) is to determine the relative efficiency for each processor. In this context, the term efficiency is used to describe the level of performance that can be reached by an economic unit in accordance with its production possibilities (Guzmán *et al.*, 2009).

The performance of a firm can be evaluated based on different efficiency measures, namely technical, allocative and economic efficiency (Dhungana *et al.*, 2004; Chavas *et al.*, 2005; Speelman *et al.*, 2008; Guzmán *et al.*, 2009). This study is, however, limited to the calculation of pure technical efficiencies. Technical efficiency relates to the degree to which a firm uses the minimum feasible amount of inputs to produce a given level of output, or produces the maximum feasible output from a given set of inputs. These two definitions of technical efficiency lead to what are known as input-oriented and output-oriented efficiency measures, respectively (Coelli *et al.*, 2002; Dhungana *et al.*, 2004; Dimara *et al.*, 2005). In this study an input-oriented efficiency measure was used.

Over time, two major approaches to measure efficiency have evolved: parametric and non-parametric approaches. The non-parametric approach constructs a linear piecewise function from empirical observations on inputs and outputs without assuming any a priori functional relationship between them (Dhungana *et al.*, 2004). In the present study, the data envelopment analysis or DEA methodology, which is the most popular non-parametric technique (Speelman *et al.*, 2008), is used to measure technical efficiency. The DEA technique, developed by Charnes *et al.* (1978) and Banker *et al.* (1984), is based on the notion that a production unit employing less input than another to produce the same amount of output can be considered more efficient. DEA is a linear programming technique which calculates the relative efficiency of firms with the presence of multiple inputs and multiple outputs (Coelli *et al.*, 2005; Guzmán *et al.*, 2009). Simultaneously an efficient frontier, determined by the most efficient decision-making units according to the productive technology applied, is constructed and efficiency measures are obtained (Speelman *et al.*, 2008; Guzmán *et al.*, 2009). The aim of a DEA is not to define the best level of efficiency but to identify which decision-making units are efficient and, therefore, belong to the frontier, and which are not (Guzmán *et al.*, 2009).

In the present study, the DEA model was made up of one output and seven input variables. The output variable is annual revenue, *i.e.* the annual income obtained by selling tertiary baobab and tamarind products. The seven input variables – and how they are calculated – are listed below.

- Cost of raw material. This cost encompasses the annual cost of purchasing primary and/or secondary baobab and tamarind products. It should be noted that other ingredients, such as sugar or flavourings, were not taken into account in this study.
- Cost of employees. As most processors work with employees which are often paid a wage, the annual cost of all these wages is called the cost of employees. Hereby, it should be noted that family workers are not paid, and thus not include in this cost.
- Cost of packaging material. Processors were asked to estimate per processing cycle how much packaging material was used and at which price they bought it. Given also the total number of processing cycles per year, the annual cost of packaging material used by the respondents was calculated.
- Cost of utensils. All utensils, such as tubs, pots, ladles, sieves and funnels, necessary during the processing of baobab and tamarind products were listed, together with their cost price and their life span. Based on this information, an estimation was made of the annual cost of utensils.

- Cost of equipment. The difference between utensils and equipment was made based on the life span, *i.e.* equipment has a life span of more than four years, whereas the life span of utensils is less than four years. The cost of equipment was estimated similarly to that of utensils. Examples of equipment are a freezer, a crown cap machine and a bag seal machine.
- Cost of resources. This cost includes the cost of electricity, gas, firewood, charcoal and water necessary to process baobab and tamarind products. It should be noted that estimating this input variable turned out to be very difficult for the respondents.
- Cost of storage and transport. The annual costs for hiring a storehouse and/or transporting products was taken into account in this cost category.

Although most of the costs listed above are variable costs, the cost of equipment can be considered a fixed cost. Knowing also the annual revenue, it was possible to calculate annual net income using the earlier defined formula. Hereby, processors were asked to attribute, as much as possible, only those costs needed to process each single baobab and tamarind product.

Qualitative data analysis

Market map As already mentioned in the literature review, market chain analysis can be seen, at the most basic level, as a methodological tool for describing markets (te Velde *et al.*, 2006). Although the most common way is to draw a map of the different chain actors and the interrelationships amongst them, there is no standard approach to map market chains (te Velde *et al.*, 2006). Mapping the market means building up an understanding of the different players or actors in the market chain and the relationships between them, along with the factors that determine how well or badly the chains are working (Hellin & Meijer, 2006).

In the present study, only the central component of the market map shown in Figure 2.5 is drawn for the market maps of baobab and tamarind products. For that objective, and for each baobab and tamarind product, the chain actors have been identified and a box-and-arrow diagram has been drawn to show their linkages and the product flows, as recommended by te Velde *et al.* (2006) and Vermeulen *et al.* (2008). By focusing on the whole range of activities and relations, the market chain approach is simultaneously a descriptive tool and an analytic instrument (Jensen, 2009). As a result, mapping the market includes not only mapping core processes and main actors involved in these processes, together with their relationships and linkages, and flows of products; but also mapping quantities and prices of products, geographical flow of products, value at different levels of the chain, flows of information and knowledge, and business services that feed into the chain (van den Berg *et al.*, 2007).

SWOT analysis The SWOT acronym stands for strengths, weaknesses, opportunities and threats. This study uses a SWOT approach to identify the major factors affecting the performance of the market chain as suggested by da Silva & de Souza Filho (2007). From this point of view, the role of SWOT analysis is to take information from the market chain analysis and separate it into current influences (strengths and weaknesses) and potential future developments (opportunities and threats). The SWOT analysis determines thus whether the information indicates something that will assist a market chain in being successful in a certain environment, or if it indicates obstacles that must be overcome or minimized (da Silva & de Souza Filho, 2007). The intention is to provide an information base to support policy recommendations in a scenario of opportunities and threats (da Silva & de Souza Filho, 2007).

When the SWOT approach is linked the market map concept, opportunities and threats – which arise from factors external to the subject of analysis – would be issues primarily associated with the enabling environment and service providers, whereas strengths and weaknesses – associated with elements internal to the object of analysis – would often include items related to the core market (da Silva & de Souza Filho, 2007). In the present study, the author used a SWOT logic to identify and list major strengths and weaknesses on domestic level, and opportunities and threats on domestic, regional and international level, based on, on the one hand, results and observations presented in the present study and, on the other hand, findings reported in literature.

4

Results

In this chapter, the results of the baobab and tamarind market chain analysis in Benin and Mali are presented. First, functions and interests of the different market chain actors are presented. Secondly, market maps of different baobab and tamarind products are drawn to show the sequence of chain actors involved in transferring the products from gatherer to consumer. Finally, data on quantities, prices, added value, gathering techniques, buying and selling period, storage and processing practices, uses and consumption trends, trade centres, quality criteria, information flows and problems are presented to analyse the market chains of baobab and tamarind products in Benin and Mali. Hereby it should be noted that when Benin and Mali are used in the text the author means the study areas in both countries, and, similarly, with chain actors the author always refers to surveyed informants.

4.1 Chain actors

The different actors participating in the baobab and tamarind market chains in Benin and Mali are gatherers, traders, processors and consumers. In this section, these actors are described in relation to their activities, roles and interests.

4.1.1 Gatherers

Individual gatherers are part of a family or household. Therefore, it is essential to start this section with an overview of the households' composition, activities and cash income, before turning to a description and identification of gatherers as being the first actor in the market chain.

Household composition

In the present study, 64 and 44 rural households have been interviewed respectively in Mali and Benin. The age and gender composition of the sampled household population is given in Figure 4.1 and corresponds well with the national age structure for both countries (Table 3.1). In Mali, an average rural household consists of 25.07 ± 18.42 persons, of which 62 % are active in household and/or subsistence tasks (8.13 men and 7.38 women). In Benin, an average rural household is significantly smaller (Mann-Whitney test, $p < 0.01$) than in Mali, and consists of 14.88 ± 9.84 persons, of which 71 % are active in household and/or subsistence tasks (5.67 men and 4.96 women).

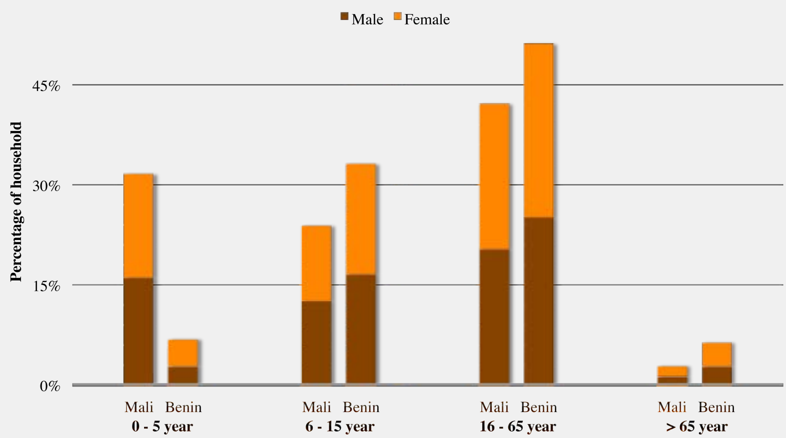


Figure 4.1: Age and gender composition of rural households in Mali and Benin

Household activities

All surveyed households reported to keep livestock, cultivate a variety of crops and harvest diverse products from trees. The latter are hereafter referred to as agroforestry tree products (AFTPs). Besides animal and crop production activities, which form the main cash income generating activities (Table 4.2), many household members reported to be also involved in other activities in order to earn some extra cash income.

Table 4.1 shows livestock distribution between households in the studied countries. Most households reported during informal interviews to derive not just one, but a number of different goods and services from their livestock, especially from small stock, such as milk, manure, savings (via herd growth), cash sales, and meat.

The average field area in Mali and Benin is respectively 7.34 and 3.44 ha (Table 4.2) and is found to be significantly larger in Mali than in Benin (Mann-Whitney Test, $p < 0.01$). In contrast, the average number of crops per household is recorded to be significantly larger in Benin than in Mali

Table 4.1: Livestock distribution per household in Mali and Benin

	Mali	Benin
Cattle	6.65±8.56	0.89±3.04
Draught cattle	2.66±2.38	–
Sheep	6.67±8.41	14.12±8.31
Goat	9.68±12.03	16.04±6.20
Donkey	1.77±1.49	–
Poultry	6.16±8.88	29.70±8.15

(Mann-Whitney test, $p = 0.03$), and is respectively 4.29 and 4.04. The median in Benin is five different crops, while in Mali it is only four crops. The top five of the most cultivated crops by the surveyed households is:

- Mali: *Sorghum bicolor* (sorghum), *Pennisetum glaucum* (millet), *Arachis hypogaea* (groundnut), *Zea mays* (maize) and *Digitaria exilis* (fonio); and
- Benin: *Manihot esculenta* (cassava), *Zea mays* (maize), *Arachis hypogaea* (groundnut), *Sorghum bicolor* (sorghum) and *Pennisetum glaucum* (millet).

Other cultivated crops mentioned by Malian households are, listed according to importance, *Solanum lycopersicum* (tomato), *Allium cepa* (onion), *Sesamum indicum* (sesame), *Mangifera indica* (mango), *Vigna unguiculata* (cowpea), *V. subterranea* (voandzou or Bambara groundnut), *Gossypium* spp. (cotton), *Ipomoea batatas* (sweet potato), *Oryza glaberrima* (rice) and *Citrus sinensis* (orange). In Benin, household members mentioned less other crops, namely *Vigna unguiculata* (cowpea), *Anacardium occidentale* (cashew nut), *Mangifera indica* (mango), *Solanum lycopersicum* (tomato) and *Gossypium* spp. (cotton).

Besides baobab and/or tamarind products, a quarter of the households in Mali reported to collect also other AFTPs, such as products from the shea (*Vitellaria paradoxa*) or African locust bean tree (*Parkia biglobosa*). In Benin, three quarters of the respondents collected AFTPs other than baobab and/or tamarind products.

Most household members are also involved in other agricultural and non-agricultural activities to earn some additional cash income. Some are agricultural workers and execute weeding or ploughing tasks for other households. Others are, mostly outside the agricultural season, craftsmen/-women, bricklayers, unskilled construction workers, smiths, etc.

Household cash income

The first two rows in Table 4.2 show the average production area and annual crop cash income from the surveyed rural households in Mali and Benin. The production area is significantly larger, *i.e.* more or less twice as large, in Mali than in Benin (Mann-Whitney Test, $p < 0.01$), whereas the annual value of crop cash income is about six times higher in Benin than in Mali (Mann-Whitney Test, $p < 0.01$). This indicates a much greater production per unit of land in Benin than in Mali, given the fact that agricultural product prices per kilogram in Benin and Mali are in the same order. In this regard it should also be noted that the mean annual cash crop income from cassava is 4,626,830 FCFA in Benin, which explains about 80% of the total crop cash income in Benin. In contrast, cassava has not been reported to be cultivated in Mali.

Besides the annual cash income data from crop production, Table 4.2 also gives average annual cash income from gathering baobab and tamarind products, and average annual cash income from harvesting AFTPs other than baobab and tamarind, such as shea or African locust bean tree. Annual cash income from baobab and tamarind products, as well as annual cash income from other AFTPs, are found to be significantly higher in Benin than in Mali (Mann-Whitney Test, $p < 0.01$ and $p = 0.03$, respectively). If all AFTPs were considered together – thus also including baobab and tamarind – then one may derive that the portion of cash income generated by gathering baobab and tamarind products is more than one third of total cash income from AFTPs. However, a link between a high cash income from baobab and tamarind products and a high cash income from other AFTPs could not be demonstrated with a correlation test in Mali ($p = 0.13$ and Pearson correlation $= 0.27$). In contrast, cash income from baobab and tamarind products and cash income from other AFTPs are found to be inversely correlated in Benin ($p = 0.01$ and Pearson correlation $= -0.42$). This implies that respondents who gather baobab and tamarind products in Benin generally not gather much other AFTPs, and vice versa. This suggests that gatherers of AFTPs specialise in one or only a few products in Benin.

Furthermore, Table 4.2 shows total annual cash income, which is the sum

Table 4.2: Mean annual cash income-related data for rural households involved in gathering baobab and tamarind food products in Mali and Benin

		Mali	Benin	p-value
Production area	ha	6.92^a	3.86^b	< 0.01
	median	5.75	3.00	
	std. dev.	6.03	2.63	
Crop income	FCFA/y	$998{,}910^a$	$5{,}656{,}020^b$	< 0.01
	median	515,060	5,931,250	
	std. dev.	1,174,100	3,812,650	
	€/y	1,523	8,623	
AFTPs income (excl. baobab and tamarind)	FCFA/y	$38{,}450^a$	$52{,}400^b$	0.03
	median	30,000	50,000	
	std. dev.	27,250	19,640	
	€/y	59	80	
Baobab and tamarind income	FCFA/y	$21{,}030^a$	$43{,}780^b$	< 0.01
	median	3,350	33,775	
	std. dev.	70,375	34,035	
	€/y	32	67	
Total income	FCFA/y	$1{,}108{,}865^a$	$5{,}742{,}375^b$	< 0.01
	median	655,685	6,073,750	
	std. dev.	1,232,585	3,821,185	
	€/y	1,690	8,754	
Income per household member (aeu)	FCFA/y	$94{,}090^a$	$746{,}330^b$	< 0.01
	median	66,470	560,910	
	std. dev.	84,530	619,395	
	€/y	143	1,138	
Portion of income of baobab and tamarind	%	2.77^a	3.32^a	0.12
	median	0.41	0.51	
	std. dev.	5.62	6.97	
	Baobab leaves	0.30^a	0.20^a	0.18
	Baobab fruit	0.08^a	4.36^b	0.04
	Tamarind fruit	5.25^a	0.05^b	< 0.01

Means with a different superscript are significantly different based on Mann-Whitney Test (p-value < 0.05); std. dev. stands for standard deviation of the three cash incomes described in the previous paragraphs and the annual cash income from off-farm activities. In comparison to the total value of crop cash income, total annual cash income per household is also about six times higher in Benin than in Mali (Mann-Whitney Test, $p < 0.01$). Based on these figures, it is clear that the cash income generated by agricultural activities forms the main cash income for rural households in both Benin and Mali.

Average annual cash income per household member in Mali and Benin, calculated by means of adjusted adult equivalent units (aeus) (as explained in the methodology), is also shown in Table 4.2. The huge difference between both countries is curious and significant (Mann-Whitney Test, $p < 0.01$). This information about household cash income can be related to the benchmark for poverty or also called poverty line, *i.e.* 1.25 $ or alternatively about 1.00 € per person per day. Based on the data, each household member receives on average respectively 0.39 and 3.12 € per day in Mali and Benin. The high value for Beninese household members is odd and far above the set poverty threshold, and also the expectations of the author.

In the last row of Table 4.2, the portion of cash income derived from baobab and tamarind products is shown. Notwithstanding the significant differences in cash income values between Mali and Benin, the portion of cash income of baobab and tamarind products does not differ significantly (Mann-Whitney Test, $p > 0.05$). However, statistical analysis indicates a significant higher portion of cash income derived from baobab fruit pulp in Benin than in Mali, whereas the portion of cash income derived from tamarind fruits is significantly higher in Mali than in Benin. The portion of cash income derived from baobab leaves is not found to be significantly different in Mali and Benin.

Households were divided into equal cash income quintiles based on total household cash income. Figure 4.2 illustrates a quintile analysis for the surveyed rural households in Mali and Benin. On the right Y-axis, total annual cash income (FCFA / household) is shown, whereas on the left Y-axis, the portion derived from cash income of baobab and tamarind products (percentage of total cash income) is displayed. On the one hand, for the richer and poorest groups of rural households in Mali, the cash income from baobab and tamarind products is higher (4-5 %) than for the middle income groups (1-2 %). On the other hand, in Benin, the pattern is different as the poorest rural households have a relatively higher portion

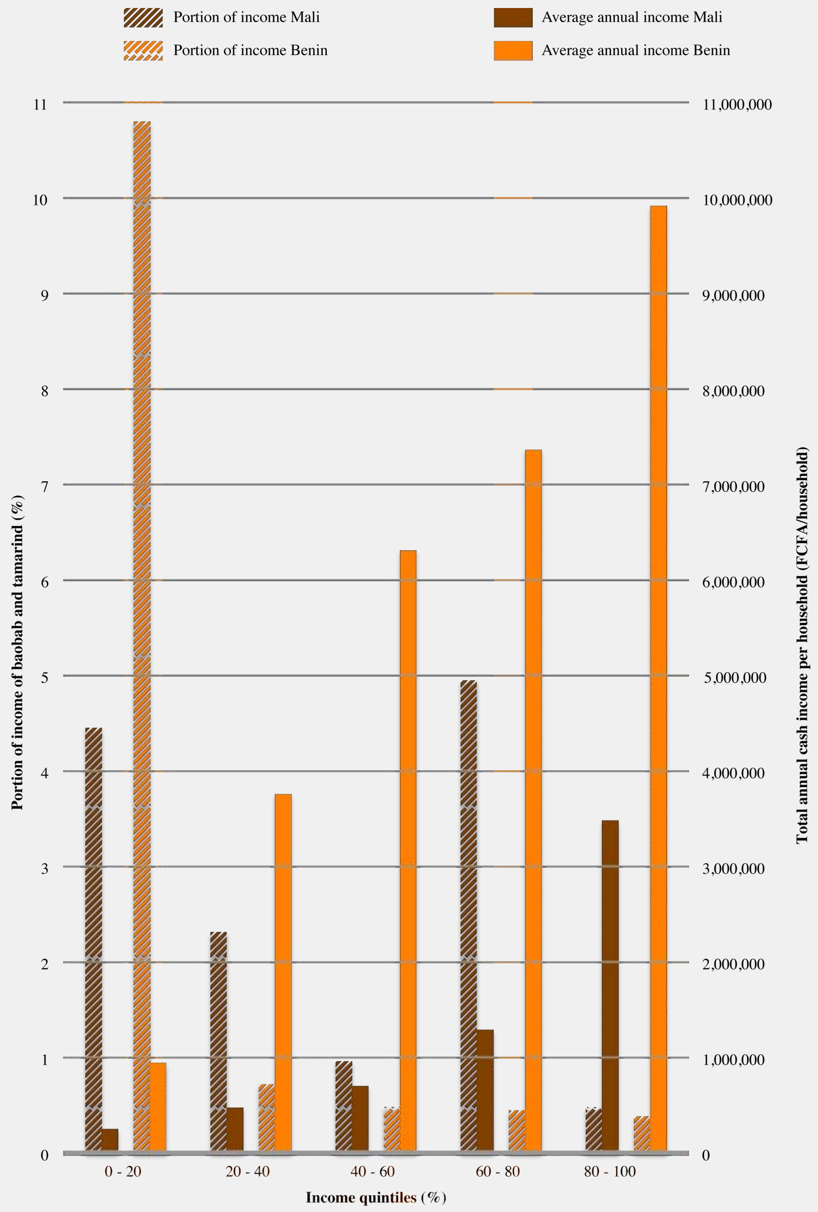


Figure 4.2: Total annual cash income per household and portion of cash income of baobab and tamarind divided per cash income quintiles in Mali and Benin

of cash income from baobab and tamarind products (up to 11 %), while their contribution to other income groups is almost negligible.

Gatherers of baobab and tamarind products

Within each rural household, one (or sometimes two) gatherer(s) of baobab and tamarind products has (have) been interviewed. In total, 83 and 44 individual gatherers of baobab and tamarind products have been sampled in respectively Mali and Benin. Some demographic characteristics of the respondents, such as gender, age and percentage of informants that went to school, are shown in Table 4.3. As can be

Table 4.3: Demographic data on baobab and tamarind product gatherers in Mali and Benin (all figures are %, except age (years))

		Mali	Benin
Gender	Men	68	80
	Women	32	20
Went to school		52	71
Age		44	49

seen in Table 4.3, more men than women were interviewed in both Mali and Benin. This gender bias is probably due to the fact that household representatives are men. The major reason for that is the patriarchal society organisation in both countries. Patriarchy is a social system in which the eldest male is head of the household, having authority over women, children and physical property. Therefore, women were often not allowed to answer questions during interviews. Table 4.3 also reveals a rather high portion of gatherers of baobab and tamarind products in Mali and Benin that went to school. The level of education of gatherers in Benin is reported to be primary school, whereas in Mali respondents mentioned – in descending order of importance – functional alphabetisation, primary school and Koran school.

The principal activity of all gatherers of baobab and tamarind products is crop production, as already mentioned above. Secondary occupations are animal husbandry, market gardening, trading and/or housekeeping. Some smallholders reported to combine their agricultural activities with a job as teacher, tailor, hairdresser, craftsman/-woman, bricklayer, unskilled construction worker or blacksmith – particularly during the dry season when there is no or little agricultural activity.

Baobab and tamarind products, as well as other AFTPs, are mainly harvested from scattered trees growing in fields and fallows, or while on the way to or from agricultural fields. After satisfying household consumption needs, surplus baobab and tamarind products are sold. The majority of gatherers in Benin and Mali, respectively 86 and 80 %, sell their products to collectors or assemblers at the farmgate, which is known as on-farm sales. The other gatherers in Benin (14 %) sell their products to other farmers, while the remaining gatherers in Mali (20 %) sell weekly on a local market to traders or directly to consumers. In two thirds of the cases in Mali, the price is set by the traders whereas only in one third of the cases gatherers determine the price. In Benin, selling prices are, according to all respondents, set by the gatherers.

4.1.2 Traders

As explained in the methods chapter, during field research, an arbitrary distinction was made between on the one hand 'large' traders, hereafter referred to as **wholesalers**, and on the other hand 'small' traders. In Mali, the arbitrary category 'large' traders consists of 70 % retailers, 26 % wholesalers and 4 % collectors or assemblers, whereas, in Benin, the category 'large' traders regroups 63 % wholesalers and 37 % collectors or assemblers. The second arbitrary category of 'small' traders regroups, in both countries, only small-scale retailers and is hereafter called **petty traders**.

In total, 40 and 6 individual wholesalers, and 102 and 29 individual petty traders of baobab and tamarind products were sampled in respectively Mali and Benin. The demographic characteristics gender, age and percentage of informants that went to school, are shown in Table 4.4. As can be seen in the latter table, more female than male wholesalers and petty traders were interviewed, which might imply that baobab and tamarind products are generally traded by women. A rather high portion of traders of baobab and tamarind products went to school. The highest level of education of wholesalers in Benin is reported to be primary school and in only a few cases secondary school, whereas in Mali respondents mentioned primary and Koran school.

Table 4.4: Demographic data on baobab and tamarind product wholesalers and petty traders in Mali and Benin (all figures are %, except age (years))

			Mali	Benin
Petty trader	Gender	Men	19	0
		Women	81	100
	Age		32	39
Wholesalers	Gender	Men	57	38
		Women	43	62
	Went to school		57	63
	Age		38	43

The principal activity of all surveyed wholesalers of baobab and tamarind products is trading (Figure 4.3). Secondary occupations mentioned are agriculture, housekeeping, processing of products and/or animal husbandry. About three quarters of the wholesalers in Benin become trader from father to son, whereas the rest learns it themselves as a profession. In Mali, about half of the traders take over the trading business from their parents and the other half learns it as a profession. All traders in both countries state that selling baobab and tamarind products is profitable because the demand for these products is great. Additionally, no product specialisation has been observed nor recorded, which means that traders are selling a great variety of products at the same time (Figure 4.3).

Trade does not appear to be a one-man's business since most wholesalers have employees, 78 % in Benin and 54 % in Mali. In Mali, four out of five wholesale businesses are family firms as on average one or two other members of the family is/are involved. All wholesale businesses in Benin are family firms whereby two or three additional family members are employed. In most cases, and in both countries, no wages are paid to family members. One fourth of the trade businesses in Mali employs permanent employees, whereas in Benin only one fifth employs permanent workers. The wages of permanent employees vary in both countries between 10,000 and 30,000 FCFA per month (15–45 €).

Figure 4.3: Retailer at marketplace selling a great variety of products

Table 4.5 shows baobab and tamarind product flows between the different types of traders in the market chain. Collectors or assemblers almost exclusively buy from gatherers in Mali and Benin. Wholesalers in Mali buy from other wholesalers, collectors or assemblers and gatherers, whereas wholesalers in Benin buy significantly more from gatherers than in Mali. (Large) Retailers in Mali buy mainly from collectors or assemblers, and wholesalers. In comparison to petty traders in Mali, Beninese petty traders buy significantly more from wholesalers and less from gatherers (Mann-Whitney Test, $p < 0.01$ and $p = 0.01$, respectively), whereas they both buy to a similar extent from collectors or assemblers.

Table 4.5: Actors from which different traders buy their products in Mali and Benin (%)

Type of trader	Source	Mali	Benin	p-value
Collector / Assembler	Gatherer	93^a	100^a	0.27
	Collector / Assembler	0^a	0^a	1.00
	Wholesaler	7^a	0^a	0.50
	Retailer	0^a	0^a	1.00
Wholesaler	Gatherer	11^a	72^b	< 0.01
	Collector / Assembler	36^a	28^a	0.56
	Wholesaler	53^a	0^a	0.08
	Retailer	0^a	0^a	1.00
Retailer	Gatherer	5	-	-
	Collector / Assembler	57	-	-
	Wholesaler	35	-	-
	Retailer	3	-	-
Petty trader	Gatherer	33^a	2^b	0.01
	Collector / Assembler	44^a	17^a	0.09
	Wholesaler	23^a	76^b	< 0.01
	Retailer	0^a	5^a	0.49

Means with a different superscript are significantly different based on Mann-Whitney Test (p-value < 0.05)

According to the surveyed wholesalers in Mali, the buying price is set by negotiation between traders and gatherers (63 %), only by wholesalers (33 %) and only by gatherers (4 %). In Benin, purchase prices are set only by wholesalers (38 %), by negotiation (35 %) and only by gatherers (27 %). In contrast, the selling price of wholesalers is, in both countries, reported to be determined by wholesalers in two thirds of cases, or by negotiation with the buyers in one third of the cases. The major price determining factors listed by Malian wholesalers are supply, demand and transport. In addition to these three factors, profit and seasonality are also mentioned by wholesalers in Benin as price determining factors. On top of these factors, petty traders in both countries listed quality, buying price, availability and price of substitution products as price determining factors.

4.1.3 Processors

In Mali and Benin, 21 and 32 individual processors of baobab and tamarind products were sampled, respectively. Processors categorise themselves as local (72 % in Mali and 62 % in Benin) or semi-industrial processors (28 % and 38 %, respectively). Processors reported to process a wide variety of products, which means that processors have no product specialisation. Gender, age and percentage of surveyed processors that went to school are shown in Table 4.6. More female than male processors

Table 4.6: Demographic data on baobab and tamarind product processors in Mali and Benin (all figures are %, except age (years))

		Mali	Benin
Gender	Men	11	30
	Women	89	70
Went to school		43	78
Age		46	34

were recorded. Besides, a rather high portion of processors of baobab and tamarind products went to school, especially in Benin. The highest level of education in Benin is equally reported to be primary school and secondary school, whereas in Mali respondents mentioned secondary and Koran school.

The principal activity of all surveyed processors of baobab and tamarind products is processing. Secondary occupations reported are trading, agriculture, teaching, housekeeping and/or hairdressing. In Mali and Benin, most respondents stated to have learned processing as a profession (respectively, 77 % and 92 %), whereas the rest took over the processing business from their parents. All processors in both countries stated that selling baobab and tamarind products is profitable because demand for these local products is great.

Two different types of processors were identified, namely individual processors and – mostly female – groups of processors. Additionally, processing is generally not reported as a one-man's business since most processors have employees (84 % in Benin and 100 % in Mali). In Mali, one out of three processing enterprises employs two or three additional family members, whereas, in Benin, two thirds employs one or two other members of the family. In most cases, in both countries, no wages are paid to family members. Additionally, respectively 79 % and 51 % of the processing businesses in Mali and Benin employ between one to ten permanent employees. The wages of permanent employees vary in both countries between 10,000 and 45,000 FCFA per month (15–70 €).

The actors in the market chain from which processors in Mali and Benin buy their baobab and tamarind products are shown in Table 4.7. The

Table 4.7: Actors from which processors buy their products in Mali and Benin (%)

	Mali	Benin	p-value
Gatherer	23^a	20^a	0.96
Collector / Assembler	47^a	34^a	0.30
Wholesaler	20^a	27^a	0.45
Retailer	10^a	19^a	0.07

Means with a different superscript are significantly different based on Mann-Whitney Test (p-value < 0.05)

majority of respondents stated to buy in the first place from collectors or assemblers, then directly from gatherers or wholesalers, and in the last place from (large) retailers. No significant differences were detected between both countries (Mann-Whitney Test, $p > 0.05$)

According to the processors surveyed in Mali, the buying price is set by traders (55 %) or by negotiation between processors and gatherers (45 %). In Benin, purchase prices are set by traders (53 %), by negotiation (34 %) or by gatherers (13 %). The majority of processors in Mali and Benin reported to determine the selling price themselves. Only one respondent in Mali stated that the selling price is set by negotiation.

4.1.4 Consumers

In the present study, in total, 197 and 66 individual consumers of baobab and tamarind products were sampled in respectively Mali and Benin, of which 113 and 13 in rural areas and 84 and 53 in urban areas in Mali and Benin, respectively. Some demographic characteristics of the respondents, such as gender, age and percentage of informants that went to school, are shown in Table 4.8. The majority of respondents are

Table 4.8: Demographic data on baobab and tamarind product consumers in Mali and Benin (all figures are %, except age (years))

		Mali	Benin
Gender	Men	9	7
	Women	91	93
Went to school		64	62
Age		38	38
Rural		57	20
Urban		43	80

women, which is explained by the fact that, within most SSA households, women are responsible for preparing meals. Although men often know surprisingly well how dishes are prepared and which ingredients are needed, they let women answer the questions concerning consumption habits. The highest level of education of consumers in Benin is reported to be – in descending order of importance – primary, secondary school and higher education, whereas in Mali respondents mentioned Koran, primary and secondary school. Household or family size of the surveyed consumers is, in each country, about half of the size reported by the gatherers, namely 12.95 ± 13.36 versus 25.07 ± 18.42 in Mali and 6.12 ± 2.14 versus 14.88 ± 9.84 in Benin. Most likely, this can be explained by the fact that households are generally smaller in size in urban than in rural areas. Indeed, in Mali and Benin, consumers' household size is significantly smaller in urban areas when compared to rural areas, *i.e.* 5.67 ± 1.33 versus 15.20 ± 15.88 and 6.21 ± 2.27 versus 9.57 ± 7.00, respectively (Mann-Whitney Test, $p < 0.01$). The principal activities of consumers of baobab and tamarind products are trade, agriculture and housekeeping. Other occupations recorded are teacher, student, tailor, taxi driver or worker. Malian consumers go to the marketplace mainly on foot and to a lesser extent by cart, car/taxi or (motor)bike. In Benin, besides going on foot, the means of transport used by consumers to go to the marketplace are (motor)bike and car/taxi.

4.2 Market chains

Based on the recorded trade relationships between the different chain actors, market maps of different baobab and tamarind products are presented in this section in order to show the sequence of actors involved in transferring a specific product from gatherer to consumer. It should be noted that the arrows in the market maps represent the product flow in the chain and the more important the product flow is, the thicker the lines are drawn.

4.2.1 Baobab fruits

The market map for baobab fruit pulp in Mali and Benin differs quite a lot in chain actors involved, linkages between actors and product flow. The market map for baobab fruit pulp in Mali is shown in Figure 4.4, whereas the map for baobab fruit pulp in Benin is presented in Figure 4.5. It should be noted that the market chain for baobab fruit pulp in Mali is exactly the same as the one observed for tamarind fruit pods in Mali.

Gatherers of baobab fruit pulp in Mali have as main buyers wholesalers or collectors, or petty traders, but sell also in a few cases to retailers, processors or even directly to consumers. Wholesalers or collectors sell the produce to processors, retailers or petty traders. Petty traders, also supplied by retailers, sell baobab fruit pulp to rural and urban consumers. In addition, retailers may also sell fruit pulp to consumers. Processors who are supplied by wholesalers or collectors, but also by gatherers and sometimes even by retailers, may use baobab fruit pulp in the processing of millet cream or baobab juice, syrup, jam and instant juice powder. These products are then generally sold directly to consumers, however, sometimes retailers or caterers, such as bars, restaurants and hotels, act as middlemen.

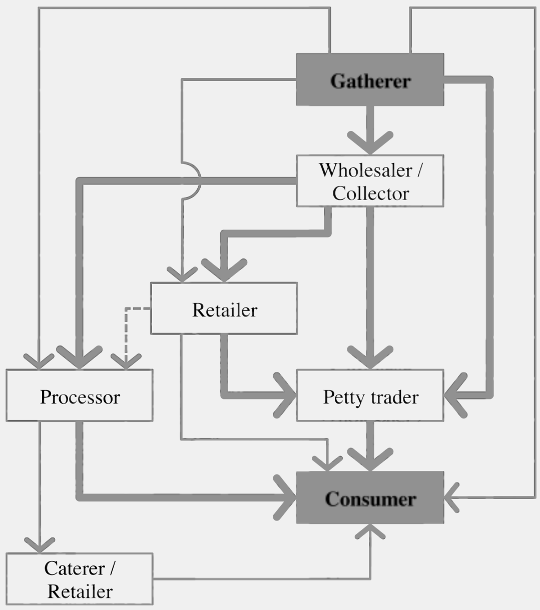


Figure 4.4: Market map of baobab fruit pulp and tamarind fruit pods in Mali (note: the thicker the lines, the more important the product flow)

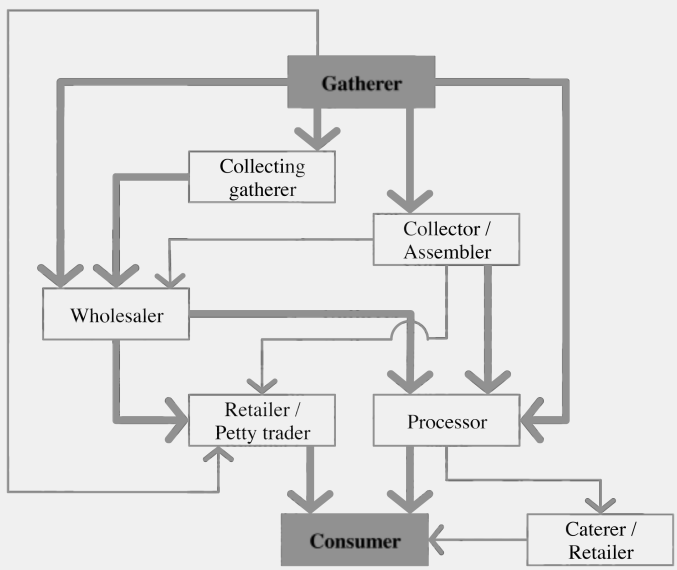


Figure 4.5: Market map of baobab fruit pulp in Benin (note: the thicker the lines, the more important the product flow)

Collectors or assemblers, wholesalers and processors all buy baobab fruit pulp from gatherers in Benin. Often, gatherers also sell to collecting gatherers who deliver the produce to wholesalers. Additionally, a few gatherers have retailers or petty traders as their customers. Collectors or assemblers are a middlemen particularly for processors, while they to a lesser extent also sell to wholesalers, retailers or petty traders. The main transport of baobab fruit pulp is done by on the one hand collectors or assemblers and on the other hand wholesalers. The latter generally have processors, retailers or petty traders as buyers. Retailers or petty traders deliver baobab fruit pulp in quantities demanded by rural and urban consumers. As already mentioned, processors receive baobab fruit pulp from collectors or assemblers, wholesalers or gatherers. In Benin, processors use baobab fruit pulp mainly to make juice. This ready-to-drink juice is sold directly to consumers, and in some cases retailers or caterers, such as bars, restaurants and hotels, intervene as middlemen.

4.2.2 Baobab leaves

Baobab leaves can be traded in three different product forms, namely fresh leaves, dry leaves and/or leaf powder.

Fresh baobab leaves As one might expect, the market chain of fresh baobab leaves, shown in Figure 4.6, is short due to their very short shelf life, which is only about two or three days because of a lack of refrigeration. In some cases, gatherers in Mali and Benin reported to sell directly to consumers at their farmgate or on a local marketplace. This means that gatherers have at the same time a harvesting and collection function, as well as a sales function. In other cases, gatherers in Mali and Benin sell harvested fresh baobab leaves to retailers and/or petty traders who in turn sell the fresh leaves to rural and urban consumers on a local marketplace.

Dry baobab leaves Many gatherers in Mali prefer to sell dry baobab leaves instead of fresh leaves, because of the latter's very short shelf life and thus perishability. Figure 4.7 shows the market map of dry baobab leaves in Mali. Gatherers sell their dry baobab leaves mainly to retailers or petty traders. Only in a few cases, gatherers reported to sell to wholesalers or directly to consumers. Retailers – and in a few cases wholesalers – sell, after transportation, the dry leaves to petty traders or to a lesser extent directly to consumers. It are mainly petty traders in both rural and

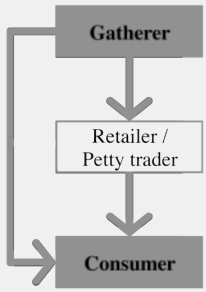


Figure 4.6: Market map of fresh baobab leaves in Mali and Benin (note: the thicker the lines, the more important the product flow)

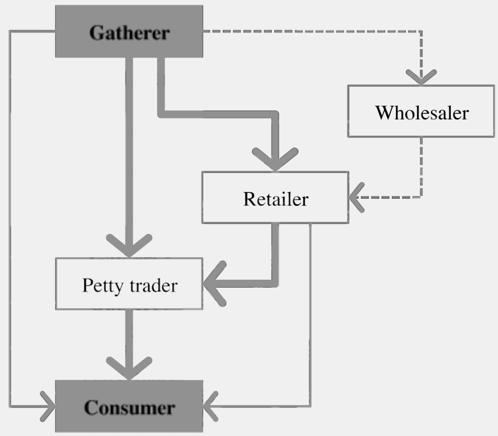


Figure 4.7: Market map of dry baobab leaves in Mali (note: the thicker the lines, the more important the product flow)

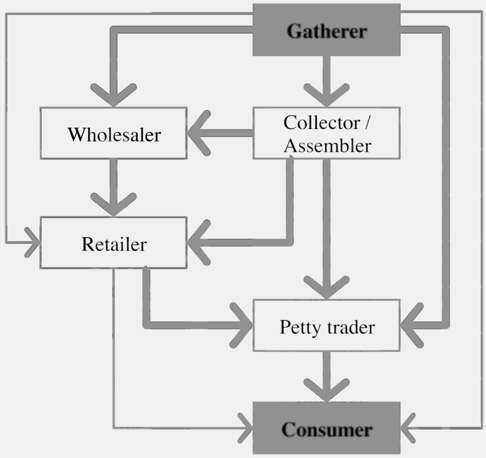


Figure 4.8: Market map of baobab leaf powder in Mali (note: the thicker the lines, the more important the product flow)

urban areas who are responsible to deliver the produce to the end users or consumers.

Baobab leaf powder The market map of baobab leaf powder is more complex in Mali than in Benin (Figure 4.8 and Figure 4.9, respectively). Gatherers in Mali have different outlets for baobab leaf powder. Generally, they sell their produce to collectors or assemblers, wholesalers or petty traders. In a few cases, gatherers also reported to sell to retailers or directly to consumers. Collectors or assemblers may sell baobab leaf powder further to wholesalers, retailers or petty traders. Wholesalers on their turn, sell the produce to retailers. It was observed that collectors or assemblers and/or wholesalers are the traders responsible for transportation of baobab leaf powder from rural areas to urban. Retailers mainly sell to petty traders, but sometimes they sell directly to consumers, which is also the main function of petty traders.
In Benin, gatherers sell baobab leaf powder mainly to collecting gatherers or retailers, or to a lesser extent to petty traders. Collecting gatherers sell large quantities leaf powder to retailers. The latter mostly sell the produce – after transportation – to petty traders, whereas in a few cases

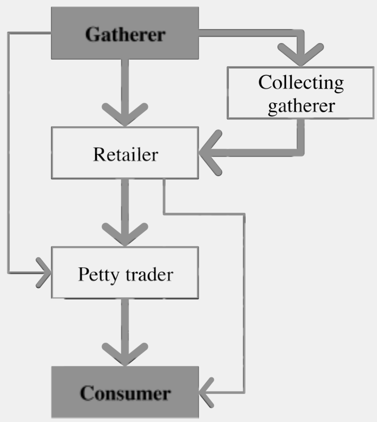


Figure 4.9: Market map of baobab leaf powder in Benin (note: the thicker the lines, the more important the product flow)

they may sell directly to consumers. Petty traders sell baobab leaf powder in small quantities to end users in both rural and urban areas

4.2.3 Tamarind fruits

As mentioned before, the market map for tamarind fruit pods in Mali is exactly the same as the one observed for baobab fruit pulp in Mali (Figure 4.4). Compared to the chain in Mali, the market map for tamarind pods in Benin differs in chain actors involved, linkages between actors and product flow, as shown in Figure 4.10. In Mali, gatherers of tamarind fruit pods sell mainly to wholesalers or collectors, or petty traders, but in a few cases also to retailers, processors or even directly to consumers. Wholesalers or collectors have processors, retailers or petty traders as customers. Retailers sell to petty traders, who on their turn have rural and urban consumers as buyers. Occasionally, retailers may also sell tamarind fruits to consumers. Besides from wholesalers or collectors, processors buy also tamarind pods from gatherers and retailers. Processors use tamarind fruits to process into tamarind juice, syrup, jam and instant juice powder. These products are mostly sold directly to consumers. In some cases, retailers or caterers, such as bars, restaurants and hotels, buy

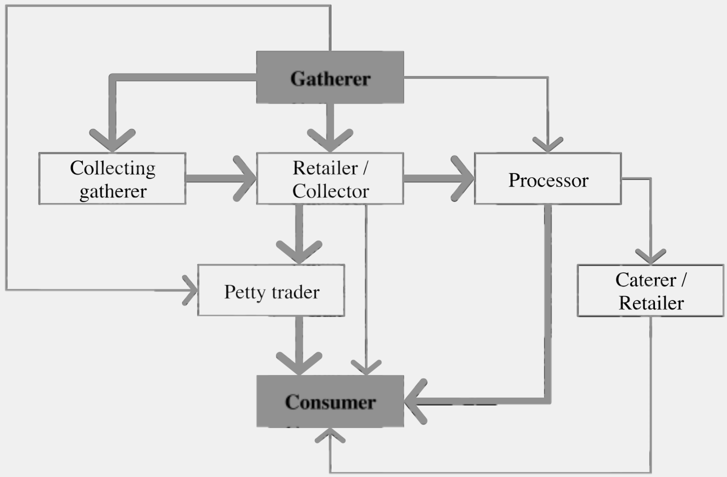


Figure 4.10: Market map of tamarind fruit pods in Benin (note: the thicker the lines, the more important the product flow)

the products from processors to resell them to end users.
Tamarind fruits harvested by gatherers in Benin are mainly collected by collection gatherers, who resell the produce to retailers or collectors. Gatherers sell to a lesser extent also to processors or petty traders. Retailers or collectors have processors and petty traders as their main buyers, but sometimes sell also directly to consumers. Petty traders in rural and urban areas sell to consumers. Processors in Benin mainly make juice from tamarind fruits, which is sold directly to consumers. Sometimes, retailers or caterers, such as bars, restaurants and hotels, intervene as middlemen to sell the ready-to-drink product to consumers.

4.2.4 Tamarind leaves

As shown in Figure 4.11, the market map of tamarind leaves in Mali is comparable to the market map of dry baobab leaves, only the wholesaler was not recorded here. Tamarind leaves are sold by gatherers directly to consumers or to petty traders who subsequently sell the produce to both urban and rural consumers. Only in a few cases, gatherers sell to retailers. The latter may then sell tamarind leaves to petty traders or directly to

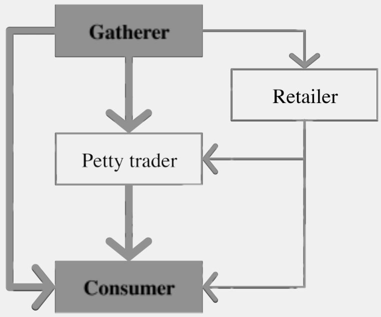


Figure 4.11: Market map of tamarind leaves in Mali (note: the thicker the lines, the more important the product flow)

consumers.

4.3 Market chain analysis

In the previous sections, each actor in the market chain of baobab and tamarind products has been presented in detail, market maps for the different products have been drawn, and linkages between and functions of the different actors have been revealed. In this section, data on quantities, prices, added value, gathering techniques, buying and selling period, storage and processing practices, uses and consumption trends, trade centres, quality criteria and information flow are presented to characterise, analyse and compare the market chains of baobab and tamarind products in Benin and Mali.

4.3.1 Quantities and prices

Each chain actor has been asked to record the quantities bought (or harvested in the case of the gatherer) and/or sold, together with the purchasing and selling price. Hereafter, buying and selling quantities and prices for each baobab and tamarind product are shown and analysed for the different chain actors.

Baobab fruits

Baobab fruit pulp is harvested, sold and consumed by many respondents in Mali and Benin as shown in Table 4.9, which summarises the mean quantities of baobab fruit pulp bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices.

Gatherers in Mali harvest about 20 times less baobab fruit pulp than gatherers in Benin, whereas the latter receive a significantly lower price for their produce than their counterparts in Mali. It should be remarked that almost no gatherers in Mali stated to sell baobab fruit pulp. As a consequence, the majority of baobab fruits gathered in Mali are used for home consumption, whereas this figure only amounts to 4 % in Benin (Mann-Whitney Test, $p < 0.01$).

The average quantities bought and sold by wholesalers and petty traders in Mali and Benin do not differ significantly within wholesalers and petty traders, respectively. In contrast, significant differences were found between these two types of traders, whereby wholesale quantities are found to be almost three times larger compared to retail quantities. In addition, purchasing and selling prices are found to differ significantly within wholesalers and petty traders in both countries. However, the purchasing price is not significant different for wholesalers and petty traders in Mali. Also selling prices for wholesalers and petty traders in the same country are not significantly different. Hereby, one should note that mean buying and selling prices for traders in Mali are almost double the corresponding prices in Benin.

Consumers in Benin buy significantly higher quantities of baobab fruit pulp than their colleagues in Mali. Although no significant differences are found when rural and urban consumers are compared for quantity bought in respectively Mali and Benin, the differences are significant when this comparison is made between respectively rural and urban consumers in both countries. No significant price differences could be reported for consumers, nor between rural and urban consumers. When purchasing prices of consumers are compared with selling prices of petty traders in both countries, similar prices are reported for Benin, *i.e.* 335 FCFA / kg versus 330 FCFA / kg, whereas in Mali consumers recorded a cheaper purchasing price than the selling price of petty traders, *i.e.* 410 FCFA / kg versus 630 FCFA / kg.

Table 4.9: Mean annual quantities of baobab fruit pulp bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices, and added value

			Mali	Benin
Quantity gathered / bought (kg)	Gatherer	mean	11^{a}	228^{b}
	($n_{Mali} = 14$)	median	4	208
	($n_{Benin} = 44$)	std. dev.	14	124
	Wholesaler	mean	$28{,}711^{e}$	$19{,}750^{e}$
	($n_{Mali} = 7$)	median	30,000	14,250
	($n_{Benin} = 6$)	std. dev.	22,159	14,794
	Petty trader	mean	$944^{c,d}$	$766^{c,d}$
	($n_{Mali} = 12$)	median	550	400
	($n_{Benin} = 35$)	std. dev.	1,309	1,062
	Processor	mean	$347^{b,d}$	712^{c}
	($n_{Mali} = 18$)	median	175	500
	($n_{Benin} = 27$)	std. dev.	430	784
	Consumer	mean	78^{f}	$726^{b,c,d}$
	($n_{Mali} = 30$)	median	13	600
	($n_{Benin} = 51$)	std. dev.	226	868
Price bought (FCFA / kg)	Gatherer	mean	-	-
	($n_{Mali} = 0$)	median	-	-
	($n_{Benin} = 0$)	std. dev.	-	-
	Wholesaler	mean	$430^{a,b}$	130^{c}
	($n_{Mali} = 7$)	median	375	125
	($n_{Benin} = 6$)	std. dev.	170	25
	Petty trader	mean	470^{a}	250^{d}
	($n_{Mali} = 12$)	median	400	250
	($n_{Benin} = 35$)	std. dev.	215	1,310
	Processor	mean	560^{a}	$325^{b,f}$
	($n_{Mali} = 18$)	median	500	325
	($n_{Benin} = 27$)	std. dev.	205	90
	Consumer	mean	$410^{a,b}$	335^{f}
	($n_{Mali} = 10$)	median	400	250
	($n_{Benin} = 50$)	std. dev.	215	180
Quantity sold (kg)	Gatherer	mean	$1.00^{a,c,e}$	227^{b}
	($n_{Mali} = 1$)	median	1	202
	($n_{Benin} = 43$)	std. dev.	-	125
	Wholesaler	mean	$28{,}711^{e}$	$19{,}750^{e}$
	($n_{Mali} = 7$)	median	30,000	14,250
	($n_{Benin} = 6$)	std. dev.	22,159	14,794
	Petty trader	mean	$944^{a,d}$	766^{d}
	($n_{Mali} = 12$)	median	550	400
	($n_{Benin} = 35$)	std. dev.	1,309	1,062

For each quantity or price, means with a different superscript are significantly different between different chain actors based on Mann-Whitney Test ($p\text{-value} < 0.05$); std. dev. stands for standard deviation

Table 4.9: Mean annual quantities of baobab fruit pulp bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices, and added value (continued)

			Mali	Benin
Price sold (FCFA / kg)	Gatherer	mean	$450.00^{a,c,d,f,h}$	180^{b}
	($n_{Mali} = 1$)	median	450	150
	($n_{Benin} = 44$)	std. dev.	-	70
	Wholesaler	mean	$520^{c,e}$	$265^{d,g}$
	($n_{Mali} = 7$)	median	475	260
	($n_{Benin} = 6$)	std. dev.	185	75
	Petty trader	mean	$630^{e,h}$	$330^{f,g}$
	($n_{Mali} = 12$)	median	580	300
	($n_{Benin} = 35$)	std. dev.	175	120
Added value (FCFA / kg)	Gatherer	mean	$450.00^{a,c,d,e}$	180^{b}
	($n_{Mali} = 1$)	median	450	150
	($n_{Benin} = 44$)	std. dev.	-	70
	Wholesaler	mean	$90^{d,e}$	$135^{a,b,c,d}$
	($n_{Mali} = 7$)	median	15	125
	($n_{Benin} = 6$)	std. dev.	315	60
	Petty trader	mean	$175^{a,b,c}$	75^{e}
	($n_{Mali} = 12$)	median	175	50
	($n_{Benin} = 35$)	std. dev.	85	35
Quantity stored (kg)	Gatherer	mean	7^{a}	193^{b}
	($n_{Mali} = 9$)	median	3	208
	($n_{Benin} = 44$)	std. dev.	10	118
	Wholesaler	mean	$5{,}860^{d}$	$4{,}083^{d}$
	($n_{Mali} = 6$)	median	2,500	3,250
	($n_{Benin} = 6$)	std. dev.	7,416	2,990
	Petty trader	mean	$337^{b,c}$	$229^{b,c}$
	($n_{Mali} = 10$)	median	200	100
	($n_{Benin} = 35$)	std. dev.	368	276
	Processor	mean	$343^{b,c}$	126^{c}
	($n_{Mali} = 14$)	median	100	100
	($n_{Benin} = 23$)	std. dev.	476	122
	Consumer	mean	28^{a}	183^{c}
	($n_{Mali} = 20$)	median	5	100
	($n_{Benin} = 48$)	std. dev.	89	244

For each quantity or price, means with a different superscript are significantly different between different chain actors based on Mann-Whitney Test ($p\text{-value} < 0.05$); std. dev. stands for standard deviation

Baobab leaves

As mentioned before, baobab leaves can be traded in the form of three different products, namely fresh leaves, dry leaves and/or leaf powder (Figure 4.12).

Fresh baobab leaves Fresh baobab leaves are only reported to be harvested in Benin, whereas only petty traders in Mali mentioned to sell fresh baobab leaves. On average, gatherers (n = 23) in Benin annually harvested 15 kg fresh baobab leaves of which 14 kg were sold at a mean price of 220 FCFA / kg. Petty traders in Mali annually buy about 2,297 kg (n = 4) fresh baobab leaves at a price of 80 FCFA / kg (n = 3), whereas they sell the whole quantity bought at a price of 90 FCFA / kg (n = 4). Rural consumers in Mali recorded to buy annually about 79 kg (n = 34) fresh baobab leaves at a mean price of 90 FCFA / kg (n = 10), whereas urban consumers reported to buy 11 kg (n = 13) at a price of 80 FCFA / kg (n = 3). The single urban consumer in Benin could not remember how much fresh baobab leaves she bought, but reported a mean price of 250 FCFA / kg. Due to a rather small sample size, in particular for the petty traders, tests for statistical significances are meaningless. However, it can be noticed that consistently a higher price for fresh baobab leaves has been reported in Benin than in Mali.

Dry baobab leaves Only chain actors in Mali reported to trade dry baobab leaves. Gatherers annually harvested 459 kg (n = 4) fresh leaves which they processed into 121 kg dry baobab leaves. On average, 76 kg (n = 3) dry leaves were sold at a price of 165 FCFA / kg (n = 3). Two wholesalers recorded to buy annually about 18,000 kg dry baobab leaves at a price of 150 FCFA / kg, whereas they sold the whole quantity bought at a price of 225 FCFA / kg. Petty traders annually buy 1,337 kg (n = 15) dry baobab leaves at a price of 95 FCFA / kg (n = 7), while they sell the whole quantity bought at a price of 310 FCFA / kg (n = 15). Rural consumers recorded to buy annually about 24 kg (n = 18) dry baobab leaves at a mean price of 225 FCFA / kg (n = 4), whereas urban consumers reported to buy 43 kg (n = 6) at a price of 165 FCFA / kg (n = 1). Due to a rather small sample size, especially for the gatherers and wholesalers, tests for statistical significances are meaningless. However, it seems that urban consumers buy more dry baobab leaves in comparison to rural consumers, whereas in the previous paragraph we could conclude that fresh baobab leaves are in larger quantities bought by rural consumers than by urban.

Figure 4.12: Above: baobab leaves drying in the sun. Below: woman selling baobab leaf powder (left) and fresh baobab leaves (right) at the marketplace

Baobab leaf powder Baobab leaf powder is harvested, sold and consumed by many respondents in Mali and Benin as shown in Table 4.10, which summarises the mean quantities of baobab leaves bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices.

Gatherers in Mali and Benin harvest on an annual basis about 216 kg and 166 kg fresh leaves, respectively, which they process into 34 kg and 26 kg baobab leaf powder, respectively. On average, they sell respectively 51 kg and 24 kg leaf powder at a price of 90 FCFA / kg and 150 FCFA / kg, respectively. All quantities reported by gatherers in Mali were found to be significantly higher than those quantities recorded in Benin. The mean selling price is significantly lower in Mali than in Benin.
One may remark that the mean quantity sold is higher than the quantity harvested for gatherers in Mali. At first sight, this seems a statistical artefact. But, when we go back to the datafile of individual respondents, none of them reported a higher quantity sold than harvested. It could be observed, based on the datafile, that gatherers who recorded a high quantity harvested did sell the majority of this quantity, whereas other gatherers who recorded only a small quantity harvested did not sell their produce. This explains a higher mean quantity sold than gathered for gatherers in Mali. Besides, it should also be noted that on average, only 13 % of the leaf powder is sold in Mali, whereas this figure amounts up to 91 % in Benin (Mann-Whitney Test, $p < 0.01$). In other words, 81 % of harvested baobab leaves in Mali is used for home consumption, whereas only 9 % is used as such in Benin (Mann-Whitney Test, $p < 0.01$). The part that is not sold nor consumed is donated to family or neighbours in Mali. Therefore, gatherers who did not sell baobab leaf powder (*i.e.* zero values) were not taken into account to calculate mean values to avoid distortions in the results.

As shown in Table 4.10, the average quantities bought and sold by Malian wholesalers are significantly higher compared to the quantities bought and sold by petty traders in Mali and Benin. In addition, also the quantities bought and sold by petty traders are significantly different for petty traders in Mali and Benin and both quantities are about ten times higher in Mali as in Benin. Purchasing and selling prices are not significantly different between on the one hand wholesalers in Mali and on the other petty traders in Mali and Benin, respectively. However, purchasing and

Table 4.10: Mean annual quantities of baobab leaf powder bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices, and added value

			Mali	Benin
Quantity gathered / bought (kg)	Gatherer	mean	34^{a}	26^{b}
	($n_{Mali} = 65$)	median	9	30
	($n_{Benin} = 24$)	std. dev.	73	6
	Wholesaler	mean	$17{,}361^{c}$	-
	($n_{Mali} = 10$)	median	11,040	-
	($n_{Benin} = 0$)	std. dev.	18,021	-
	Petty trader	mean	866^{d}	84^{e}
	($n_{Mali} = 34$)	median	390	75
	($n_{Benin} = 22$)	std. dev.	1,483	73
	Consumer	mean	$53^{b,f}$	$18^{a,f}$
	($n_{Mali} = 60$)	median	23	18
	($n_{Benin} = 26$)	std. dev.	159	9
Price bought (FCFA / kg)	Gatherer	mean	-	-
	($n_{Mali} = 0$)	median	-	-
	($n_{Benin} = 0$)	std. dev.	-	-
	Wholesaler	mean	$155^{a,b,d}$	-
	($n_{Mali} = 10$)	median	135	-
	($n_{Benin} = 0$)	std. dev.	70	-
	Petty trader	mean	$210^{a,d}$	165^{b}
	($n_{Mali} = 33$)	median	200	150
	($n_{Benin} = 22$)	std. dev.	110	20
	Consumer	mean	320^{c}	$200^{a,d}$
	($n_{Mali} = 17$)	median	250	200
	($n_{Benin} = 26$)	std. dev.	210	10
Quantity sold (kg)	Gatherer	mean	51^{a}	24^{b}
	($n_{Mali} = 14$)	median	11	27
	($n_{Benin} = 24$)	std. dev.	95	5
	Wholesaler	mean	$17{,}361^{c}$	-
	($n_{Mali} = 10$)	median	11,040	-
	($n_{Benin} = 0$)	std. dev.	18,021	-
	Petty trader	mean	866^{d}	84^{e}
	($n_{Mali} = 34$)	median	390	75
	($n_{Benin} = 22$)	std. dev.	1,483	73

For each For each quantity or price, means with a different superscript are significantly different between different chain actors based on Mann-Whitney Test (p-value < 0.05); std. dev. stands for standard deviation

Table 4.10: Mean annual quantities of baobab leaf powder bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices, and added value (continued)

			Mali	Benin
Price sold	Gatherer	mean	90^{a}	150^{b}
(FCFA / kg)	($n_{Mali} = 14$)	median	90	150
	($n_{Benin} = 24$)	std. dev.	30	10
	Wholesaler	mean	$220^{c,d}$	-
	($n_{Mali} = 10$)	median	220	-
	($n_{Benin} = 0$)	std. dev.	85	-
	Petty trader	mean	305^{c}	215^{d}
	($n_{Mali} = 34$)	median	265	200
	($n_{Benin} = 22$)	std. dev.	205	20
Added value	Gatherer	mean	90^{a}	150^{b}
(FCFA / kg)	($n_{Mali} = 14$)	median	90	150
	($n_{Benin} = 24$)	std. dev.	30	10
	Wholesaler	mean	$65^{a,c}$	-
	($n_{Mali} = 10$)	median	50	-
	($n_{Benin} = 0$)	std. dev.	35	-
	Petty trader	mean	100^{a}	50^{c}
	($n_{Mali} = 34$)	median	50	50
	($n_{Benin} = 22$)	std. dev.	130	-
Quantity stored	Gatherer	mean	$31^{a,g}$	26^{b}
(kg)	($n_{Mali} = 52$)	median	8	30
	($n_{Benin} = 24$)	std. dev.	71	6
	Wholesaler	mean	$1{,}269^{f}$	-
	($n_{Mali} = 7$)	median	500	-
	($n_{Benin} = 0$)	std. dev.	1,781	-
	Petty trader	mean	215^{c}	20^{a}
	($n_{Mali} = 28$)	median	50	15
	($n_{Benin} = 22$)	std. dev.	487	18
	Consumer	mean	23^{d}	3^{d}
	($n_{Mali} = 51$)	median	1	4
	($n_{Benin} = 26$)	std. dev.	61	2

For each quantity or price, means with a different superscript are significantly different between different chain actors based on Mann-Whitney Test (p-value < 0.05); std. dev. stands for standard deviation selling prices are found to be significantly lower for petty traders in Benin than in Mali.

Consumers in both countries buy similar quantities of baobab leaf powder. Additionally, no significant difference is found when rural and urban consumers are compared in and between Mali and Benin. However, the price consumers in Mali pay for baobab leaf powder is reported to be significantly higher compared to the purchasing price in Benin. This difference in buying price was not found when rural and urban consumers in both countries were compared, also not between rural consumers in Mali. But the significant difference in purchasing price was confirmed between urban consumers in Mali and Benin, meaning that urban consumers in Mali purchase baobab leaf powder for a higher price than urban consumers in Benin. Finally, it should be noted that when purchasing prices of consumers in Mali and Benin, *i.e.* 320 FCFA / kg and 200 FCFA / kg, respectively, are compared with selling prices of petty traders, *i.e.* 305 FCFA / kg and 215 FCFA / kg, respectively, they seem very similar, as was expected.

Tamarind fruits

Tamarind fruit pods are harvested, sold and consumed by many respondents in Mali and Benin as shown in Table 4.11, which summarises the mean quantities of tamarind fruit pods bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices.

Gatherers in Mali harvest about ten times more tamarind fruit pods and receive a lower price for their produce than gatherers in Benin. As there are only a few gatherers in Benin, tests for statistical significances between gatherers are pointless and should be treated with care. Additionally, it should be noted that on average only 28 % of the harvested tamarind fruits are sold in Mali, whereas 92 % in Benin (Mann-Whitney Test, $p < 0.01$). The majority (65 %) of harvested tamarind pods in Mali is thus used for home consumption, compared to only 8 % in Benin (Mann-Whitney Test, $p < 0.01$). The part of the harvest that is not sold nor consumed is donated to family or neighbours in Mali.

Quantities bought and sold, as well as purchasing and selling prices, are not found to be significantly different between wholesalers in Mali and Benin. In contrast, significant differences were reported in quantities

Table 4.11: Mean annual quantities of tamarind fruit pods bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices, and added value

			Mali	Benin
Quantity gathered / bought (kg)	Gatherer	mean	$212^{a,b}$	$22^{a,c}$
	($n_{Mali} = 49$)	median	50	20
	($n_{Benin} = 5$)	std. dev.	606	8
	Wholesaler	mean	$18{,}195^{e}$	$27{,}500^{e,g}$
	($n_{Mali} = 33$)	median	4,000	27,500
	($n_{Benin} = 2$)	std. dev.	32,285	3,536
	Petty trader	mean	860^{f}	207^{b}
	($n_{Mali} = 53$)	median	600	55
	($n_{Benin} = 16$)	std. dev.	1,323	586
	Processor	mean	$1{,}047^{d,f}$	302^{d}
	($n_{Mali} = 29$)	median	300	267
	($n_{Benin} = 10$)	std. dev.	1,988	190
	Consumer	mean	81^{c}	$197^{a,c}$
	($n_{Mali} = 94$)	median	21	18
	($n_{Benin} = 28$)	std. dev.	368	422
Price bought (FCFA / kg)	Gatherer	mean	-	-
	($n_{Mali} = 0$)	median	-	-
	($n_{Benin} = 0$)	std. dev.	-	-
	Wholesaler	mean	180^{b}	$125^{b,d}$
	($n_{Mali} = 33$)	median	175	125
	($n_{Benin} = 2$)	std. dev.	60	-
	Petty trader	mean	175^{b}	$315^{c,e}$
	($n_{Mali} = 49$)	median	160	300
	($n_{Benin} = 16$)	std. dev.	65	40
	Processor	mean	$220^{a,d}$	265^{a}
	($n_{Mali} = 28$)	median	235	275
	($n_{Benin} = 10$)	std. dev.	80	105
	Consumer	mean	$235^{a,d}$	$360^{c,e}$
	($n_{Mali} = 33$)	median	225	300
	($n_{Benin} = 26$)	std. dev.	130	135
Quantity sold (kg)	Gatherer	mean	$177^{a,f}$	$20^{a,b}$
	($n_{Mali} = 23$)	median	52	20
	($n_{Benin} = 5$)	std. dev.	351	8
	Wholesaler	mean	$18{,}192^{d}$	$27{,}500^{b,d}$
	($n_{Mali} = 33$)	median	4,000	27,500
	($n_{Benin} = 2$)	std. dev.	32,286	3,536
	Petty trader	mean	859^{e}	207^{f}
	($n_{Mali} = 53$)	median	600	55
	($n_{Benin} = 16$)	std. dev.	1,323	586

For each quantity or price, means with a different superscript are significantly different between different chain actors based on Mann-Whitney Test (p-value < 0.05); std. dev. stands for standard deviation

Table 4.11: Mean annual quantities of tamarind fruit pods bought (or harvested in the case of gatherers), sold and stored by all different chain actors in Mali and Benin, together with the mean buying and selling prices, and added value (continued)

			Mali	Benin
Price sold (FCFA / kg)	Gatherer	mean	170^{a}	200^{b}
	($n_{Mali} = 23$)	median	90	200
	($n_{Benin} = 5$)	std. dev.	250	35
	Wholesaler	mean	$235^{b,e}$	$275^{d,e}$
	($n_{Mali} = 33$)	median	250	275
	($n_{Benin} = 2$)	std. dev.	55	-
	Petty trader	mean	$235^{b,e}$	405^{f}
	($n_{Mali} = 52$)	median	225	400
	($n_{Benin} = 16$)	std. dev.	90	50
Added value (FCFA / kg)	Gatherer	mean	$170^{a,e}$	200^{b}
	($n_{Mali} = 23$)	median	90	200
	($n_{Benin} = 5$)	std. dev.	250	35
	Wholesaler	mean	55^{d}	$150^{a,b}$
	($n_{Mali} = 33$)	median	50	150
	($n_{Benin} = 2$)	std. dev.	30	-
	Petty trader	mean	70^{d}	90^{e}
	($n_{Mali} = 53$)	median	50	100
	($n_{Benin} = 16$)	std. dev.	55	30
Quantity stored (kg)	Gatherer	mean	216^{a}	$22^{a,b,e,h}$
	($n_{Mali} = 43$)	median	40	20
	($n_{Benin} = 5$)	std. dev.	645	8
	Wholesaler	mean	$2{,}056^{d}$	$5{,}500^{f}$
	($n_{Mali} = 30$)	median	1,000	5,500
	($n_{Benin} = 2$)	std. dev.	3,617	707
	Petty trader	mean	196^{c}	25^{b}
	($n_{Mali} = 46$)	median	100	15
	($n_{Benin} = 16$)	std. dev.	271	30
	Processor	mean	$455^{a,d}$	$38^{a,e}$
	($n_{Mali} = 21$)	median	120	43
	($n_{Benin} = 8$)	std. dev.	629	13
	Consumer	mean	99^{h}	74^{h}
	($n_{Mali} = 81$)	median	35	3
	($n_{Benin} = 27$)	std. dev.	453	190

For each quantity or price, means with a different superscript are significantly different between different chain actors based on Mann-Whitney Test ($p\text{-value} < 0.05$); std. dev. stands for standard deviation

bought and sold, and in purchasing and selling prices for petty traders in both countries. Again, as there are only two wholesalers in Benin, tests for statistical significances between traders should be treated with care. Quantities of tamarind pods bought and sold are significantly bigger for wholesalers than for petty traders. Wholesale prices are found to be similar to prices for Malian petty traders, whereas significantly higher prices were observed for petty traders in Benin.

Consumers in Mali and Benin buy similar quantities of tamarind fruits. In addition, no significant differences in quantity bought are found for respectively rural and urban consumers in both countries, nor when rural and urban consumers are compared in Benin. The only significant difference for quantity bought was found between rural and urban consumers in Mali: rural consumers buy about twice the quantity as their urban colleagues. Consumers in Benin pay significantly more for tamarind fruit pods than consumers in Mali. This is probably due to a significantly higher price reported by urban consumers in Benin, compared to rural and urban consumers in Mali and urban consumers in Benin. When purchasing prices of consumers are compared with selling prices of petty traders in both countries, similar prices are reported for Mali, *i.e.* 235 FCFA / kg versus 235 FCFA / kg, whereas in Benin consumers recorded a slightly cheaper purchasing price than the selling price of petty traders, *i.e.* 360 FCFA / kg versus 405 FCFA / kg.

Tamarind leaves

As for the dry baobab leaves, only chain actors in Mali reported to trade tamarind leaves. Gatherers (n = 22) annually harvested 26 kg tamarind leaves, but none of the gatherers reported to sell tamarind leaves. However, one wholesaler and 12 petty traders reported the sale of tamarind leaves. Hereby, it should be noted that some petty traders reported to harvest themselves tamarind leaves for selling purposes. The wholesaler recorded to buy annually about 240 kg tamarind leaves at a price of 125 FCFA / kg, whereas she sells the whole quantity bought at a price of 250 FCFA / kg. Petty traders annually buy 152 kg (n = 12) tamarind leaves at a price of 160 FCFA / kg (n = 7), while they sell the whole quantity bought at a price of 200 FCFA / kg (n = 12). Rural consumers recorded to buy annually about 53 kg (n = 14) tamarind leaves at a mean price of 105 FCFA / kg (n = 3), whereas urban consumers (n = 5) reported to buy 6 kg, but they could not remember the purchasing price.

Although it seems that rural consumers buy more dry baobab leaves in comparison to rural consumers, no significant difference was observed for the quantity bought between rural and urban consumers in Mali. Because there is only one wholesaler, tests for statistical significances between this wholesaler and the petty traders are meaningless.

4.3.2 Added value

Added values, defined as the price received by each actor minus the price paid by that actor, for baobab leaf powder, baobab fruit pulp and tamarind fruit pods are reported in Tables 4.9, 4.10 and 4.11 and shown graphically in Figure 4.13. For baobab leaf powder, the added value for gatherers in Benin is significantly the highest. Subsequently, added values for petty traders and gatherers in Mali are higher compared to wholesalers in Mali and petty traders in Benin. Concerning baobab fruit pulp, the added values for gatherers and processors in Mali, gatherers in Benin and petty traders in Mali are higher than the added values for wholesalers and processors in Benin, wholesalers in Mali and petty traders in Benin. The added value for Malian processors stands out for tamarind fruit pods in comparison to all other chain actors. In general, added values for the three products concerned tend to be the highest for processors and gatherers.

4.3.3 Harvesting techniques

Baobab and tamarind leaves can be harvested by climbing in trees or not. In the first case, leaves are picked by hand or whole branches are cut using sickles or axes. In the latter case, branches are cut by using a *dolé* or *coupe-coupe* as tool. A *dolé* is a sickle mounted on a long stick, whereas a *coupe-coupe* is a long stick with a fixed knife blade.

There are many different baobab and tamarind fruit harvesting techniques, such as shaking branches, using sticks to knock the fruits to the ground, throwing objects to dislodge fruit and climbing up trees. Moreover, baobab and tamarind fruits can be harvested with a *dolé* or *coupe-coupe* (Figure 4.14).

4.3.4 Buying and selling periods

Each chain actor was asked to record the buying (or harvesting in the case of the gatherer) and/or selling period during which he/she buys

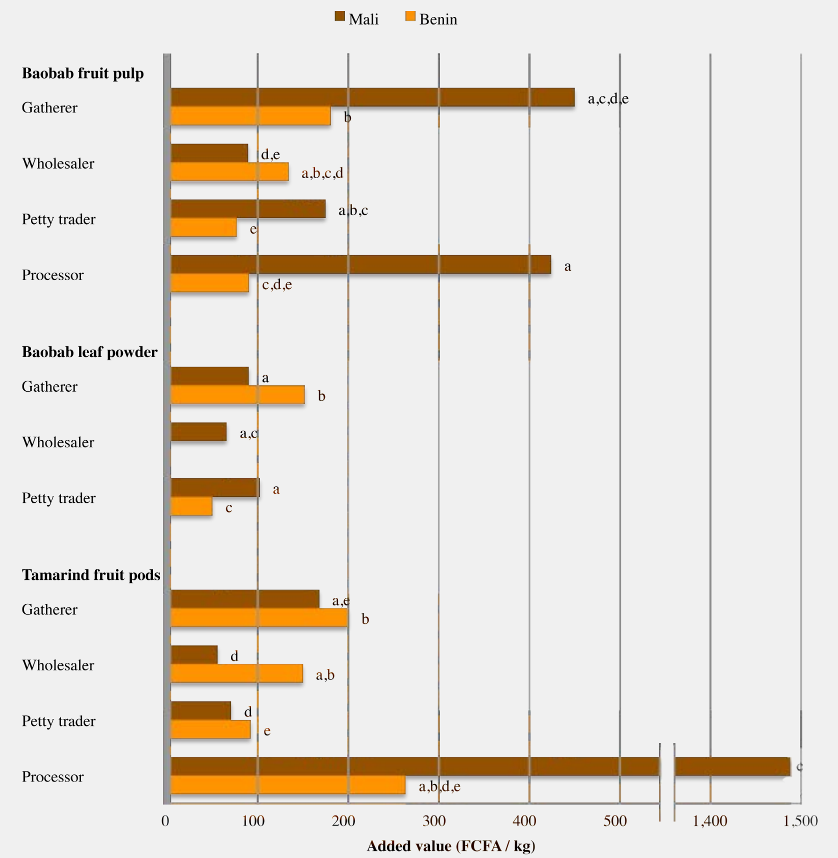


Figure 4.13: Added value of baobab and tamarind products for different chain actors in Mali and Benin

Figure 4.14: Local harvesting technique of baobab fruits with a *dolé*

and (re)sells his/her baobab and tamarind products. In addition, buying frequency of different baobab and tamarind products has been reported for consumers. Buying and selling periods for each baobab and tamarind product reported by the different chain actors are given in Figure 4.15.

Baobab fruits The period of harvesting and selling baobab fruits is reported by Malian and Beninese gatherers to be exclusively the dry season, which coincides with the fruiting period of the baobab tree in West Africa. Baobab fruit pulp is purchased by traders in Mali during the dry season or all year round, whereas they sell the fruit pulp throughout the year. In Benin, traders buy and sell baobab fruit pulp mainly during the dry season. Processors in both countries buy baobab fruit pulp and sell tertiary baobab products during the whole year long. One group consumers in both countries reported to purchase baobab fruit pulp during the whole year, whereas another group buys the same product solely during the dry season. Malian consumers buy baobab fruit pulp monthly (26 %), weekly (24 %), twice a week (11 %), daily (11 %), or several times a month (28 %). In Benin, consumers purchase baobab fruit pulp on a monthly basis (61 %), and either less frequently (26 %) or more frequently (13 %).

Baobab leaves A common harvesting practice of baobab leaves observed in Mali is the following. As soon as the first leaves have developed in May or June, women start harvesting fresh leaves for daily consumption. During the rainy season, on the way home coming from their cropping fields, women (or sometimes men) continue to harvest on a regular basis small amounts of leaves for home consumption and/or to sell at the local marketplace. Towards the end of the wet season, in September or October, when the main work in the fields ends, men engage in mass leaf harvesting for storage purposes during the dry season. This means gatherers harvest and sell fresh leaves in Mali during the wet season, whereas, in Benin, gatherers stated to harvest and sell baobab leaves all year round, which is partly conflicting with the baobab's phenology as baobab is deciduous during the dry season. Petty traders in Mali buy and sell baobab fresh leaves exclusively during the rainy season. In Mali and Benin, also consumers reported to buy fresh baobab leaves solely during the wet season. Malian consumers purchase fresh leaves daily (21 %), twice a week (20 %), weekly (16 %) or three times a week (14 %), while the rest purchases them several times a month. In Benin, one consumer mentioned

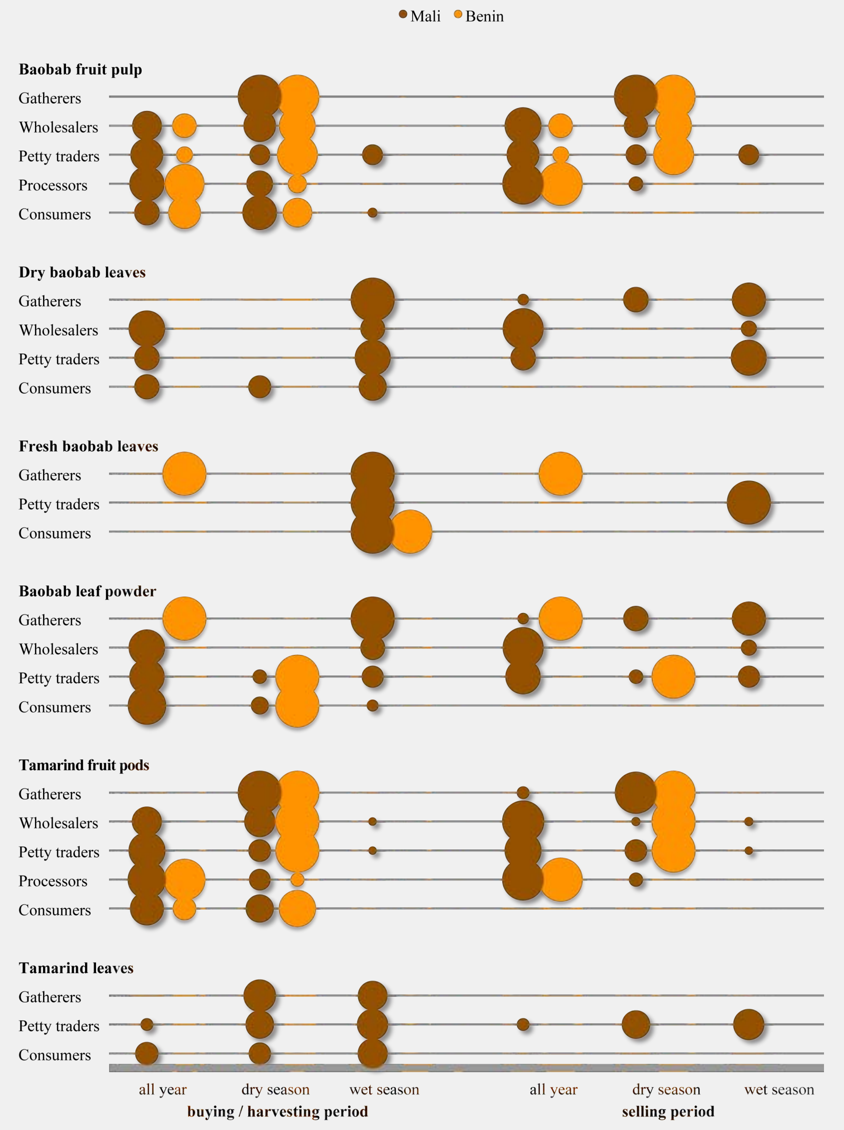


Figure 4.15: Buying and selling periods of baobab and tamarind products reported by different chain actors in Mali and Benin (note: the bigger the bubble, the more important the period)

to purchases fresh baobab leaves on a monthly basis. Only chain actors in Mali reported to trade dry baobab leaves. Gatherers harvest fresh leaves during the rainy season and sell the dried leaves during both the wet and dry season. Traders buy and sell the produce all through the year or solely during the rainy season. Consumers reported to buy dry baobab leaves during the wet or dry season, or all year round on a weekly basis (78 %) or more frequently. Concerning baobab leaf powder, gatherers in Mali harvest fresh leaves during the rainy season and sell leaf powder during either the wet or dry season, whereas gatherers in Benin reported to harvest and sell all through the year. Traders in Mali purchase and sell baobab leaf power all year round while petty traders in Benin trade the produce during the dry season. According to Beninese consumers, baobab leaf powder is uniquely purchased during the dry season, whereas, in Mali, baobab leaf powder is mainly purchased throughout the year. Malian consumers buy baobab leaf powder weekly (36 %), daily (22 %), twice a week (14 %) or several times a month (28 %). In Benin, consumers purchase baobab leaf powder on a monthly basis (89 %) or more frequently (11 %).

Tamarind fruits All gatherers in Mali and Benin reported to harvest and sell tamarind fruits during the dry season, which corresponds with the fruiting period of the tamarind tree in West Africa. In Benin, traders buy and sell tamarind fruits exclusively during the dry season, whereas only about half of Malian traders buy tamarind pods during this season; the other half purchases tamarind fruits all year round. Tamarind fruits in Mali are mainly sold all year round. Processors in Mali and Benin buy tamarind fruit pods throughout the year and sell their tertiary tamarind products as well all over the year. According to consumers in both countries, tamarind fruit pods are either purchased solely during the dry season or throughout the year. In Mali, tamarind fruit pods are bought weekly (35 %), daily (33 %) or several times a month (32 %). Consumers in Benin purchase tamarind fruit pods on a monthly basis (80 %) or more frequently (20 %).

Tamarind leaves Half of the gatherers in Mali harvests tamarind leaves during the wet season and the other half during the dry season, which agrees with the fact that tamarind is an evergreen tree. Petty traders buy or sell tamarind leaves either during the dry season or the wet season. Malian consumers reported to buy tamarind leaves during the wet season, throughout the year or during the dry season and they buy tamarind leaves on a daily (40 %), weekly (26 %) or monthly (11 %) basis, while the rest purchases tamarind leaves on an intermediary frequency.

4.3.5 Storage practices

The quantity stored, which is the maximum total quantity of a baobab or tamarind product that is annually stored in Mali and Benin, is given in Tables 4.9, 4.10 and 4.11. In Figure 4.16, on the left hand side, storage places used by the different chain actors for different baobab and tamarind products are given, whereas, on the right hand side, the importance of the used storage material is shown. Based on this figure, storage practices will hereafter be described for each baobab and tamarind product.

Baobab fruit pulp In Table 4.9, the average quantities of baobab fruit pulp stored by all chain actors are given. Wholesalers, petty traders and processors in Mali and Benin reported similar quantities stored. Moreover, the storage duration is not found to differ significantly between the chain actors and ranges between one month and a half and almost nine months. All chain actors in Mali, except consumers, and wholesalers in Benin reported to store baobab fruit pulp in a storehouse; all other actors in Benin and Malian consumers store fruit pulp in their house. Baobab fruit pulp is mainly kept in recycled rice bags. In addition, traders in Mali keep fruit pulp in plastic bags, whereas gatherers and consumers in Mali keep it in plastic tubs. Processors of baobab fruit pulp in Mali and Benin also reported to store tertiary products, such as baobab juice and millet cream or *dégué*. Small plastic bags containing baobab juice are mainly kept in a fridge or freezer, while plastic bottles with juice are reported to be stored also in the store or storehouse. Plastic bags with *dégué* are kept in the store or storehouse (Figure 4.17). On a 5-point scale (1 = very bad, 5 = very good), storage conditions for baobab fruit pulp are scored between 3.70 and 4.78. All actors in both countries reported humidity and bug, mice and fungi attacks as the major problems during storage. The major problem reported by processors during storage of baobab juice is the risk of fermentation.

Baobab leaf powder The mean quantities of baobab leaf powder stored by the different chain actors are presented in Table 4.10. Petty traders in Benin store significantly less compared to petty traders in

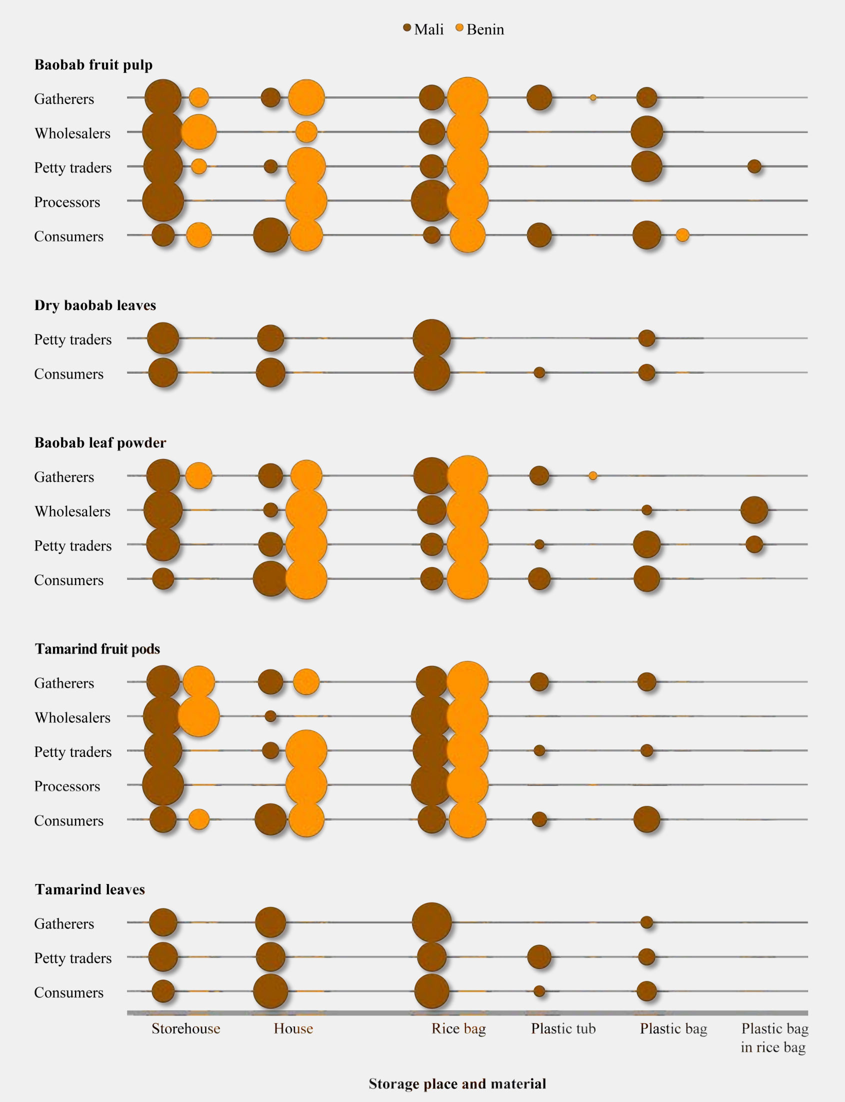


Figure 4.16: Storage place and material for baobab and tamarind products in Mali and Benin (note: the bigger the bubble, the more important the storage place or material)

Figure 4.17: Kiosk and storage function of processor

Mali. This can possibly be explained by a shorter storage duration of leaf powder by petty traders in Benin, one month versus to two months and a half in Mali. All chain actors in Mali, except consumers, store leaf powder in a storehouse, whereas all actors in Benin, together with Malian consumers, reported to store the product in their house. Baobab leaf powder is generally kept in recycled rice bags, however, traders in Mali also keep leaf powder in plastic bags or in a plastic bag which is put in a recycled rice bag. On a 5-point scale (1 = very bad, 5 = very good), storage conditions for baobab leaf powder receive by all actors a score between 3.95 and 4.44. However, in both countries, all actors recognise humidity and bug, mice and fungi attacks as the major problems during storage.

Tamarind fruit pods Average mean quantities of tamarind fruit pods stored by chain actors in Mali and Benin are given in Table 4.11. Many significant differences in quantity stored are found when actors are compared within and between countries. Generally, these differences can be related to differences in storage duration. *E.g.* processors in Benin store a rather small quantity of tamarind fruits during one month, whereas, in Mali, processors store large quantities during during seven and a half month. Gatherers and consumers in Mali reported to store tamarind pods in their house, while traders and processors store the fruits in a storehouse. A storehouse in Benin is used by gatherers and wholesalers in Benin to store tamarind fruit. The other actors in Benin recorded storage in their house. Tamarind fruits are mainly kept in recycled rice bags. Processors of tamarind fruit pods recorded also to store tamarind juice either in small plastic bags which are kept in a fridge or freezer, or in plastic bottles stored in the store or storehouse. On a 5-point scale (1 = very bad, 5 = very good), storage conditions for tamarind fruits receive by all actors a score between 3.85 and 4.28. In both countries, all actors mentioned humidity and bug, mice and fungi attacks as the major problems during storage. The major problem reported by processors during storage of tamarind juice is the fermentation risk.

4.3.6 Uses and consumption trends

Fresh baobab leaves in Benin are prepared as a sauce. In addition, Malian consumers reported to prepare couscous with baobab leaves, or else dry and crush fresh leaves in order to obtain leaf powder, which has a longer shelf life. Dry baobab leaves are generally crushed into powder and used in couscous and sauce preparation. Baobab leaf powder is used as the main ingredient in the preparation of sauces in Benin and Mali. Consumers in both countries use baobab fruit pulp to make porridge (*bouillie*) (Figure 4.18) and juice. In Mali, baobab fruit pulp is also used in the preparation of millet cream (*dégué*). Additionally, almost one fifth of respondents in Benin stated to buy also ready-to-use products made from baobab fruit pulp, such as juice or syrup. Malian consumers use tamarind fruits and leaves in porridge (*bouillie*), millet cream (*dégué*), juice, sauce and couscous preparations. Tamarind fruit pods in Benin are mainly used to make juice. Additionally, almost one fifth of respondents in Benin stated to buy also ready-to-use products made from tamarind fruits, such as juice or syrup.

Besides daily consumption, baobab and tamarind food products are also used for special events. In Mali, one fifth of all consumers stated to use baobab and tamarind products to prepare dishes to celebrate births and weddings, and during Ramadan. In particular, tamarind fruits are used during birth celebrations and to break the fast during Ramadan. Beninese consumers link baobab and tamarind products less to special occasions, although one tenth used these products to prepare dishes for new year. The majority of consumers in Mali (93 %) stated to sometimes substitute baobab and tamarind products, especially when they are not easily available and prices increase. Only 26 % of Beninese consumers reported to replace these products. Substitution products are shown in Table 4.12. Baobab leaf products can primarily be replaced by okra (*Abelmoschus*

Figure 4.18: Preparation of baobab fruit pulp porridge. Above: pulp, seeds and fibres are diluted in water. Middle: seeds and fibres are removed and dissolved pulp remains. Below: at the same time, water is added to *e.g.* maize flour, boiled and thickened to a porridge which is mixed with the dissolved baobab pulp

Table 4.12: Substitution products for baobab and tamarind products

	Baobab		Tamarind	
	Leaves	Fruits	Leaves	Fruits
Baobab fruit pulp	–	–	x	x
Citrus fruits	–	x	x	x
Roselle	x	x	x	x
Kapok flower	x	x	–	–
Milk, yoghurt	–	x	x	–
Okra	x	x	–	–
Other leaves	x	x	x	x
Tamarind fruit	–	x	x	-
Tamarind leaves	–	–	–	x
Vinegar	–	–	x	x

X: reported as substitution product; -: not reported as substitution product

caillei), and to a lesser extent by other leaves (not further specified), and flowers of roselle (*Hibiscus sabdariffa*) and kapok (*Ceiba pentandra*). Baobab fruit pulp is reported to be substituted by citrus fruits, roselle or kapok flowers, milk or yoghurt and tamarind fruits. Tamarind fruits and leaves can both be replaced by citrus fruits, roselle flowers and vinegar. Additionally tamarind fruits and leaves can substitute each other.

On a 5-point scale (1 = very decreased, 3 = constant, 5 = very increased), consumption of baobab and tamarind products during the last five years increased and received a score of 3.59 and 3.25 in Mali and Benin, respectively. Expected consumption during the coming five years will also increase and was scored 3.95 and 3.57 by consumers in Mali and Benin, respectively. Changes in consumption during the last years and the coming years are found to be significantly higher in Mali than in Benin (Mann-Whitney Test, $p < 0.01$). Similar consumption trends were observed when rural and urban consumers are compared for Mali and Benin. However, within each country, no significant differences regarding consumption changes in both past and future were observed for rural and urban consumers. Furthermore, no significant differences or particularities in consumption trends were observed for specific baobab and tamarind products in both countries nor for rural and/or urban consumers. Most consumers are satisfied with the supply (two thirds in Mali and all respondents in Benin). However, on the question if, in case there are more baobab and tamarind products available, they would buy more,

Figure 4.19: Primary processing of baobab fruits into baobab fruit pulp

about half of the respondents said ‘yes’ in Mali and Benin. Consumers are particularly willing to purchase more baobab fruit pulp in comparison to other baobab and tamarind products.

4.3.7 Processing practices

As already mentioned above, primary baobab and tamarind products are processed into secondary and/or tertiary products for sale and consumption purposes. Hereafter, processing practices are given for baobab and tamarind fruits. Furthermore, the results of an efficiency analysis of processors in Mali and Benin are presented.

Baobab fruits

Primary processing of baobab fruits, *i.e.* from baobab fruit pods to baobab fruit pulp is reported to be done by the gatherers. To obtain baobab fruit pulp, fruit shells are first cracked, fruit pulp is then separated from fibres, dried pulp is subsequently crushed gently in order to remove seeds, and finally pulp is further crushed and sieved to obtain a fine powder (Figure 4.19). Gatherers often reported problems to crack fruits because of the very hard pod and itching caused by the short hairs that covered the fruits.

Secondary processing of baobab fruit pulp is done by processors in Mali and Benin. In Mali, baobab fruit pulp is used in the preparation of millet cream (locally called *dégué*) (44 %) or processed into baobab juice (22 %),

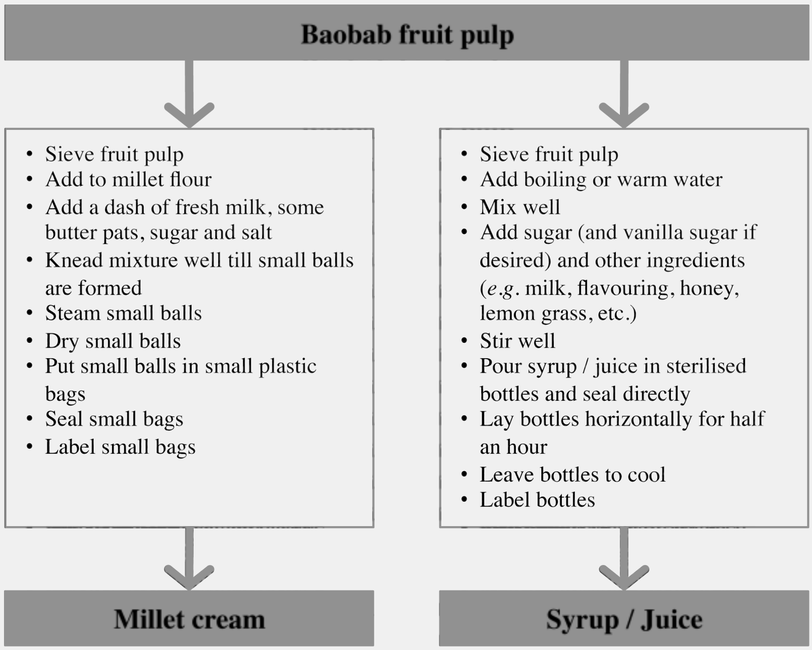


Figure 4.20: Processing methods of baobab fruit pulp for obtaining millet cream, syrup and juice

syrup (17 %), jam (11 %) and instant juice powder (6 %). Processors in Benin solely reported to make juice from baobab fruit pulp. Figure 4.20 shows the processing of baobab fruit pulp into the tertiary products juice (or syrup) and millet cream. It should be noted that not all respondents were willing to share their recipes for the preparation of tertiary baobab fruit products. For that reason, the processing method of baobab jam and instant juice powder could not be described in the present study. Moreover, processors were even less keen to share quantities of ingredients used during processing. The processes described in Figure 4.20 are thus a generalisation of all processes mentioned by the processors in Mali and Benin.

As presented in Table 4.9, processors in Mali (n = 18) buy annually about 347 kg baobab fruit pulp at a mean price of 560 FCFA / kg. In Benin,

Figure 4.21: Tamarind fruits sold at market place

processor (n = 27) buy significantly more baobab fruit pulp, 712 kg, at a significantly cheaper price, 325 FCFA / kg, than processors in Mali. Annually, 993 l baobab juice at a price of 1,005 FCFA / l and/or 5,480 kg *dégué* at a price of 735 FCFA / kg are sold by Malian processors (n = 4 and n = 8, respectively). In Benin, processors (n = 27) sell annually 7,409 l baobab juice at a price of 415 FCFA / l.

Tamarind fruits

Before consumption or selling, all gatherers processes tamarind fruits by first drying the pods in the sun and then removing their shell. Some gatherers and petty traders reported also to press tamarind fruit pulp into balls for storage and sale purposes (Figure 4.21).

In Mali, tamarind fruit pods are processed into syrup (52 %), juice (31 %), instant juice powder (10 %) and jam (7 %), whereas, in Benin, processors solely reported to make juice from tamarind fruits. Figure 4.22 shows the processing steps of tamarind fruit pulp into juice (or syrup), jam and instant juice powder. However, it should be noted that the majority of respondents was not willing to share quantities of ingredients used during processing. Therefore, the described processes are a generalisation of all processes mentioned by the processors in Mali and Benin. An important note is that tamarind jam can be seen as a by-product of juice / syrup processing.

Table 4.11 shows the mean annual quantity and price of tamarind fruit pods bought by processors. In Mali, processors (n = 29) buy annually

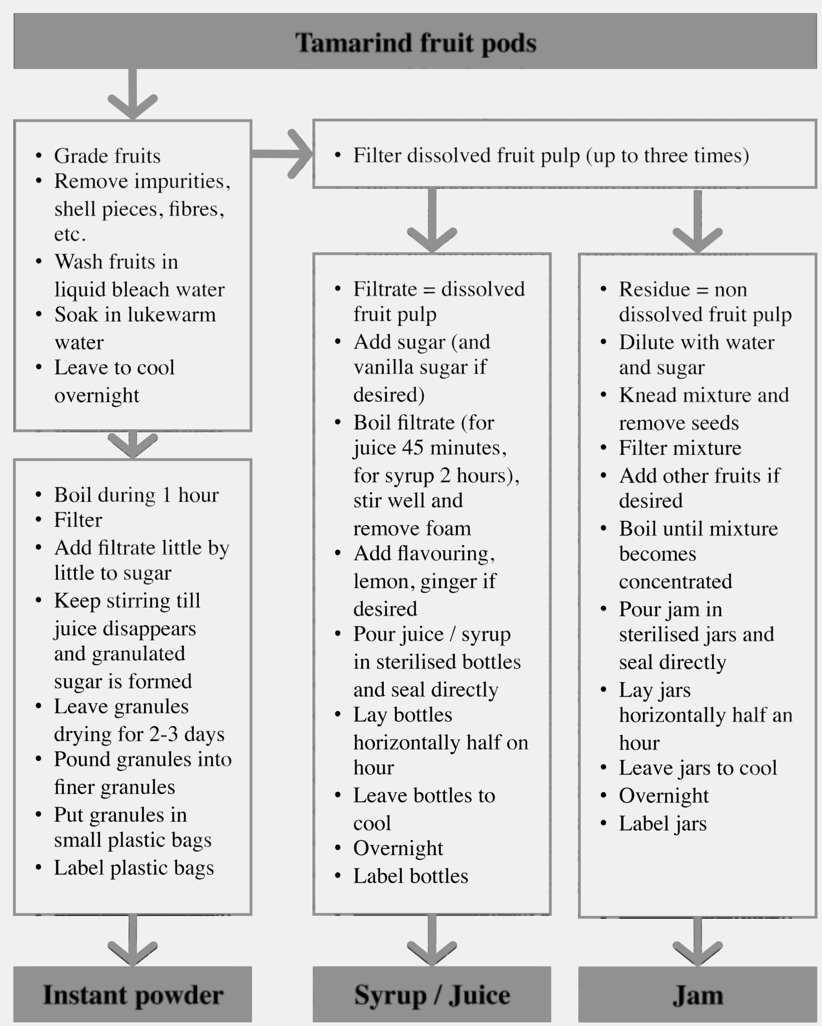


Figure 4.22: Processing method of tamarind fruit pulp into instant juice powder, syrup, juice and jam

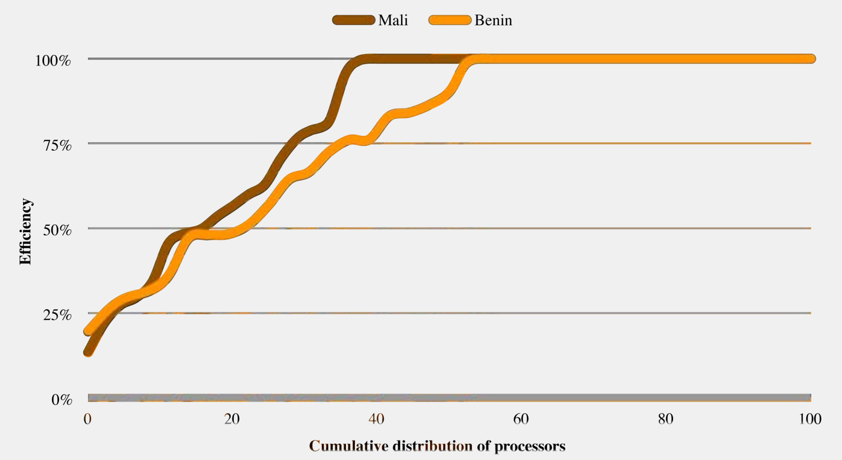


Figure 4.23: Cumulative distribution of processors in function of efficiency

about 1,047 kg tamarind pods at a mean price of 220 FCFA / kg. In comparison with processors in Mali, Beninese processors (n = 10) buy less tamarind fruits, 302 kg, at a similar price, 265 FCFA / kg. On an annual basis, 3,558 l tamarind juice and 4,072 l tamarind syrup are sold at a price of 635 and 425 FCFA / l by processors in Mali (n = 9 and n = 15), respectively. In Benin, processors (n = 10) sell annually about 2,805 l tamarind juice at a mean price of 1,745 FCFA / l.

Efficiency of processing units

Based on the results of a DEA analysis, 63 % of the surveyed processors in Mali and 49 % in Benin appear to work quite efficiently under the given conditions. The model used was made up of one output (*i.e.* annual revenue obtained by selling tertiary baobab and tamarind products) and seven input variables (*i.e.* costs of raw material, employees, packaging material, utensils, equipment, resources, and storage and transport). Cumulative distribution of processors in function of efficiency is shown in Figure 4.23. Additionally, Table 4.13 shows revenue and processing costs for inefficient and efficient processors in Mali and Benin. Based on these variables, mean annual net income was calculated and presented in the same Table. The mean annual net incomes of inefficient (*i.e.* less

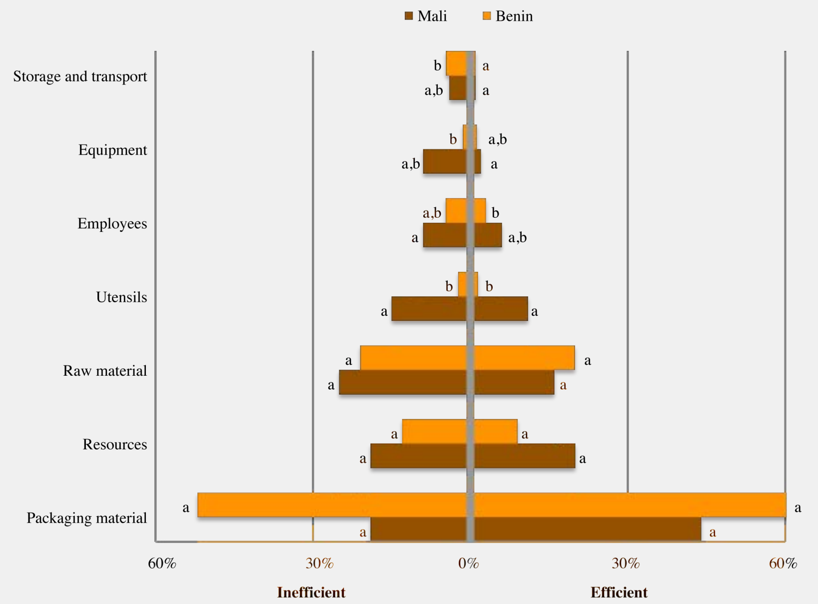


Figure 4.24: Relative importance of different processing costs on net income of efficient and inefficient processors of baobab and tamarind products in Mali and Benin

than 100 % efficient) processors in Mali and Benin are, respectively, -79,815 FCFA and 1,030,735 FCFA. Notwithstanding the huge difference between both values, no significant difference was detected (Mann-Whitney Test, $p = 0.08$). On a 90 % significance level there is, however, a significant difference found. Efficient (*i.e.* 100 % efficient) processors in Mali and Benin have a mean annual net income of 3,204,490 FCFA and 2,909,960 FCFA (Mann-Whitney Test, $p = 0.12$), respectively.

When we take a look at the relative importance of each of the costs listed above on net income (as shown in Figure 4.24 and Table 4.13), we can clearly see that packaging costs are the major costs for processors in Mali and Benin. Moreover, local packaging materials are often reported to be of bad quality and not suited for the product packaged, *e.g.* small plastic bags and plastic bottles are often not well sealed (Figure 4.25).

Table 4.13: Mean annual net income, revenue and processing costs for (in)efficient processors in Mali and Benin (all figures are expressed in FCFA)

		Mali		Benin	
		Efficient n = 29	Inefficient n = 17	Efficient n = 18	Inefficient n = 19
Net income	mean	3,204,490^{b,c}	-79,815^{a}	2,909,960^{c}	1,030,735^{a,b}
	median	415,600	-42,550	1,120,990	301,300
	std. dev.	8,731,480	833,145	3,687,735	2,437,765
Revenue	mean	4,195,465^{a}	1,352,505^{a}	3,958,785^{a}	1,884,105^{a}
	median	656,250	562,500	1,291,000	600,000
	std. dev.	10,037,260	1,420,320	4,957,620	3,591,295
Costs of:					
raw material	mean	154,120^{a}	351,320^{a}	206,220^{a}	173,015^{a}
	median	50,000	124,995	112,500	100,000
	std. dev.	211,280	710,845	240,205	231,730
employees	mean	63,355^{a,b}	131,245^{a}	29,280^{b}	40,265^{a,b}
	median	0	105,000	0	2,000
	std. dev.	103,845	135,065	60,295	73,730
packing material	mean	432,020^{a}	277,690^{a}	682,960^{a}	457,365^{a}
	median	37,500	68,100	175,000	80,000
	std. dev.	1,090,135	570,100	894,745	1,060,820
utensils	mean	108,030^{a}	220,595^{a}	7,370^{b}	19,670^{b}
	median	68,840	66,665	3,195	6,630
	std. dev.	143,285	373,915	8,195	33,695
equipment	mean	24,450^{a}	123,105^{a,b}	11,400^{a,b}	12,325^{b}
	median	2,300	15,000	10,335	12,000
	std. dev.	60,255	187,520		11,020
resources	mean	194,525^{a}	266,585^{a}	97,710^{a}	110,775^{a}
	median	45,600	57,925	36,000	50,400
	std. dev.	369,155	464,800	138,270	111,940
storage and transport	mean	14,475^{a}	61,780^{a,b}	13,890^{a}	39,955^{b}
	median	5,000	9,500	5,000	14,300
	std. dev.	20,945	155,900	17,760	59,525

Means with a different superscript are significantly different based on Mann-Whitney Test (p-value<0.05); std. dev. stands for standard deviation

Figure 4.25: Low quality of local sealing practice of processed materials

Additionally, it can be noticed that the cost of utensils is significantly lower for efficient processors in Benin than in Mali. None of the costs is reported to be significantly different between efficient and inefficient processors in Mali and Benin. Therefore, no conclusion could be made regarding the determining factors of efficiency.

4.3.8 Trade centres

By linking data about origin and destination, it is possible to identify regions in Mali and departments in Benin where trade of specific baobab and tamarind products is concentrated. In Mali, the major trade centres are (listed according to importance) situated in the capital district Bamako and the regions Ségou, Mopti, Kayes and Sikasso. The major trade centres of baobab and tamarind products identified in Benin are, according to decreasing importance, the departments of Alibori, Littoral (Cotonou), Borgou, Atacora and Collines. Additionally, Figures 4.26

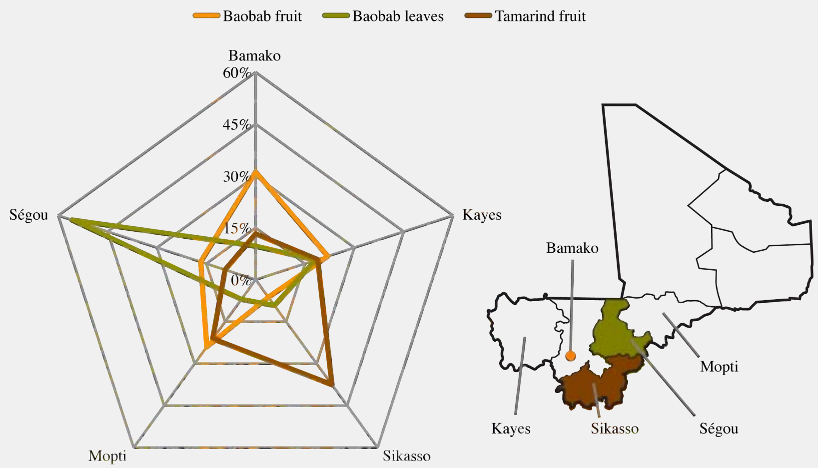


Figure 4.26: Trade centres of baobab leaf powder, baobab fruit pulp and tamarind fruit pods in Mali (note: the axes in the radar chart represent percentage of product traded in given region)

and 4.27 shows the trade centres per main traded baobab and tamarind product.

Baobab leaf powder Baobab leaf powder has both in Mali and Benin a marked trade centre, namely the region of Ségou in Mali and the department Borgou in Benin, respectively.

Baobab fruit pulp The trade centre of baobab fruit pulp in Mali is situated in the capital district Bamako. Additionally, the regions of Kayes and Mopti are also important for trade of baobab fruit pulp. In Benin, the main trade centre of baobab fruit pulp is situated in the department Collines, whereas also Cotonou, in the department Littoral, plays a major role in trading baobab pulp.

Tamarind fruit pods In Mali, tamarind fruit pods are mainly sold in Sikasso. However, the regions of Kayes and Mopti may not be neglected as trade centres for tamarind fruits. The most important trade centre in Benin is found to be the department of Atacora and to a lesser degree also

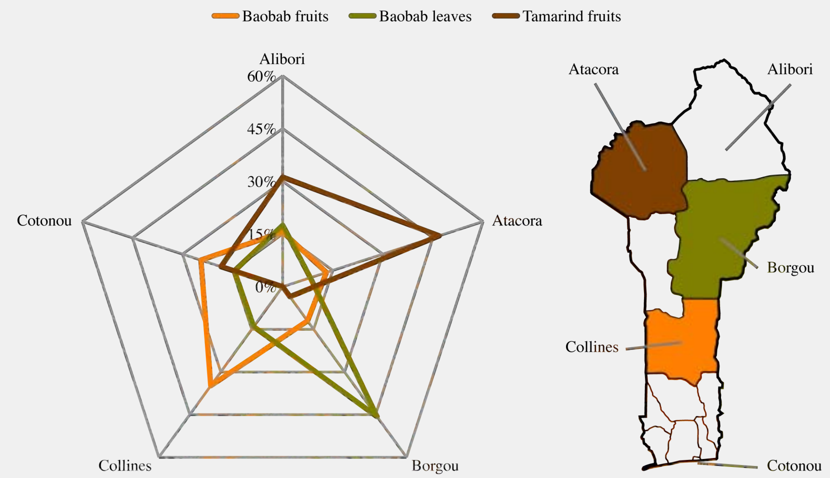


Figure 4.27: Trade centres of baobab leaf powder, baobab fruit pulp and tamarind fruit pods in Benin (note: the axes in the radar chart represent percentage of product traded in given department)

the Alibori department. In Mali and Benin, traded baobab and tamarind products are by wholesalers reported to be mainly and respectively from Malian and Beninese origin. Nevertheless, a small portion of the products in Mali and Benin are reported to be from Burkinabe origin, which is particularly the case for tamarind fruit pods and baobab fruit pulp. In Mali, also export of baobab and tamarind products to Senegal and Mauritania is reported, whereas, in Benin, some traders reported to export baobab fruit pulp to Niger and Nigeria.

Curiously, only a few consumers in the present study are interested in the origin of products. About two thirds of Malian consumers is not at all interested in the origin of the purchased products, while one third stated to be interested in the origin (mean score of 1.99 on a 5-point scale with 1 = not at all interested and 5 = very interested). In Benin, consumers are generally only limitedly interested in the origin of these products (2.53 on a 5-point scale). The interest in origin is significantly different between both countries (Mann-Whitney Test, $p < 0.01$). In addition, consumers who are interested in the origin of the products are convinced that the origin determines the quality of the latter products.

4.3.9 Quality criteria

In Figure 4.28, quality criteria adopted by surveyed chain actors are shown per baobab or tamarind product. However, in the present study, it should be noted that traders surveyed in the present study trade in non-standardised products, and direct inspection is the only reported method by which quality is assessed. Hereafter, quality criteria used by different chain actors are discussed for each baobab and tamarind product.

Baobab fruit pulp All chain actors in Mali and Benin attach great importance to processing and storage techniques, so that a dry and fine powder without impurities is obtained. Moreover, in Mali, all chain actors use colour as an important quality parameter, whereas in Benin taste is adopted as criterion – with the exception of consumers, who use colour as parameter.

Fresh baobab leaves In Benin, gatherers consider the absence of insect lesions on the leaves, maturity, freshness, size, and processing and storage techniques important to judge the quality of fresh baobab leaves. Petty traders in Mali use processing and storage techniques as the main quality parameter for fresh baobab leaves, whereas consumers adopt several criteria. When consumers in Mali and Benin are compared, it is obvious that Beninese consumers attach greater importance to absence of insects and product freshness than Malian consumers.

Dry baobab leaves In Mali, gatherers, petty traders and consumers adopt a number of quality criteria to distinguish good and bad quality of dry baobab leaves. Colour, and processing and storage techniques are the main parameters to assess quality of dry baobab leaves.

Baobab leaf powder For baobab leaf powder, Figure 4.28 shows clearly that chain actors in Mali use colour as an important quality criterion, whereas in Benin processing and storage techniques are of primary importance.

Tamarind fruit pods Important quality criteria for tamarind pods are processing and storage techniques, absence of insects, maturity, freshness

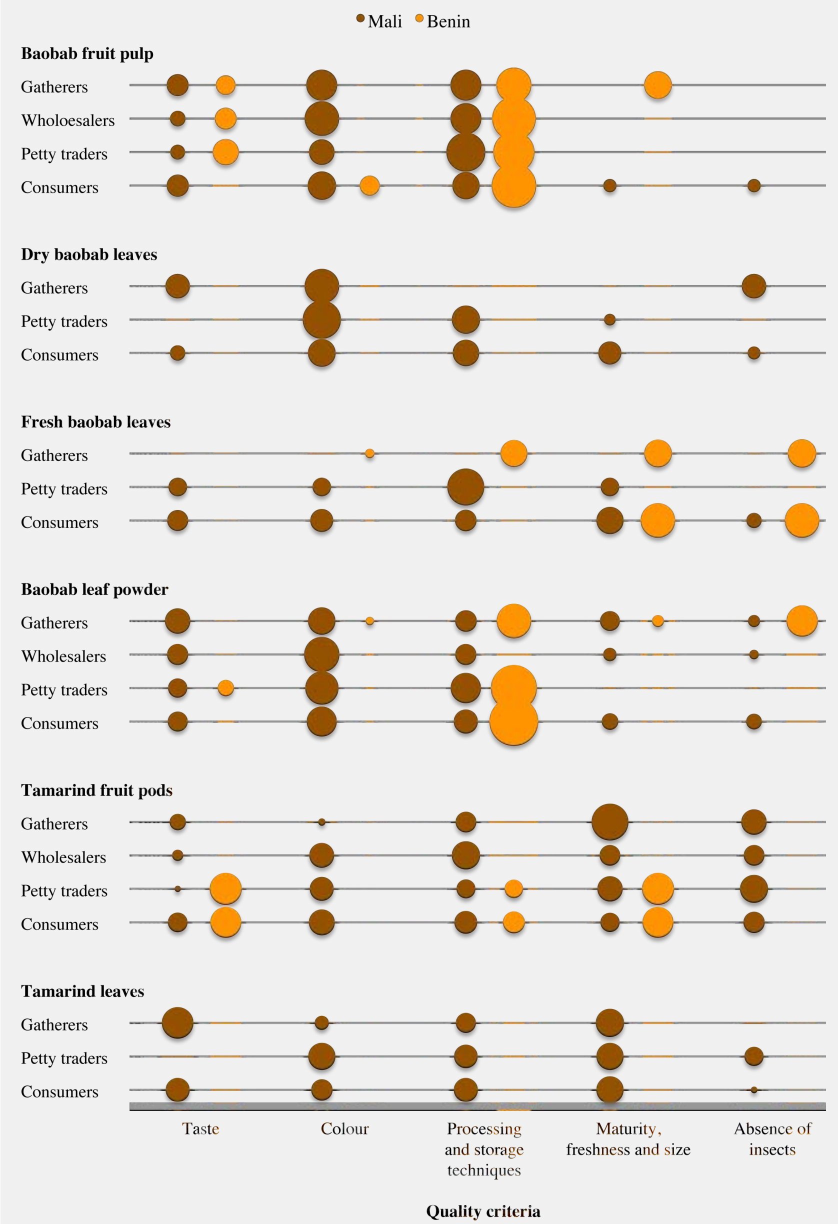


Figure 4.28: Quality criteria of baobab and tamarind products adopted by different chain actors in Mali and Benin (note: the bigger the bubble, the more important the quality criteria)

and size, but also colour (in Mali) and taste (in Benin).

Tamarind leaves In Mali, processing and storage techniques are about the most important quality parameter.

Until now, no certification or labels have (yet) been ascribed to baobab and tamarind food products. On a 5-point scale (1 = not at all useful, 5 = very useful), Malian consumers consider the certification of baobab and tamarind food products useful (4.15), whereas only half of the respondents in Benin believe certification would be useful whereas the other half think it would only be slightly useful (3.50). The usefulness attributed to certification is significantly higher in Mali than in Benin (Mann-Whitney Test, $p < 0.01$). Consumers who consider certification useful are convinced that certification will guarantee good quality and increase consumer confidence.

4.3.10 Information flow

Figure 4.29 shows how chain actors in Mali and Benin score availability of market information and overall satisfaction of access to this information. It is remarkable to see that overall satisfaction is scored much lower in Mali than in Benin. Further, it can be noticed that for the factor price information there are large differences between chain actors, whereas for demand there are large differences between Mali and Benin. Hereafter, availability of information and overall satisfaction is discussed per chain actor.

Gatherers Generally, gatherers in Benin score the availability of information significantly better than in Mali. However, it is remarkable to notice that gatherers in Benin score the availability of quality-related information as low as their gatherer colleagues in Mali. Overall satisfaction of access to information follows the same trend as availability and is significantly lower in Mali (1.64 on a 5-point scale) than in Benin (3.10) (Mann-Whitney Test, $p < 0.01$). Thus, Malian gatherers are not satisfied with the access to market information, while in Benin they are rather satisfied.

Traders The availability of information about quality and demand differs significantly between Mali and Benin, whereas the availability of information about price and supply does not differ significantly.

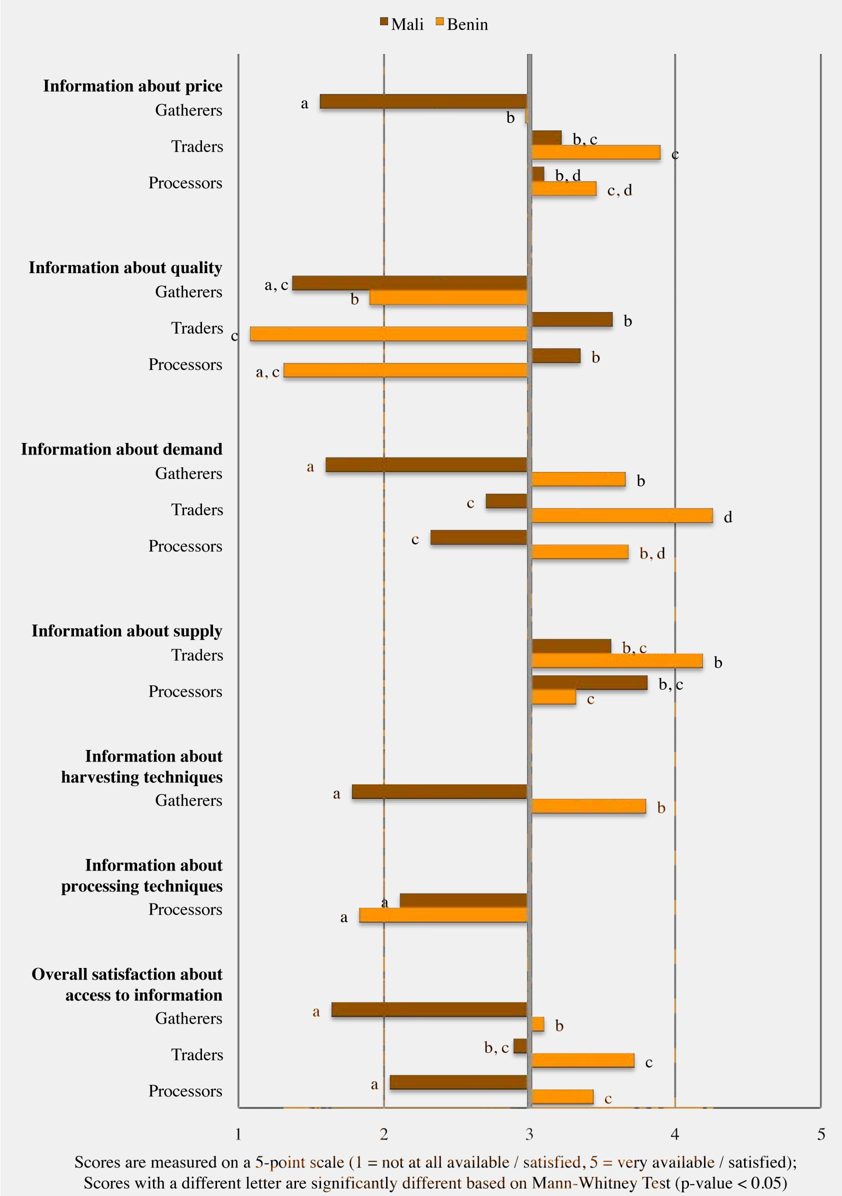


Figure 4.29: Availability of information and overall satisfaction of access to information according to different chain actors in Mali and Benin

In comparison to wholesalers in Mali, Beninese wholesalers score the availability of information about quality and demand respectively significantly lower and higher. In addition, it is remarkable that there is a fair degree of dispersion in the scores of individual Malian wholesalers. By contrast, in Benin, wholesalers are rather unanimous about the availability of information. Overall satisfaction of access to information is comparable and thus not significantly different in Mali and Benin (respectively 2.89 and 3.72 on a 5-point scale) (Mann-Whitney Test, $p = 0.11$).

Processors In comparison to processors in Mali, Beninese processors score the availability of information about quality and demand significantly lower and higher, respectively. The availability of information about price, supply and processing techniques does not differ significantly between both countries. Overall satisfaction of access to information is significantly higher in Benin than in Mali (respectively 3.44 and 2.04 on a 5-point scale) (Mann-Whitney Test, $p < 0.01$). Additionally, in Mali, many processors (82 %) stated to be willing to pay for information, whereas, in Benin, only 38 % of respondents reported to be willing to pay for market information. On average, processors in both countries are willing to pay annually about 2,000 FCFA.

4.3.11 Problems

Each chain actor in Mali and Benin has been informally asked to identify the problems encountered regarding the commercialisation of baobab and tamarind products. Table 4.14 shows the compiled results for both countries as no country specific problems were recorded. Lack of market information is a common problem for all actors, and none of the traders was well informed about the conditions that need to be fulfilled to access the market. Based on the latter, the author assumes that most baobab and tamarind products are traded on the informal market in Mali and Benin.

Gatherers Gatherers mention as harvesting problems the risk of accidents while climbing trees, the long distance between the trees and their home to carry the produce, and the itchy and irritating hairs that cover baobab fruits. Some gatherers mentioned also a limited number of baobab and tamarind trees in their region which causes a low availability of fruits and leaves. The seasonality of most baobab and tamarind

Table 4.14: Problems mentioned by the different actors in the market chain of baobab and tamarind products in Mali and Benin

	Gatherers	Wholesalers	Petty traders	Processors	Consumers
Harvest	x	–	–	–	–
Seasonality	x	–	x	–	x
Availability	x	–	x	–	–
Quality	x	x	x	–	x
Supply	–	x	–	–	x
Demand	–	–	x	–	–
Price	–	–	–	–	x
Storage	–	x	x	–	x
Transport	–	x	–	x	–
Finance	–	x	x	x	–
Information	x	x	x	x	x
Processing	x	–	–	–	–
Packaging	–	–	–	x	x
Equipment	–	–	–	x	–

x: mentioned as problem; –: not mentioned as problem products influences the availability too. Furthermore, fruits and leaves are sometimes attacked by insects which influences the product quality. Processing is generally seen as a time-consuming task and drying of particularly baobab leaves is considered difficult as it mostly takes place during the rainy season.

Traders Wholesalers identify product quality as a major problem as baobab and tamarind products are not graded. Storage space is often limited, which may hamper the supply further down the market chain, thus towards the end users. Transport is severely hampered due to poor roads and lack of infrastructure, which raises the costs and risks of transport. Moreover, there is no access to formal financial services such as loans and insurance. Petty traders face problems due to the seasonality and thus availability of products. Also varying quality is seen as a constraint in the marketing of baobab and tamarind products. Furthermore, petty traders have no access to financial services, have limited storage possibilities and complain about a lack of demand.

Processors Processors of baobab and tamarind products mention bad transport and lack of financial means as constraints. In addition, they have limited equipment and difficulties to find appropriate packaging materials. Additionally, printing of labels is very expensive.

Consumers Consumers complain about limited supply and high prices due to the seasonality of the products. Quality is mostly judged as unreliable, as good and bad quality products are mixed. Packaging materials are considered to be inappropriate which may limit storage life.

5
Discussion and recommendations

In this chapter the results are discussed and confronted with findings of other authors. Subsequently, a SWOT and impact analysis of market chains of baobab and tamarind products in Mali and Benin are presented. To conclude, possible scenarios for intervention are formulated and substantiated with references on how to add more value to baobab and tamarind products and how to improve the organisation of their market chains.

5.1 Discussion of results

5.1.1 Chain actors and activities

Whenever a product moves along a market chain, *i.e.* from production or gathering to final use or consumption, various stakeholders are involved. These actors have different functions – such as gathering, collecting, processing, storing, packaging, marketing and selling of the products – and add value to the product at each stage in the chain. Each actor thus plays a role that is important in the successful commercialisation of the product, and each actor has different incentives and abilities to influence the chain (Marshall *et al.*, 2006a).

Gatherers and harvesting practices

According to Davis (2006), small-scale farmers derive their livelihoods from a holding smaller than 5 ha and around 10 to 20 heads of livestock. Moreover, smallholders practice a mix of commercial and subsistence production (in crops or livestock), whereby the family provides the majority of labour and the farm provides the principle source of income. Based on this broad definition, the surveyed households in Mali and Benin can be categorised as smallholders. Because individual gatherers of baobab and tamarind products in Mali and Benin are part of a family or household, households were incorporated as a unit of analysis in the present study.

Household activities Informal interviews and observation in the present study showed that, irrespective of the primary reasons for cattle and livestock ownership – such as ploughing, milk and/or savings –, most surveyed households derive not just one, but a number of different goods and services from their livestock, especially from small stock. This has also been confirmed by Dovie *et al.* (2006) who added that, for cattle, the largest contributors to the total gross value were savings, milk and manure. Goats provide less goods and services, with savings, meat and cash sales being the main benefits (Dovie *et al.*, 2006).

Four out of the five most cultivated crops by the informants in Mali and Benin are staple food crops, which are prepares into gruels and/or thick porridges for daily consumption. The FAO defines a staple food as one that is eaten regularly and in such quantities as to constitute the dominant part of the diet and supply a major proportion of energy and nutrient needs (Loftas, 1995). However, FAO adds that in order to meet a population's total nutritional needs, a variety of foods is required. In Mali, cereal crops, such as millet, sorghum, maize, rice and fonio, constitute the main component of each meal and are accompanied by or alternated with cowpea, groundnut and/or voandzou (FAO, 1999a). The main components of daily meals in Benin are cassava, yam, maize, millet, sorghum and rice (FAO, 2003). The legume *Arachis hypogaea* (groundnut or peanut) is cultivated mainly by small-scale farmers both as a subsistence and cash crop (Stoate & Jarju, 2008; ICRISAT, 2010). Groundnuts are often used as a snack or in sauce and stew preparation in SSA, and can also be processed into a nutritious and commonly used edible oil, which makes it an important ingredient of the local diet.

The annual cash income per household obtained from AFTPs other than baobab and tamarind – *i.e.* mainly shea and African locust bean tree products – ranges between 10,000 and 100,000 FCFA in Mali and 25,000 and 100,000 FCFA in Benin, with as mean values respectively 42,775 and 53,520 FCFA. These values seem higher as those reported by Schreckenberg (2004). In 1993, the latter author found that the annual cash income obtained solely from shea kernel sales varied from 2,000 to 10,000 FCFA in Benin. This difference might be explained by, on the one hand, the sharp devaluation of the CFA franc in the period 1994-1998 that doubled prices in order to help stimulating African exports (van den Boogaerde & Tsangarides, 2005), and, on the other hand, annual inflation rates.

Household cash income In Mali, the portion of cash income obtained from baobab and tamarind products is about 4 % for the poorest and 5 % for the richer households, whereas, in Benin, contributions of up to 11 % are reported for the poorest smallholders. As the results in the present study show that poor households – particularly in Benin – earn a relatively high proportion of their cash income from baobab and tamarind, interventions in these two products have a high potential to improve livelihoods of the poor. However, in a similar study, Ambrose-Oji (2003) found that the middle income groups derive the greatest benefit from NTFP collection, use and sale. The lower contribution of cash income obtained from baobab and tamarind products in Mali can possibly be explained by the fact that home consumption of these products is reported to be more important than in Benin. Moreover, Fandohan *et al.* (2010a) reported contributions to cash income ranging from 8.76 % to 56.40 % for tamarind fruits by several ethnic groups in Benin. These results indicate that the potential baobab and tamarind products have to contribute to household cash income might be underestimated in the present study. However, our results show that baobab and tamarind cash income is considered additional to the cash income derived from selling crops. Therefore, it can be said that baobab and tamarind products – as well as other AFTPs – fall into the so-called gap-filling income category (Marshall *et al.*, 2006b). This means that even products contributing a relatively small share of a households total income may be perceived to play a valuable role in a household's livelihood strategy. The major reason that even small amounts of income derived from NTPFs can become important is that they may come at times of the year when households have no other income generating activities. Therefore, income from most NTFP activities is often complementary to the highly seasonal income from agricultural activities, providing the household with a combined income flow (Marshall *et al.*, 2006b), which has been confirmed in the present study.

Gatherers of baobab and tamarind products Due to the patriarchal society organisation in Mali and Benin, more men than women have been asked about their harvesting practices of baobab and tamarind products. Notwithstanding this gender inequality, the author believes that this had no significant influence on the results of the study. Also Vogl *et al.* (2009), Buchmann *et al.* (2010) and van der Stege *et al.* (2011) reported that the majority of respondents in their ethnobotanical surveys did not identify any specific gender issue related with gathering and/or harvesting baobab and tamarind products.

In the present study, the majority of gatherers in Mali reported to harvest baobab and tamarind food products chiefly for their own consumption, whereas in Benin only a limited percentage of the produce seems to be used for home consumption. Similarly, Akinnifesi *et al.* (2008a) reported that, in the Miombo woodlands of southern Africa, more than half of baobab fruits harvested were often retained for home consumption. However, in general and after satisfying household consumption needs, gatherers of baobab and tamarind products in Mali and Benin reported to sell their surplus products directly to consumers or to middlemen at the farmgate, which is also known as on-farm sales, or on the local market. This confirms the findings of Agea *et al.* (2005) and Fafchamps & Hill (2005). The latter authors stated that most farmers in SSA produce on a small scale and are geographically isolated – and thus often outside the reach of formal market institutions. Although farmgate selling appears to be less remunerative, it may be the only alternative open to smallholders who cannot afford carrying their products to the market, which is usually located at many kilometres from the homestead. When deciding whether to sell at the farmgate or to travel to the nearest market, a farmer must thus choose between receiving a lower price on-farm, or receiving a higher price but incurring transaction costs (Fafchamps & Hill, 2005). The latter authors found that the likelihood of selling at the marketplace increases with quantity sold and proximity to the market. In addition to the two earlier mentioned marketing channels, namely on-farm sales and selling at a marketplace, which are reported to be used by the surveyed gatherers of baobab and tamarind products in Mali and Benin, a third channel has been recorded. Indeed, in Benin, some surveyed gatherers reported to sell their produce via collecting gatherers which is a form of group marketing.

Harvesting techniques There are many different fruit harvesting techniques observed and recorded, such as shaking branches, using sticks to knock the fruits to the ground, throwing objects to dislodge fruit and climbing up trees. These traditional harvesting methods, together with picking fruit up from the ground once they have fallen, have also been reported in literature (Hughes & Haq, 2003; Dhillion & Gustad, 2004; Assogbadjo, 2006; Kadzere *et al.*, 2006; Akinnifesi *et al.*, 2008a; Ham *et al.*, 2008; Haq *et al.*, 2008; Wickens & Lowe, 2008; Kalaba *et al.*, 2009; Vogl *et al.*, 2009). Also the use of a *dolé* or *coupe-coupe* (machete) to harvest fruits as observed in the present study has been confirmed by several authors (Dhillion & Gustad, 2004; Assogbadjo, 2006; Vogl *et al.*, 2009).

Similarly to the practice of baobab leaf harvesting reported in Mali in the present study, Sidibé *et al.* (1998b) and Dhillion & Gustad (2004) recorded that fresh baobab leaves are on a regular basis harvested in the course of the wet season, whereas, during the last month of the rainy season, leaves are harvested in great quantities, dried and stored for domestic use and/or for selling during the dry season. Baobab and tamarind leaves are reported to be harvested by either climbing in trees or not. In the first case, leaves are picked by hand or else whole branches are cut using sickles or axes. In the latter case, branches are cut by using a *dolé* or *coup-coup* as tool. The same harvesting techniques for leaves and the use of both tools have been reported by Dhillion & Gustad (2004), Assogbadjo (2006), Vogl *et al.* (2009), Buchmann *et al.* (2010), van der Stege (2010) and van der Stege *et al.* (2011). As complete branches are often cut in order to harvest baobab leaves, Buchmann *et al.* (2010) reported that such technique reduces the number of flower buds, and consequently fruit numbers. This phenomenon has been observed during field work and may result in a strange picture of a baobab tree, which bears only fruits in the highest parts of the crown where people cannot reach (Figure 5.1).

Generally, local harvesting of fruits and leaves of both baobab and tamarind in Mali and Benin is carried out in a non-destructive way using manual labour and low-cost tools. The latter has been confirmed by Buchmann *et al.* (2010) who reported that traditional harvesting requires virtually no cash investment, as equipment is generally confined to inexpensive hand tools. In addition, Schreckenberg (1999) and Belcher & Schreckenberg (2007) stated that harvesting of fruits, seeds or leaves of long-lived species is generally managed in a sustainable way. Harvesting of fruits and leaves can be difficult according to gatherers in Mali and Benin as climbing can sometimes cause accidents, due to the trees' height, or tear one's clothes. Although traditional harvesting methods have often been reported to result in heavy losses in quantity (Hughes & Haq, 2003; Haq *et al.*, 2008), this was not confirmed in this study. In addition, Odetokun (1996) and Tiisekwa *et al.* (2005) mentioned that a lot of fruits remain uncollected and therefore left to rot. Despite their high nutritional value and taste, more than 92 % of baobab fruits remain unprocessed in Nigeria each year (Odetokun, 1996).

Traders and trading practices

Due to a lack of functional specialisation observed during field research, traders of baobab and tamarind products in Mali and Benin were found

Figure 5.1: Baobab tree, which bears only fruits in the highest parts of the crown

to have different and varying functions, such as collecting, transporting, distributing and selling. Moreover, observation showed that many collectors and assemblers were at the same time also wholesalers or retailers of the same products, whereas some traders were simultaneously wholesalers for some products and retailers for other products. This finding justifies the arbitrary distinction that has been made between on the one hand 'wholesalers' – including collectors and assemblers, wholesalers and large retailers – and on the other 'petty traders' – regrouping all small-scale retailers (see methodology). Additionally, it is worth mentioning that traders are not specialised in baobab and tamarind products (or other AFTPs), and thus sell a great variety of products.

Traders of baobab and tamarind products are found to be mostly women. This confirms earlier findings by Ndoye *et al.* (1998) and Ahenkan & Boon (2010). The first authors suggest that the main reason that NTFPs are generally traded by women, may be attributed to the fact that NTFP trade is traditionally considered a marginal activity. Furthermore, Fafchamps & Gabre-Madhin (2001) stated that the fact that women dominate trade in Benin, reflects a long tradition of female involvement in trade along the West African coast. Other authors reported that women dominate the retail trade, while men concentrate on wholesale (Awono *et al.*, 2002; Marshall *et al.*, 2006b; Akinnifesi *et al.*, 2008a). Women's involvement in trade activities depends usually on whether or not the activity takes place far from the community, as distance tends to present an obstacle to women. In contrast, men tend to be involved in decision-making and income generating activities (Marshall *et al.*, 2006b).

Previous research about food crop traders in Benin by Fafchamps & Gabre-Madhin (2001) confirmed that, apart from the trader him/herself, surveyed enterprises did not employ a lot of manpower. Average total manpower of surveyed firms was two individuals, with most employees being family members. Wages paid were very low and the majority of family workers received no wage. Non-family workers nearly always received a wage and remuneration level was around 4,200 FCFA per month (Fafchamps & Gabre-Madhin, 2001). This figure is lower than the in the present study reported monthly wages of permanent employees ranging between 10,000 and 30,000 FCFA. This increase in wages is most likely associated with inflation.

Prices of baobab and tamarind products were found to depend mainly on supply, demand and transport conditions. Supply is determined by amount of product gathered as well as quantity stored, whereas demand is determined by the quantities traders are willing and able to purchase. The process of price setting between seller and buyer involves bargaining to reach an equilibrium price somewhere between the lowest price the seller is willing to accept and the highest price the buyer is willing to pay (Ndoye *et al.*, 1998). The latter authors added that the bargaining power of sellers and buyers depends primarily on whether sellers bring the products to the market or whether buyers buy the produce at the farmgate. For products sold at the market, the bargaining power of sellers depends on the type of products they are selling, the quantity of these products available at the market, their own financial needs, the number of traders present at the market, prices that prevailed during previous market days, the number of farmers selling these products, and overall transparency of the market (Ndoye *et al.*, 1998). In the other case, the bargaining power of buyers depends to a large extent on the prevailing prices in urban and/or border markets (*i.e.* expected prices), the quantity of these products available at the market, the number of traders present at the market, and the actual marketing costs and expected margins (Ndoye *et al.*, 1998). When this theory is applied to the findings in the present study, the following price setting processes can be detected. Two thirds of the traders in Mali and one third in Benin agree that price setting is done by fair negotiation between buyers and sellers. The rest of the traders in Mali, together with another third of the traders in Benin, believe that the buyers, *i.e.* wholesalers, have more influence on the price than the sellers, which is probably the case for on-farm sales. Finally, about one third of the traders in Benin are convinced that sellers, *i.e.* gatherers, have more influence in price setting of baobab and tamarind products than buyers. The latter case can possibly be related to the fact that, in Benin, some gatherers reported to sell their produce to collecting gatherers, who then sell large quantities to wholesalers.

The price determining factors recorded in this research for wholesalers are supply, demand, transport, profit and seasonality, whereas petty traders reported – in addition to the aforementioned factors – also quality, buying price, availability and price of substitution products. Most of these price determining factors have also been found by other authors. Lamien & Traore (2003) reported availability, buying price and transport as major price determining factors. Others reported that prices vary with time of the season (availability) and location (Lamien *et al.*, 1996; Akinnifesi *et al.*, 2005). Generally, higher prices are observed in the beginning and at the end of the fruiting season. As is to be expected, prices also increase considerably as the specific market outlet moves from rural areas to semi-urban and urban areas (Akinnifesi *et al.*, 2005).

Processors and processing practices

The present study confirmed that, in Mali and Benin, many local people have traditional ways of processing baobab and tamarind products for auto-consumption, marketing and preservation (Assogbadjo *et al.*, 2006a). Processors are generally involved in secondary processing, whereas gatherers apply primary processing techniques. Although unprocessed fruits and fresh leaves are directly marketable, value is generally added through processing and packaging. This has been confirmed in the present study for the processing of fresh baobab leaves into dry baobab leaves of baobab leaf powder in Mali, as prices increased from 80-90 FCFA / kg for fresh leaves to 95-310 FCFA / kg for dry leaves or 90-320 FCFA / kg for leaf powder. Processed products, such as dried leaf powder and fruit pulp powder are sold on local and regional markets in West Africa (Sidibé & Williams, 2002; Chadare *et al.*, 2008). Petty traders usually pack small quantities – convenient to consumers – of their products up in small plastic bags for sales purposes.

Gatherers transform fresh baobab leaves into dry baobab leaves and/or baobab leaf powder, baobab fruits are processed into baobab fruit pulp, tamarind leaves are dried, and tamarind fruit pods are stripped from their shell. Drying of food products is commonly practised in Africa to make the products more durable and in order to preserve them for food insecure periods (Hell *et al.*, 2009). However, during processing, products can become infected with fungi and other contaminants. According to Hell *et al.* (2009), high fungal levels were recorded in ground baobab leaves, the most prevalent fungi being *Aspergillus* spp. Crushing has been identified by the same authors as the step, in the processing method of making dry leaf powder, that can lead to a higher risk of fungal contamination, *i.e.* the critical control point. Additionally, it should be noted that the leaves are typically sun-dried which is reported to be unfavourable to maintain vitamin A levels. As mentioned in the literature review, the simple practice of drying leaves in the shade doubles the provitamin A content of the leaf powder (Sidibé *et al.*, 1996, 1998b; Scheuring *et al.*, 1999).

In some cases, gatherers and petty traders press tamarind fruit pulp into balls for storage and sales purposes. In the present study, about 20 % of Malian petty traders reported to sell mainly tamarind fruit balls. The latter has also been reported by Fandohan (2007) and Vogl *et al.* (2009). The most common process of making tamarind balls observed and recorded in this study has been described by Fandohan (2007). Dehusked pods are placed in the sun and wetted every now and then. After some time the fruits are pressed into balls and dried thoroughly in order to preserve them well. Tamarind balls are always sold for a fixed price (generally 25 or 50 FCFA per ball), but their size, and consequently weight, vary between seasons, and range between 80 and 250 g in Mali. When tamarind fruits are well-available during the dry season balls will be big, whereas during the rainy season when tamarind fruits are not available, balls will be small. Similarly, Schreckenberg (2004) reported the same for shea butter pats in Benin. These butter pats are always sold at 25 FCFA, but their weight varies from 110 g just before harvest period to 266 g a few months later.

Some processors reported to add boiling water to baobab fruit pulp when making juice or syrup. This traditional practice is, however, reported to decreases the level of vitamin C. To maintain vitamin C content, Sidibé *et al.* (1996) recommend not to boil baobab fruit pulp during food preparation. It is thus advisable to add pulp to drinks while they are cold or to hot drinks after they have been removed from the heat source.

In the present study, all processors reported manual processing techniques for baobab and tamarind fruits. The processing of primary products into secondary, such as pulp and leaf powder, faces several problems. It requires several repetitions of crushing (with mortar and pestle) and sieving to remove impurities, fibres and/or seeds. Besides contamination risks (Hell *et al.*, 2009), these operations are made difficult by air currents that take away part of the product (Chadare *et al.*, 2008). Baobab Fruit Company in Senegal (BFCS, 2011) developed a mechanical process for pulp extraction. Extension of this mechanical process may be beneficial, if adapted to local realities; otherwise, it would be interesting to investigate how this operation can best be improved for rural local populations (Chadare *et al.*, 2008). Additionally, Kazembe-Phiri (2005) reported the development of two simple hand-operated fruit juice extractors. A horizontal and vertical extractor were developed to increase fruit utilization and minimize post-harvest losses in Malawi.

Notwithstanding the manual processing techniques and simplicity of equipment used, the number of efficient processors found in both countries is rather high. A first possible explanation is that processors are efficient under the given circumstances in Mali and Benin. Secondly, this can probably be explained by the fact that many technical efficiencies are possible due to several input variables used in the DEA model, which was made up of one output and seven input variables. In addition, Jordaan *et al.* (2008) documented, based on a feasibility analysis, that benefits of small-scale indigenous fruit processing enterprises in southern Africa are potentially significant in terms of improved livelihoods. Also Kazembe-Phiri (2005) found that it is possible and remunerative to extract fruit juice for small-scale fruit juice production under both rural and urban conditions. The present study has not been able to reveal the explanation behind being efficient or not as none of the (major) processing costs did differ significantly between efficient and inefficient processors.

Cost of packaging material is found to be the highest cost that processors in Mali and Benin face. Handling costs, including the cost of packaging material, were reported elsewhere to represent 20-30 % of the marketing margin of processors (Fafchamps & Gabre-Madhin, 2001; Gabre-Madhin, 2001; Fafchamps, 2004; Shepherd, 2007). Also, Abeyrathne & Jaenicke (2006) mentioned that the cost of packaging materials was one of the major bottlenecks that small-scale processors are facing. Moreover, as shown in the results of the present study and reported earlier by Chadare *et al.* (2008) packaging techniques are very poor and thus need to be studied and improved to increase shelf life of products. Next to packaging, other constraints reported by processors of baobab and tamarind products in Mali and Benin are a lack of equipment or infrastructure, transport, finances, and information about processing techniques and marketing possibilities. Ham *et al.* (2008) added difficulties in provision of raw materials, a lack of training in processing practices, insufficient legislation, and limited storage space as constraints for processors.

Consumers and uses

In West Africa, fruits and leaves of baobab trees are consumed daily and all year round (Lamien *et al.*, 1996; Mertz *et al.*, 2001; Lykke *et al.*, 2002; Assogbadjo *et al.*, 2008; Maranz *et al.*, 2008; Buchmann *et al.*, 2010). Baobab fruit pulp is mainly used in porridges and/or juices, whereas leaves – eaten fresh in the rainy season and dried for consumption during the dry season – are used in sauce preparations. Dhillion & Gustad (2004) estimated that 11.1 g of baobab dried leaf powder is daily consumed in West Africa per person. On a larger scale, several thousands of tons of baobab leaves are consumed in the Sahel per year (Gebauer, 2003). In addition, leaf and fruit products of the tamarind tree are reported to be the most commonly used products for souring meals, such as porridge and *bouillie* (Lamien *et al.*, 1996; Lykke *et al.*, 2002). The methods used for home-processing are likely to be those that have been in use for generations and are based on trial and error rather than on scientific research (Akinnifesi *et al.*, 2006).

Substitution of baobab leaves with okra (*Abelmoschus caillei*) has also been reported by Schreckenberg (2000). Although their flavours differ, the sauces of baobab leaves and okra are substitutable because of the mucilaginous texture they share. Lamien *et al.* (1996) confirmed the possibility to replace tamarind products by citrus fruits. Further, Seck *et al.* (1999) reported the substitution of tamarind leaves with roselle flowers (*Hibiscus sabdariffa*). If tamarind fruits are not available, Vogl *et al.* (2009) and van der Stege *et al.* (2011) reported that tamarind leaves are widely used as substitute product. The fact that tamarind leaves, and not other fruits, are used in case of unavailability of tamarind fruits indicates a high local appreciation of the typical sour taste of tamarind products (van der Stege *et al.*, 2011).

5.1.2 Market chains

The market maps presented in the results chapter show the different chain actors involved in bringing a specific baobab and/or tamarind product from gatherer to end user or consumer, and the linkages between them. Hereby, products flow up the chain while money flows down the chain. Each transfer involves marketing activities, such as harvesting, collection, processing, storage, transport and sales. The sequence and importance of each activity differs from product to product mainly due to product characteristics. All these activities involve costs, called transaction or marketing costs. Regretfully, the data collected for this study did not allow to calculate any transaction costs.

In the literature review, different types of markets were identified and documented by Tracey-White (1999), Tracey-White (2005) and Ferris *et al.* (2006), namely on-farm sales, rural primary markets, assembly markets, wholesale markets, retail markets and supermarkets. As reported in the present study and also concluded by Ndoye *et al.* (1998), a trader can simultaneously act as collector/assembler, wholesaler and/or retailer. Due to this lack in specialisation it has been difficult to distinguish different types of traders and thus to recognise the different types of markets. Moreover, for certain products, assembly and wholesale markets were not encountered. This observation matches the findings of Tollens (1997) that, on the one hand, most major African cities lack specialized and efficient wholesale markets and, on the other hand, it is often difficult to distinguish between wholesale and retail operations. In addition, the author also observed that supermarkets are not (yet) a player in the trade of baobab and tamarind products in Mali and Benin. Based on these findings and interpretations, four market types were considered to be important in the trade of baobab and tamarind products:

- on-farm sales,
- rural primary markets,
- assembly/(semi-)wholesale markets, and
- rural and urban retail markets.

In Table 5.1, these market types are linked with the results of the present study about the different actors and their linkages in the market chains of baobab and tamarind products in Mali and Benin, and will be used in the discussion below.

In the present study, six different baobab and tamarind products were reported to be commercialised in Mali and Benin. Based on the market maps drawn for each of these products in the results chapter, three different market chains can be identified which have all another level of importance and potential for further development.

Market chain of fresh baobab leaves and tamarind leaves

To start with, the market maps for fresh baobab leaves in Mali and Benin and tamarind leaves in Mali, presented in respectively Figures 4.6 and 4.11, show short and comparable chains. Between two and four different chain actors can be identified, namely gatherers, retailers, petty traders and consumers. The possible linkages between the different actors are the following.

Table 5.1: Occurence of different actors, in the market chain of baobab and tamarind products in Mali and Benin, in different market types

		On-farm sales	Rural primary market	Assembly/(semi-) wholesale market	Retail market
Gatherer	Selling	x	x	–	x
Collecting gatherer	Buying	x	–	–	–
	Selling	x	–	x	x
Collector / Assembler	Buying	x	x	–	–
	Selling	–	–	x	–
Wholesaler	Buying	–	x	x	–
	Selling	–	–	x	x
Retailer	Buying	–	x	x	x
	Selling	–	–	–	x
Petty trader	Buying	–	x	–	x
	Selling	–	x	–	x
Processor	Buying	x	x	x	x
	Selling	–	x	x	x
Consumer	Buying	–	–	–	x

x: actor present in market type; –: actor not present in market type gatherer → consumer

→ petty trader → consumer

→ retailer → consumer
→ petty trader → consumer

Regarding fresh baobab leaves and tamarind leaves, the main functions of the market chain are – together with the involved chain actors between brackets – harvesting (gatherer), transportation (gatherer and retailer/petty trader), selling (gatherer and retailer/petty trader) and buying (retailer/petty trader and consumer). On top of these, two more activities are recorded in the market chain of tamarind leaves, *i.e.* processing (gatherers) and storage (gatherer, retailer/petty trader and consumer). As can be derived from the results and Table 5.1 the two most important market types for trading fresh baobab leaves and tamarind leaves are on-farm sales and rural primary markets. In addition, rural and urban retail markets play a minor role. This means that the travel distance of the produce between gatherer and consumer is short, thus, that there is only little (or even no) transportation over short distances required. For fresh baobab leaves this can be explained by their perishability, whereas for tamarind leaves this is probably linked to a rather low demand and only local utility. Moreover, only small quantities of both products are generally traded, while the market chain of fresh baobab leaves is seasonal because baobab is deciduous during the dry season. In conclusion, the market chain of fresh baobab leaves in Mali and Benin and tamarind leaves in Mali can be characterised as being principally locally important with a domestic potential.

Market chain of dry baobab leaves and baobab leaf powder

Secondly, the market maps for dry baobab leaves in Mali and baobab leaf powder in Mali and Benin show similarities when Figures 4.7, 4.8 and 4.9 are compared. The number of actors involved varies between two and six in Mali, and consists of gatherers, collectors/assemblers, wholesalers, retailers, petty traders and consumers. In Benin, up to five actors take part in the market chain, *i.e.* gatherers, collecting gatherers, retailers, petty traders and consumers. Thus, in Benin no wholesaler was identified in the baobab leaf powder market chain. Another difference is that in Mali the collecting and bulking function is mainly done by collectors/assemblers, whereas in Benin this is the task of collecting gatherers. For simplicity reasons, the collector/assembler in Mali and the collecting gatherer in Benin are hereafter called collector. The possible linkages between the different actors are given below.

gatherer	→ consumer				
	→ petty trader	→ consumer			
	→ retailer	→ consumer			
		→ petty trader	→ consumer		
	→ wholesaler	→ retailer	→ consumer		
			→ petty trader	→ consumer	
	→ collector	→ petty trader	→ consumer		
		→ retailer	→ consumer		
			→ petty trader	→ consumer	
		→ wholesaler	→ retailer	→ consumer	
				→ petty trader	→ consumer

The different functions of the market chain of baobab leaf powder and dry baobab leaves are – together with the involved chain actors between brackets – harvesting (gatherer), processing (gatherer), collecting (collector), bulking (collector), transportation (collector, wholesaler, retailer), selling (gatherer, collector, wholesaler, retailer, petty trader), buying (collector, wholesaler, retailer, petty trader, consumer) and storage (gatherer, collector, wholesaler, retailer, petty trader, consumer). Based on the results and Table 5.1, on-farm sales are important in two different cases, namely when gatherers sell directly to consumers in Mali and when collectors are involved in the chain. The latter is also the condition for assembly/(semi-) wholesale markets to become important as market type. Further, rural primary and retail markets are the places were most transactions take place. In contrast with the market chain of fresh baobab and tamarind leaves, the market chain of baobab leaf powder and dry baobab leaves is not only locally important, but also provincially and nationally. As a consequence, transport over long(er) distances is required. Therefore, the market chain of baobab leaf powder in Mali and Benin and dry baobab leaves in Mali is important on domestic level. As regional trade in baobab leaf powder has been reported, this market chain has regional potential.

Market chain of baobab and tamarind fruits

Finally, the market maps for baobab and tamarind fruits in Mali and Benin, shown in Figures 4.4, 4.5 and 4.10, bear resemblance to each other. Up to seven different actors are involved in the market chain in Mali and include gatherer, wholesaler/collector, retailer, petty trader, processor, caterer/retailer and consumer. In Benin, ten different actors have been identified, namely gatherer, collecting gatherer, collector/assembler, wholesaler, retailer/collector, retailer/petty trader, petty trader, processor, caterer/retailer and consumer. It should, however, be noted that all these different actors are not necessarily interlinked with each other. Moreover, some of them have similar tasks and can consequently become competitors of each other. As the collector/assembler and collecting gatherer have similar functions, and are not interlinked, they are hereafter referred to as collector. In addition, for simplicity reasons, wholesaler/collector will be called wholesaler, whereas retailer/collector will become retailer. As no clear distinction is made between retailer and petty trader in the chain of baobab fruit pulp in Benin and as they both have a retail function, they will be called retailer. Finally, retailer will also refer to caterer/retailer in both countries. All possible linkages between the different actors are listed below.

gatherer	→ consumer				
	→ petty trader	→ consumer			
	→ processor	→ consumer			
		→ retailer	→ consumer		
	→ retailer	→ consumer			
		→ petty trader	→ consumer		
		→ processor	→ consumer		
			→ retailer	→ consumer	
	→ wholesaler	→ petty trader	→ consumer		
		→ processor	→ consumer		
			→ retailer	→ consumer	
		→ retailer	→ consumer		
			→ petty trader	→ consumer	
			→ processor	→ consumer	
				→ retailer	→ consumer
	→ collector	→ processor	→ consumer		
			→ retailer	→ consumer	
		→ retailer	→ consumer		
			→ petty trader	→ consumer	
			→ processor	→ consumer	
				→ retailer	→ consumer
		→ wholesaler	→ retailer	→ consumer	
			→ processor	→ consumer	
				→ retailer	→ consumer

For baobab and tamarind fruits, the main functions of the market chain are – together with the involved chain actors between brackets – harvesting (gatherer), processing (gatherer, processor), collecting (collector, wholesaler, retailer), bulking (collector, wholesaler, retailer), transportation (collector, wholesaler, retailer, processor), selling (gatherer, collector, wholesaler, retailer, petty trader, processor), buying (collector, wholesaler, retailer, petty trader, processor, consumer) and storage (gatherer, collector, wholesaler, retailer, petty trader, processor, consumer). Deduced from the results and Table 5.1 assembly/(semi-) wholesale markets are an important market type when collectors and wholesalers are participating in the chain. Also rural primary markets, and rural and urban retail markets are identified as important transaction places. On-farm sales become important when gatherers sell directly to consumers in Mali or when collectors are involved in the chain. The tentacles of the market chain of baobab and tamarind fruits spread all over Mali and Benin, and also regional trade has been recorded. As a result, the market chain has domestic and regional importance. Moreover, international trade of baobab and tamarind fruits has been recorded, which gives this chain also an international potential.

5.1.3 Market chain analysis

Quantities and prices

Although baobab and tamarind products play an important role in local markets in West Africa (Gustad *et al.*, 2004; Assogbadjo *et al.*, 2008; Buchmann *et al.*, 2010; Fandohan *et al.*, 2010a; van der Stege *et al.*, 2011), up till now, only a handful of authors have reported about quantities and prices in the commercialisation of baobab and tamarind products. The present study is the first that has recorded quantities bought and sold, and purchasing and selling prices for different actors involved in the commercialisation of baobab and tamarind products in Mali and Benin. Based on the recorded quantities and prices in the present study, baobab fruit pulp is traded in larger quantities in Benin than in Mali, whereas baobab leaf powder and tamarind fruit pods are marketed in larger quantities in Mali than in Benin. Prices are lower in Benin for baobab fruit pulp and baobab leaf powder than in Mali, while tamarind fruit pods are cheaper in Mali compared to Benin. However, it is important to note that some findings show that answers of respondents might not always be very reliable. For instance, Table 4.9 shows that all chain actors in Mali claim to sell the baobab fruit pulp at a higher price than the price consumers reported to pay and raises the following question: where does this consumer gets his/her products? The answer is most certainly that the consumer buys his/her products with the petty trader – who is the most expected buying source of consumers. But this cannot be concluded based on Table 4.9 as consumers in Mali recorded a cheaper purchasing price than the selling price of petty traders, *i.e.* 410 FCFA / kg versus 630 FCFA / kg.

A three months market survey in 2001 showed that 6,923 kg baobab fruit pulp generated 900,000 FCFA (1,372 €) per year on a small market in Boukoumbé in north-west Benin. In total, 48 traders were involved, thus the revenue per trader amounted to 18,750 FCFA (29 €) for about 144 kg sold (Codjia *et al.*, 2001, 2003). Codjia *et al.* (2003) calculated a mean product price for baobab pulp of 130 FCFA/kg. Another study in Malanville (north-east Benin) showed that during a five months period (2003-2004), ten tons of baobab pulp and one ton of baobab leaf powder were commercialised and generated up to 400,000 FCFA (610 €) and 200,000 FCFA (305 €) for 139 rural households involved in that business (Assogbadjo, 2006). Based on these data, a mean price of 40 FCFA/kg for baobab fruit pulp and 200 FCFA/kg for baobab leaf powder was calculated. In Burkina Faso, Lamien *et al.* (1996) reported in 1994-95 a mean product price for baobab leaf powder of 110 FCFA/kg, 143 FCFA/kg for tamarind fruits and 100 FCFA/kg for tamarind leaves. On the weekly market in Cinzana (near Ségou in Mali), Gustad *et al.* (2004) reported wholesale and retail prices for baobab fruit pulp, 310 and 950 FCFA/kg, respectively, as well as for baobab leaf powder, 75 and 440 FCFA/kg, respectively, and tamarind fruits, 100 and 80 FCFA/kg, respectively.

Prices of baobab fruit pulp in literature thus range from 40 to 950 FCFA/kg, whereas in the present study prices ranged from 180 to 630 FCFA/kg for baobab fruit pulp in Benin and Mali. Additionally, higher retail prices than wholesale prices, and higher prices in Mali compared to prices in Benin for baobab fruit pulp were confirmed in literature. This study found prices of baobab leaf powder ranging from 90 to 305 FCFA/kg, which match prices reported in literature differing between 75 and 440 FCFA/kg. Tamarind fruit pods cost between 170 and 405 FCFA in the present study, while cheaper prices varying between 80 and 143 FCFA/kg were recorded from literature. Hereby, the author is aware that prices should first be corrected for inflation before they can be compared.

However, recording price fluctuations was not an objective of the present study. Lamien *et al.* (1996) and Assogbadjo (2006) reported price differences throughout the year for baobab and tamarind products. Prices of baobab leaves and tamarind fruits were found to vary according to kind of tree on which products were harvested, whereby products from personal trees were cheaper than products from communal trees (Lamien *et al.*, 1996). Product price was also determined by ecological zone: the scarcer a product, the higher the price. Prices thus reflect the laws of supply and demand (Lamien *et al.*, 1996; Mertz *et al.*, 2001; Assogbadjo, 2006). Additionally, price differences were strongly affected by the time of the year and availability of products (Lamien *et al.*, 1996). Finally, some price differences were observed between rural and urban markets, whereby prices in rural market were – contrarily to expectation – higher than in urban markets. It should hereby be noted that most baobab and tamarind products are processed into dry products to extend storage life, and thus to guarantee a rather constant availability throughout the year and limit price fluctuations.

FAO has estimated the annual quantity of baobab and tamarind fruits harvested in the 2006-07 period (FAO Stat, 2010). In Mali, 4,811 ton baobab fruit pulp and 8,008 ton tamarind fruits were recorded; no national statistics for Benin were found. When compared to the results of the present study, one can extrapolate that more than 400,000 gatherers, about 165 wholesalers and at least 5,000 petty traders are involved in trading baobab fruit pulp. For tamarind, it can be assumed that at least 35,000 gatherers, about 440 wholesalers and more than 9,000 petty traders take part in the commercialisation of tamarind fruits. These estimations show clearly the job creation potential generated by trading baobab and tamarind products. However, it should be noted that this rather concerns small supplementary incomes than structural employment opportunities.

Added value

In the present study, added values for baobab and tamarind products in Mali and Benin tend to be the highest for processors and gatherers. Hereby, it should be noted that added value may not be confused with profit as no variable nor fixed costs were taken into account in the present added value analysis. This means that for processors, the cost of *e.g.* other ingredients such as sugar has not been taken into account and may explain the high added values. At first sight, the present study does not confirm an exploitative role of middlemen as suggested by *e.g.* te Velde *et al.* (2006). In general, traders are reported to have higher margins than smallholders, and in particular travelling wholesalers are those profiting most (Schreckenberg, 2003; Horna *et al.*, 2007). Sissoko & Kergna (2003) reported a much higher margin for retailers compared to wholesalers. In addition, Akinnifesi *et al.* (2008a) also reported that retailers made more profit than wholesalers, but that producer' profits were intermediate. Similar results show that collectors/gatherers have the lowest margins while retailers have the highest, and wholesaler margins were found to be intermediate (Vodouhê *et al.*, 2008). However, some studies suggest that the role of middlemen has been underestimated (Padoch, 1992; te Velde *et al.*, 2006; Jensen, 2009) and that it would be a mistake to try to bypass them (Corry, 1993). Fafchamps & Gabre-Madhin (2001) reported for the median trader in Benin variable marketing costs, which represent about one tenth of total purchase price.

Buying and selling periods

In general, the harvesting and buying period of baobab and tamarind products coincides with the dry season. In Benin, selling of baobab and tamarind products remains limited to the dry period, whereas in Mali the products are sold throughout the year. As a result, marketing of baobab and tamarind products happens principally in the dry season, *i.e.* the period when other agricultural products are becoming scarce and thus more expensive. This suggests that commercialisation of baobab and tamarind products may provide cash income complementary to other income generating activities, and thus act as a financial buffer.

The availability of baobab and tamarind fruits and leaves is determined by the phenology of the tree. Baobab is a drought deciduous tree (Sidibé & Williams, 2002). In West Africa, baobab bears leaves from April till November (Codjia *et al.*, 2001; Sidibé & Williams, 2002; Dhillion & Gustad, 2004; Assogbadjo *et al.*, 2005a; Diop *et al.*, 2005; Assogbadjo, 2006), *i.e.* during the rainy season. In order to extend the period during which fresh baobab leaves are available, farmers could adopt the technology developed by the World Agroforestry Centre to produce and harvest fresh leaves all year round (Box 5.1). Baobab fruits appear after flowering in June and July. The first fruits in West Africa are ripe in December or January and harvesting may go on until April (Codjia *et al.*, 2001; Sidibé & Williams, 2002; Dhillion & Gustad, 2004; Assogbadjo *et al.*, 2005a; Diop *et al.*, 2005; Assogbadjo, 2006), and thus coincides with the dry season. In contrast with baobab, tamarind leaves are available throughout the year as tamarind is an evergreen tree (El-Siddig *et al.*, 2006). In West Africa, flowering and fruiting of tamarind generally takes place in the dry season. Fruits are ripe as from December (El-Siddig *et al.*, 2006). Because all tamarind fruit pods on a tree do not ripen at the same time, several harvests may be required (Daniel & Dudhade, 2007). Moreover, Yahia *et al.* (2008) report that tamarind is a non-climacteric fruit and will does not ripen off the plant. Therefore fruit pods should only be harvested when ripe. When fully ripe, shells are brittle, and easily broken and removed (Yahia *et al.*, 2008).

Box 5.1: Baobab market gardens

Until now, the baobab tree has never been planted deliberately. It grows virtually wild, as part of a traditional parkland agroforestry system (ICRAF, 2003). Baobab leaves are typically harvested during the rainy season, then dried and stored for further use during the long dry season. However, it has been reported that during the drying process, the vitamin A content of leaves decreases significantly (Sidibé *et al.*, 1998b; Scheuring *et al.*, 1999; Sidibé & Williams, 2002; Traoré, 2003).

An alternative technology, developed and proposed by the World Agroforestry Centre and its partners in West Africa, is to grow young baobab trees in irrigated garden plots and harvest the leaves regularly throughout the year (ICRAF, 2003; Kalinganire *et al.*, 2007; Bationo *et al.*, 2009). Results in the Ségou district of Mali indicate that, despite some constraints, the technique is accessible to farmers in terms of feasibility. Constraints include the availability of sufficient manpower, land and water, and seed (Savard *et al.*, 2003; Olivier *et al.*, 2006; Savard *et al.*, 2006). Uncertainties over the profitability of the technique may also be a major constraint (Traoré, 2003; Savard *et al.*, 2006).

An additional advantage is that when people start to plant and cultivate their own trees, they will no longer have to strip so many leaves from adult trees around the village. Knowing that leaf stripping prevents 90 % of wild baobab trees from bearing fruit, this technique has thus the potential to simultaneously increase fruit production of wild trees (ICRAF, 2003; Buchmann *et al.*, 2010).

Storage practices

First and foremost, field research learned that storage is difficult to estimate because it fluctuates in time. Also the meaning seemed often not well understood by local respondents. Most surveyed actors in the chain of baobab and tamarind products typically purchase a certain volume of produce, which is kept until it is sold, after which they replenish their stock. This practice was also reported by Fafchamps & Gabre-Madhin (2001). The latter authors add that the great majority of traders in SSA does not undertake speculative or seasonal storage. Knowing that, on the one hand, when a trader holds stocks, he/she runs both physical and commercial risks (van der Laan, 1999), and, on the other hand, traders in Mali and Benin lack storage infrastructure, space and financing, this can explain why no seasonal storage is undertaken.

Baobab and tamarind products are mainly stored in recycled rice bags in the house (Benin) or in a storehouse or granary (Mali). Dry baobab leaves are traditionally stored as powder. These storage practices have also been reported by several other authors (Sidibé *et al.*, 1998b; Codjia *et al.*, 2003; Lamien & Traore, 2003; Dhillion & Gustad, 2004; Assogbadjo, 2006; Vogl *et al.*, 2009). They found that cleaned and sun-dried leaves, as a whole or powdered, are stored in polyethylene bags, or in cups or tins and kept in the house or small granaries. To maintain the initial vitamin content at its maximum, storage of baobab leaves as whole leaves rather than ground leaf powder is, however, recommended (Sidibé & Williams, 2002). Similar storage practices for baobab fruit pulp have been reported in literature (Assogbadjo, 2006; Dhillion & Gustad, 2004). However, Cisse *et al.* (2009) and Chadare (2010) pointed out that, without precaution, pulp composition evolved and quality quickly degraded during storage. Chadare (2010) detailed that especially vitamin C degraded. Moreover, browning of fruit pulp during storage increases by high temperatures and high humidity (Chadare, 2010). Tamarind fruits can be stored either with the shell or as separate dry pulp. As reported by Yahia *et al.* (2008), the dry, dark-brown pulp becomes soft, sticky and almost black during storage.

In the present study, humidity and bug, mice and fungi attacks have been identified as the main problems during storage of baobab and tamarind products. Chadare *et al.* (2008) reported that after 6 months, insect larvae invade baobab fruit pulp if it is exposed to humidity. In addition, the latter authors also recorded discoloration of baobab pulp as a major constraint to storage. Most of the problems listed here are related to exposure to humidity, light and high temperatures, and indirectly depend on the quality of packaging material and the packaging techniques. Notwithstanding some storage problems, storage capacity of baobab and tamarind products was documented as good by Soloviev *et al.* (2004) due to easy handling during transportation.

Trade centres

The region of Ségou in Mali and the department Borgou in Benin have been identified as main trade centre for baobab leaf powder. The trade centres for baobab fruit pulp are the capital district Bamako, and the regions of Kayes and Mopti. In Benin, the department Collines and Cotonou (in the department Littoral) are assigned as baobab fruit pulp trade centres. Tamarind fruit pods are mainly traded in the region of Sikasso, and to a lesser degree also in the regions of Kayes and Mopti. The most important trade centre of tamarind fruits in Benin is found to be the department of Atacora.

Traders in Mali and Benin reported that baobab and tamarind fruits may be imported from Burkina Faso. Export to Senegal and Mauritania is recorded for baobab and tamarind products of Malian origin, whereas baobab fruit pulp in Benin is exported to the neighbouring countries Niger and Nigeria. In addition, Eyog Matig *et al.* (2002) and Assogbadjo (2006) reported an intensive regional trade of baobab and tamarind products in West Africa. In Benin, export markets for baobab products – fruit pulp, leaf powder and kernels – are situated in the Atacora and Alibori departments (Assogbadjo, 2006). Export to Nigeria, Niger, Burkina Faso, Togo and Mali are recorded by Assogbadjo (2006). In Mali, tamarind fruits are important in the trade with Senegal. Unpublished results of Hamady Djouara (agricultural economist at IER, Mali) showed that, in the 2006-07 period in Mali, baobab and tamarind products were exported to Burkina Faso, Senegal and Ivory Coast, and imported from Nigeria and Niger (Table 5.2).

Quality criteria

In the present study, all baobab and tamarind products traded are undifferentiated and not graded nor standardised. Direct inspection is the only method reported by which quality is assessed. These findings have been confirmed by Fafchamps & Gabre-Madhin (2001) and

Table 5.2: Export and import of baobab and tamarind products in Mali in the period 2006-07 (figures are ton / year)

		Baobab fruit pulp	Baobab leaf powder	Tamarind fruits
Export	Burkina Faso	155	813	4,384
	Senegal	220	111	4,527
	Ivory Coast	30	89	66
Import	Nigeria (via Burkina Faso)	–	–	2,736
	Niger	28	–	–

Akinnifesi *et al.* (2005). The latter authors added also that indigenous fruits are marketed with little value adding in the form of packaging, processing, certification, quality control, and other utilities, therefore only eliciting small marketing margins. Any attempt to add value or increase the marketing margin must be associated with targeting higher-income consumers, who are able to compensate for this (Akinnifesi *et al.*, 2008a).

Standards are a set of technical specifications that define quality features, size, weight and/or packaging of a product. Standards help to make trade more efficient, more remunerative and more client-oriented (KIT & IIRR, 2008). The quality of a product can be defined by many objective and subjective parameters, such as size, shape, colour, gloss, absence of defects, texture and flavour (Yahia *et al.*, 2008). As shown in this study, quality attributes may differ according to the ultimate destination of the product. In other words, quality criteria used for a specific product by local gatherers may not necessarily be the same as those used by wholesalers or consumers. *E.g.* in addition to the overall agreed importance of processing and conservation techniques, consumers in Benin judge colour of baobab fruit pulp important, whereas gatherers and traders use taste as parameter. The quality criteria reported in the present study can be classified as, on the one hand, search attributes and are those that can be verified at the time of the transaction (*e.g.* colour), and, on the other hand, experience attributes which can be assessed only after the transaction has taken place (*e.g.* taste) (based on Gibbon & Ponte, 2005). A third category, namely credence attributes, was not mentioned in this study. Credence attributes are attributes that cannot be objectively verified and are based on trust (*e.g.* organic and fair trade).

Certification of baobab and tamarind products is considered more useful to consumers in Mali compared to consumers in Benin. Certification is an inspection process carried out by an independent body which demonstrates that a company or product complies with the requirements that are defined in 'the standard' (KIT & IIRR, 2008). A certified product gets a stamp or seal, so the consumer knows that it complies with the regulations. Certification improves the credibility of the standard, but it entails higher costs for the applicant (KIT & IIRR, 2008). Moreover, trademarks and labels can be effective mechanisms for differentiating products in the marketplace. These not only add value to the product, but also make the product unique by differentiating it from similar products. This uniqueness might be of great relevance for the consumer, but it is also relevant for producers, who protect themselves from competitors by conveying greater negotiation power (Bernet *et al.*, 2006).

Information flow

Lack of market information is commonly recognised to be a major constraint to developing NTFP commercialisation (Neumann & Hirsch, 2000). This was confirmed in the present research as the majority of surveyed gatherers, traders and processors stated that market information is lacking. Areas of particular concern are harvesting techniques, appropriate processing technologies, and marketing information about price, quality and demand. FAO (1995b) and Hellin *et al.* (2005) confirmed that smallholders have little or no information on market conditions, prices and quality of goods. Besides, they are not organised collectively and have limited experience with market negotiations. As a result, Hellin *et al.* (2005) concluded that market literacy is lacking at the level of smallholders in SSA. The latter authors define market literacy as the awareness, understanding and capacity to build the process, institutions, competencies and relationships that enable market systems to work for resource-poor farmers. Tollens (1997) also recognised that information asymmetry between traders and producers is a common problem in food marketing systems in SSA. Consequently, this weakens the bargaining position of the producers and exposes them to considerable price uncertainty. Market information, together with market intelligence and the ability to use that information, are thus important prerequisites for entering new markets and maintaining market share (Marshall *et al.*, 2006b)

The present study showed that buyers and sellers need accurate information on availability, price and quality for making good decisions as to where, when, from/to whom, and at what price to buy or sell. Incomplete or non-transparent market information leads to what is called market failure (KIT & IIRR, 2008). However, KIT & IIRR (2008) add that it is one thing to have market information, but that it is a different thing to be able to actually use that information. The particular challenge, however, is to develop information that can be effective in countries with high levels of illiteracy (Azami, 2002). Up till now, talking to (other) traders has been proven to be the main source of information, and was also confirmed by Fafchamps & Gabre-Madhin (2001). But, KIT & IIRR (2008) expect that the recent spectacular growth of the telecommunication sector in SSA – and thus of mobile phone use – may offer great possibilities to enhance information flow between gatherers and traders. In addition, Russell & Franzel (2004) suggested that to create and promote market intelligence systems, we can build on mobile phone networks that are growing throughout Africa and better integrate market information into extension programmes.

Problems

All problems identified by the actors in the market chain of baobab and tamarind products in Mali and Benin can be attributed to a lack of market literacy, development and coordination along the chain. Many authors acknowledge the problems reported in the present study (Fafchamps & Gabre-Madhin, 2001; Awono *et al.*, 2002; Veeman, 2002; Hughes & Haq, 2003; Russell & Franzel, 2004; Akinnifesi *et al.*, 2006, 2008b; KIT & IIRR, 2008). It can be noted that most of these constraints reflect conditions typical for developing countries and many governments fail to provide the basic public goods that are required for markets to operate efficiently and reliably, such as basic market infrastructure, mechanisms for contract enforcement and standardization of quality grades (KIT & IIRR, 2008).

Variations in supply are mainly caused by seasonality of fruits and leaves, and can – under ideal conditions – be met by good processing and storage practices. But storage is poor (Awono *et al.*, 2002) and storage space is limited. In addition, post-harvest handling, including storage methods, drying, grading, processing, packaging and quality assurance, is poorly developed and supported (Akinnifesi *et al.*, 2008b). Grading and quality standards are non-existent in Mali and Benin. However, a substantial tree-to-tree variation in fruit characteristics has been recorded for baobab and tamarind (Sidibé & Williams, 2002; Assogbadjo *et al.*, 2005b; Assogbadjo, 2006; Assogbadjo *et al.*, 2006b; El-Siddig *et al.*, 2006; Fandohan *et al.*, 2010b; Assogbadjo *et al.*, 2011; Fandohan *et al.*, 2011a; Kouyaté *et al.*, 2011) and may thus result in a lack of uniformity in quality.

The largest marketing cost for traders is transport (Fafchamps & Gabre-Madhin, 2001; Awono *et al.*, 2002) due to poor infrastructure, such as bad roads and poor quality of transport means used. Moreover, there is a lack of access to credit. The majority of actors faces a variety of problems when seeking credit, including lack of information and high interest rates (Azami, 2002). Next to limited and conflicting market knowledge, other market constraints include lack of marketing networks and associations, and inadequate policies (Russell & Franzel, 2004). Indeed, indigenous fruit trees have not been subjected to agricultural or forest policies (Akinnifesi *et al.*, 2004) and their inclusion in national agricultural research programmes in developing countries is limited (Hughes & Haq, 2003).

All transfers in the market chain of baobab and tamarind products involve marketing activities in some form or other, and all these activities involve costs (Shepherd, 2007). Due to an incomplete dataset, the present study has failed to calculate the marketing costs such as handling, transport and storage costs. According to Fafchamps & Gabre-Madhin (2001), marketing costs can be decomposed in transport (49 %), handling (13 %), travel/search for information (11 %), packing material (8 %), commissions (7 %), taxes (5 %), storage (4 %) and other costs (3 %). Due to limited data, no detailed marketing costs are reported in the present study.

5.2 SWOT and impact analysis

5.2.1 SWOT analysis

Commercialisation of baobab and tamarind products shows great potential on domestic, regional and international level. But, at the same time, the production-to-consumption chain faces different challenges. Based on, on the one hand, results and observations presented in the present study and, on the other hand, findings reported in literature, the author used a SWOT logic to identify and list major strengths and weaknesses on domestic level, and opportunities and threats on domestic, regional and international level.

Strengths

Baobab and tamarind are both indigenous tree species that are well-known and often used by local populations in Mali and Benin. As they provide numerous products – such as fruit pulp, seeds, leaves and bark – for numerous food and medicinal uses and also supply tools and services, they are considered as multi-purpose tree species. Besides, baobab and tamarind have been identified by local people as priority species for domestication. Other strengths of baobab and tamarind products are their nutritional value, health benefits and potential to generate income. In most producing countries, such as Benin and Mali, there already exists a local and national market for baobab and tamarind products, and traditional processing methods have been reported to exist and be used by local communities. Furthermore, the commercialisation of baobab and tamarind products has a substantial job creation potential.

Weaknesses

Baobab and tamarind are not (yet) cultivated in West Africa, but rather grown in the wild (Abeyrathne & Jaenicke, 2006; Jama *et al.*, 2008). Fruit harvesting has an impact on dispersal and establishment, while leaf harvesting causes mutilation that reduces the number of fruits on each tree (Dhillion & Gustad, 2004). Wild gathering of products from undomesticated trees creates significant problems regarding variation in availability, product quality and reliability of supply (Akinnifesi *et al.*, 2006; Belcher & Schreckenberg, 2007; Nevenimo *et al.*, 2007). Product quality is also affected by rudimentary processing techniques, and systems for quality grading, standardisation and certification are non-existent in Mali and Benin. Markets of baobab and tamarind products are marked by a lack of product differentiation, poor storage facilities, lack of coordination and limited market information. Buyers and sellers have limited access to formal financial services and are, as a result, always in need of money, either for their businesses or for their families (KIT & IIRR, 2008). Because of low levels of educational attainment, entrepreneurial skills of local chain actors are relatively undeveloped. Moreover, linkages between various rural and urban markets tend to be weak due to poor roads and infrastructure (KIT & IIRR, 2008).

Opportunities

It has been estimated that insufficient fruit and vegetable intake, and micronutrient deficiencies that often result from such shortages, cause some 2.7 million deaths each year, making it one of the top ten risk factors contributing to mortality (Ezzati *et al.*, 2002). Iron and pro-vitamin A deficiencies are two of the top three micronutrient deficiencies noted worldwide, responsible for serious health problems (*e.g.* anaemia and night blindness). Indigenous fruit trees, such as baobab and tamarind, are rich in minerals and vitamins and should be promoted in developing countries to assure food and health security.

Many international research organisations, such as CGIAR, FAO, World Health Organisation (WHO), GFU and the Global Forum on Agricultural Research (GFAR), have expressed keen interest in underutilised species, including baobab and tamarind, for improving food and health security and poverty alleviation in developing countries (Lumpkin *et al.*, 2005). In addition, the World Agroforestry Centre has identified baobab and tamarind as priority species for domestication in semi-arid West Africa (Franzel *et al.*, 1996), whereas together with the World Vegetable Centre (AVRDC) they are also developing baobab gardens (as explained in Box 5.1).

Others, such as PhytoTrade Africa – a non-profit trade association that promotes sustainable harvesting of fair-traded natural products from southern Africa – and Baobab Fruit Company Senegal (BFCS) – a private company limited by shares – market and export processed baobab fruit products. In 2008, baobab fruit pulp of PhytoTrade Africa was acknowledged as novel food by the European Union (EU), whereas baobab fruit pulp produced by BFCS has been recognised as novel food in 2009. The approval as novel food may boost the trade of this product from African countries (Box 5.2). Additionally to this international market potential, also regional trade has been reported to be important.

In West Africa, seeds are an underutilised by-product of the processing of baobab and tamarind fruits (Sidibé & Williams, 2002; Ajayi *et al.*, 2003, 2006; El-Siddig *et al.*, 2006; Kumar & Bhattacharya, 2008). Though seeds can supply significant amounts of oil which can be used as edible and cosmetic oils (Akinnifesi *et al.*, 2005; Ajayi *et al.*, 2003, 2006; Kumar &

Bhattacharya, 2008). In Zimbabwe for instance, the two biggest producers of baobab oil, *i.e.* African Biodiversity Trading Company and Creative Oils, collectively produce approximately 20,000 l of oil worth 100,000 $ per year (Akinnifesi *et al.*, 2005). Also PhytoTrade Africa and BFCS are involved in the extraction of oil from baobab seeds for use in cosmetics industry. According to Bennett (2006) growth market areas for natural products are cosmetics and functional food ingredients.

Although, in the present study, undifferentiated baobab and tamarind products were marketed and no quality control standards were reported to exist in Mali and Benin, standards are important as they determine access to specific segments of markets (Gibbon & Ponte, 2005). As a consequence, up till now, baobab and tamarind products in Mali and Benin are solely reported to be intended for domestic consumption, which is a very broad and low income market segment. However, potential market segments for baobab and tamarind fruits are food and beverage, cosmetics, health and functional foods, nutraceuticals, organic foods and ethnic products (Sidibé & Williams, 2002; Ledda, 2004; Gruenwald & Galizia, 2005; Bennett, 2006; El-Siddig *et al.*, 2006) (see also socio-below under economic and economic impact).

European consumers have a strongly increased interest in a healthy life and, consequently, in the consumption of health food (CBI, 2005c). The latter refers to food products, which are low in fat and have limited sugar and salt content. Health food also includes functional foods, which have specific health promoting properties, and food products with added vitamins and minerals or bacteria, which support the intestinal function (CBI, 2005c). Fresh fruits and vegetables are generally associated with health foods. This is because fruit and vegetables contain vitamins and natural antioxidants, which are supposed to have properties to prevent heart diseases and cancer (CBI, 2005c). Due to this increasing consumer concern for healthier lifestyles, the tropical fruit market in the EU will continue to grow (CBI, 2005d). Baobab fruit pulp has been identified as an interesting candidate for a new generation of functional foods and nutraceuticals, due to a combination of its nutritional and health claims, together with its food technological functions (Gruenwald & Galizia, 2005). Similar characteristics have been reported for tamarind. This trend thus opens major opportunities to baobab and tamarind food products.

Box 5.2: Novel food regulation

On 27 June 2008, the European Union (EU) decided to authorise the placing on the market of dried baobab fruit pulp as a novel food ingredient under Regulation (EC) No 258/97 of the European Parliament and of the Council (European Union, 2008). This approval refers only to those producers who are member of PhytoTrade Africa, and who supply the market through PhytoTrade Africa's partner in South Africa, Afriplex (Lombard & Leakey, 2010). In August 2009, baobab fruit pulp produced by BFCS has also been recognised as novel food (BFCS, 2011).

The novel food regulation regulates the placing of novel foods in EU member states to protect public health by ensuring food safety. It calls for anyone wishing to place a food product on the EU market to first evaluate whether the food is novel and then to present evidence that it is safe (Will, 2008).

A novel food is defined as a food or food ingredient, which does not have a significant history of consumption within the EU prior to May 1997. All novel foods are subject to a premarket safety assessment under the novel food regulation (EC) No. 258/97 (Arvanitoyannis *et al.*, 2005).

To market a food product within the EU, it must have been sold in at least one member state prior to 15 May 1997 to a significant degree. If this is not the case, the product will be considered a novel food and must go through an expensive process to prove its safety. Each company that wants to bring a novel food onto the EU market must submit its proposal to the food and safety authority of a EU country. This request will then be sent to all other EU countries for their endorsement (CBI, 2005a; Gruenwald & Galizia, 2005). The novel food regulation, with an average duration of 39 months for traditional food products, creates thus a non-tariff barrier (Hermann, 2009).

Box 5.2: Novel food regulation (Continued)

The EU authorized the novel food application of baobab fruit pulp 23 months after submission by PhytoTrade Africa and on behalf of the consortium's 55 members drawn from eight southern African countries, including small producer groups, private sector companies, non-governmental organisations, research and government organisations (Hermann, 2009). According to a press report, PhytoTrade expended in total more than 170,000 € on the baobab application (Hermann, 2009). Conveniently extracted and traded at a wholesale price of approximately 35 € / kg and a retail price of 200 € / kg, baobab fruit pulp has potential for use as a functional ingredient in smoothies, cereal bars, confectionery and related products (Hermann, 2009).

Approving baobab fruit pulp as a novel food opens the door of the European market to the African export of pulp from baobab fruits (Buchmann *et al.*, 2010; Chadare, 2010). However, it is important that the current use of baobab in supporting the livelihood of local people is not undermined by commercialisation and that access to wild baobab populations remains guaranteed for local communities (Buchmann *et al.*, 2010).

Another criticism to the novel food regulation is the fact that it fails to differentiate between genuinely new foods that have not been consumed anywhere before, and foods that are merely new to Europe (Moorhead, 2007). These latter foods, described as exotic, may have been eaten safely by many people over centuries, but this is not taken into account when assigning these foods to a novel category in the EU. Therefore, a new, simple procedure for exotic foods should be introduced with requirements appropriate to foods which are new to EU countries but which have a history of consumption elsewhere (Moorhead, 2007). The goal is to allow safe exotic foods access to the EU market, via a procedure that is neither prohibitively expensive nor excessively time-consuming (Moorhead, 2007).

Threats

A series of marketing constraints that hamper the development of baobab and tamarind markets in Mali and Benin is related to the overall context of widespread poverty and low economic development in SSA. Many governments in SSA fail to provide the basic public goods required for markets to operate efficiently and reliably, such as infrastructure, mechanisms for contract enforcement and standardisation of quality grades. Also market facilities, such as access and feeder roads, areas for loading and unloading, storage facilities, security and sanitation, could be greatly improved (KIT & IIRR, 2008). Over the past decades, government investments in the agricultural sector have steadily declined, which is evident from the state of the rural infrastructure and agricultural research. These adverse policies tend to push agricultural marketing into the so-called informal economy (Dijkstra, 1997; KIT & IIRR, 2008).

In addition, due to a lack of official recognition and national regulations or policies, the inclusion of underutilised species in national agricultural research programmes in developing countries is limited (Hughes & Haq, 2003; Ndoye *et al.*, 2004). Very few governments in SSA are aware of the extent of yhe use, or the value, of NTFPs in the informal sector. Nor are they aware of the magnitude of dependence of the rural poor on these resources (Taylor *et al.*, 1996). As a result, the contribution of indigenous fruit trees to many farmers' livelihoods is often not acknowledged in neither national nor international level poverty reduction strategies (Schreckenberg *et al.*, 2006). Moreover, NTFP-related activities usually fall under the responsibility of several ministries, such as national planning, agriculture and forestry, trade and industries, health and education. Consequently, collaboration of the various policy making bodies at the national level is thus lacking (Lintu, 1995).

Competition with similar products from other countries or continents, *e.g.* Asian tamarind varieties and baobab fruit pulp from southern Africa, may for a barrier to further develop the existing markets.

In developed countries, numerous tropical fruits and their derived products are quite unknown to many consumers and are likely to remain so, unless consumers' acceptance of these products, followed by successful market introduction, occurs (Sabbe *et al.*, 2008). As a consequence, it is unlikely that tropical fruits will easily become part of consumers' daily diet. Consumers show both an interest in and a reluctance to try unfamiliar foods (Martins *et al.*, 1997). The latter, called food neophobia, is expected to have a negative effect on the acceptance of functional foods (Sabbe *et al.*, 2009a). Sensory characteristics, and taste in particular, are the primary drivers for consumers' food choice and purchasing intention, followed by health considerations (Sabbe *et al.*, 2009b). However, most tropical fruits are so exotic in taste and other sensory attributes that this may act as an important barrier to consumption (Sabbe *et al.*, 2009b). Sabbe *et al.* (2009b) reported that consumers' general expectations were negatively disconfirmed after tasting baobab juice and tamarind jam, which resulted in a decreased purchasing intention. As consumers seem to prefer sweet tastes and pleasant smells in food (Clark, 1998), it is possible that the more acid taste of tamarind led to a negative disconfirmation of taste expectations. Unfamiliarity with new and unknown exotic flavours, as is the case with baobab juice, may explain the negative disconfirmation of taste expectations for baobab (Sabbe *et al.*, 2009b).

5.2.2 Impact analysis

Most factors reported in the SWOT analysis may have a beneficial or negative impact on food security, and (socio-) economic and natural environment. Impacts associated with the commercialisation of baobab and tamarind products in Mali and Benin are hereafter discussed.

Impact on food security

Food security implies access to food for a productive and healthy life (Shah & Strong, 1999), *i.e.* the ability of households to produce, purchase, or acquire an adequate amount of food to meet all biological requirements. There are various degrees of food insecurity such as protein energy malnutrition, micronutrient deficiencies (vitamins and minerals) and anaemia due to iron deficiency (UNICEF, 1992; Kavishe, 1993).

In developing countries, it is estimated that over one billion people do not have enough food to meet their daily requirements (FAO, 2010f) whereas a further two billion people are deficient in one or more micronutrients (Azam-Ali & Battcock, 2001; Micronutrient Initiative, 2004, 2009), and thus suffering from 'hidden hunger'. Deficiency of iron and vitamin A is prevalent in most parts of West Africa, including Benin and Mali (FAO, 1999a, 2003).

According to WHO and FAO, up to 2.7 million lives could be saved annually with sufficient fruit and vegetable consumption. As a result, low fruit and vegetable intake is among the top ten selected risk factors for global mortality (WHO, 2003; FAO & WHO, 2005). A report on the Joint FAO/WHO Expert Consultation on diet, nutrition and the prevention of chronic diseases, recommends the intake of a minimum of 400 g of fruit and vegetables per day (excluding potatoes and other starchy tubers) for the prevention of chronic diseases such as heart disease, cancer, diabetes and obesity, as well as for the prevention and alleviation of several micronutrient deficiencies, especially in less developed countries (WHO, 2003; FAO & WHO, 2005).

Fruit and vegetable initiatives in developing countries should be integrated into national food and nutrition policies, and should be consistent with the predominant stage of the nutrition transition in each country (WHO, 2003; FAO & WHO, 2005). The nutrition transition refers to the movement from a famine stage (*i.e.* scarce, monotonous, low energy and cereal-based diets) through a receding famine stage (*i.e.* less scarce, less monotonous, but still low in energy, minimally processed, cereal-based diets) to a westernised, mass consumption stage (*i.e.* low fibre, high energy, fatty, salty, sugary diets with increasing animal products) (WHO, 2003; FAO & WHO, 2005). Most low-income countries are situated between the famine and receding famine stages where undernutrition disorders prevail. West Africa is below the target of 400 g of fruits and vegetables per person per day (WHO, 2003; FAO & WHO, 2005) with an average consumption of 223 g per day per person (FAO Stat, 2010).

Edible indigenous plants of the West Africa, including baobab and tamarind, are widely used to supplement the largely cereal-based diets of many of the rural populations (Nordeide *et al.*, 1996; Glew *et al.*, 1997; Sena *et al.*, 1998; Lockett *et al.*, 2000; Glew *et al.*, 2005) and have thus the potential to play a pivotal role in achieving the target set by FAO and WHO (Smith & Eyzaguirre, 2007). A thorough literature review on baobab and tamarind food products pointed out that both species have a high nutritional value (De Caluwé *et al.*, 2009b,c, 2010a,b). Baobab fruit pulp is extremely rich in vitamin C and has a high content of calcium. Baobab seeds are rich in the two essential fatty acids, linoleic and α-linolenic acid, whereas leaves are rich in vitamin A and iron, and are good sources of protein. Tamarind fruit pulp is rich in vitamin B and several amino acids, and is a good source of magnesium, copper, potassium and calcium. Tamarind seeds are important as protein source and are a good source of linoleic acid and calcium. The effective supply of micronutrients depends on three elements: (i) the intake of food, (ii) the nutrient content of food, and (iii) the bioavailability of these nutrients (Slingerland *et al.*, 2006). Bioavailability is the proportion of ingested nutrients available for metabolic processes and storage in humans (Slingerland *et al.*, 2006). Many authors have indicated the need to assess the bioavailability of essential nutrients in edible indigenous plants (Yazzie *et al.*, 1994; Nordeide *et al.*, 1996; Smith *et al.*, 1996; Glew *et al.*, 1997; Barminas *et al.*, 1998; Sena *et al.*, 1998; Lockett *et al.*, 2000; Glew *et al.*, 2005). However, according to the author's knowledge, up till now, no studies have been done to assess the bioavailability of essential nutrients in these plants. In addition, Boukari *et al.* (2001) report that food processing and methods of preparation greatly influence mineral composition and bioavailability.

Even though biochemical analyses indicate that baobab and tamarind food products are rich in minerals and vitamins, bioavailability studies are urgently needed to assess the effective supply of these essential nutrients. It is only based on the results of the latter studies that the real potential contribution of baobab and tamarind food products to food security can be assessed.

Socio-economic and economic impact

Local, national, regional and international markets exist for baobab and tamarind products and open perspectives for further market expansion. Local markets are important as they are easily accessible by smallholders, create job opportunities and generate income. Market opportunities for baobab and tamarind products are reported to be substantial. *E.g.* the current trade in the southern African development community is estimated to be around 8,486,800 € / y and to employ about 1,165,965 households for gathering alone, whereas potential trade is estimated at around 728,214,000 € / y and with potential to employ about 2,640,333 households for gathering (Bennett, 2006).

As mentioned earlier, baobab and tamarind products are frequently used by rural households. However, it is unclear how this consumption may change under the present globalisation of trade, demographic growth and increasing urbanisation. Some authors predict that increased urbanisation may be an important factor in the expansion of the size of local markets because it creates a new type of consumer who, unlike rural people, has to buy rather than gather for subsistence use (Ndoye *et al.*, 1998). Also Gustad *et al.* (2004) expect that the regional demand for indigenous tree products will not decline in West Africa (Gustad *et al.*, 2004). Irungu (2007) documented an increased demand and found that traditional African leafy vegetables, which were once considered primitive and unfashionable, have now become a delicacy in Nairobi and are consumed in most homes at all levels. Thus, globalisation, urbanisation and demographic changes could change present consumption patterns, which in turn may cause traditional food products to be lost from the diet (Azam-Ali & Battcock, 2001).

Due to globalisation, the ethnic population in the European Union has grown and this has increased the demand for ethnic food products. Although ethnic groups may have adopted much of the European cuisine, they maintain at least a part of their culinary traditions (Babb, 1990; CBI, 2006). Lively ethnic markets exist in France, UK, Portugal and Belgium (Tabuna, 1999, 2000), and baobab and tamarind products have been encountered on the ethnic markets of Paris, London and Brussels (Verhaeghe, 2009). The latter study reported, however, that all tamarind products sold were all imported from Asia.

In addition, more and more European tourists enjoy a 'tropical lifestyle' during their holidays and take home memories of the tropical cuisine and refreshing juices. Because of that, European consumers tend to be open towards new ethnic and tropical fruits and juices (CBI, 2005d, 2006). Indeed, Sabbe *et al.* (2008) found that tropical fruits are generally perceived by consumers in Europe as attractive, special, tasty, healthy and nutritious. The potential of, in particular, baobab is great when the variation in marketable products is considered. *E.g.* BFCS (2011) sells baobab fruit shells as packaging material, baobab fruit pulp as dietary supplements or for cosmetic formulations, baobab seed powder as exfoliant or scrub, and baobab seed oil for use in cosmetics or nutritional formulation. In addition, Bennett (2006) published a list with the potential growth and key markets for various baobab products. Gruenwald & Galizia (2005) identified baobab fruit pulp as an interesting candidate for a new generation of functional foods and nutraceuticals due to its nutritional and health claims, and food technology functions.

In Europe, food niche markets, such as fair-traded and organic-labelled foods, are among the fastest expanding market segments in the food distribution sector. In addition, they do not require large volumes for trade, and offer possibilities for obtaining premium prices for producers (Vantomme, 2003b). Several NTFPs are ideally fit for such markets, particularly those which have at the same time a high per unit value, a long shelf live, and are easy to process, store and handle (Vantomme, 2003b). In fact, both baobab and tamarind products are characterised by those properties and can thus be considered good candidates for fair trade and/or organic markets (Box 5.3).

Environmental impact

In West Africa, increasing population and a high rate of land use intensification are resulting in the degradation of the Sahelian parklands and thus a decrease in the most important indigenous trees, which in turn reduces the availability of wild products to local populations (Dhillion & Gustad, 2004; Kalinganire *et al.*, 2007). Additionally, local and regional high demand of baobab leaves in West Africa may reduce the number of fruiting baobab trees due to unsustainable leaf harvest techniques that often include removing flower buds (Assogbadjo, 2006). Large branches of baobab trees are often deliberately pruned to stimulate leaf growth instead of fruit production. Local people in West Africa use certain specific criteria to differentiate baobab and tamarind individuals *in situ* (Assogbadjo *et al.*, 2006a, 2008; Fandohan *et al.*, 2011a). As a result, gathering may affect the genetic diversity of baobab and tamarind population being exploited, especially when harvesting fruits that show different traits (Arnold & Ruiz Pérez, 2001). In addition, some authors warn that successful development and commercialisation of NTFPs may lead to increased harvesting and overexploitation (Stewart, 2003; Ticktin, 2004; Belcher *et al.*, 2005) as sustainable harvesting is rarely reported (Bennett, 2002). This suggests that many NTFPs will require some kind of management if they are to withstand heavy harvest pressure (Ticktin, 2004) and this could mean bringing NTFPs into domestication (Marshall *et al.*, 2006b).

In West Africa, baobab and tamarind might be classified as species in the early stages of domestication, yet without established, well-known varieties (Assogbadjo *et al.*, 2008). Although there are currently no plantations nor conservation areas that have been specifically set aside for their protection, both species bear great potential for sustainable domestication and development, and to promote their conservation. Therefore, it is crucial to develop and formulate policies, regulations

Box 5.3: Niche markets

Conventional export markets bypass many of the poor small-scale farmers. Therefore, it is more likely that smallholders will be able to benefit from global markets if they are able to tap into niche markets (Hellin & Higman, 2002), such as fair trade and organic markets. In both cases, there are a number of environmental and social criteria that have to be met before a product can be sold in either of these markets (Hellin & Higman, 2002). Success stories of fair and organic trade are the baobab products traded by both PhytoTrade Africa/Afriplex and BFCS (BFCS, 2011; PhytoTrade Africa, 2011).

Certification is becoming very important in the natural product sector, including that of NTFPs (Ham *et al.*, 2008). Providing consumers with assurances that products have certain embedded values is a significant growth area in agriculture and natural product marketing (Bennett, 2006). Indeed, because consumers are increasingly concerned about social and ecological impacts of modern agriculture (Hellin & Higman, 2002; CBI, 2005c; Van Looy *et al.*, 2008), fair trade and organic markets are growing in Europe, with annual growth rates of respectively 42.3 % and 5-15 % (CBI, 2005b).

Fair trade Fair trade aims to improve the social, environmental and economic conditions of the most disadvantaged producers in developing countries by offering them the opportunity to move out of extreme poverty through creating market access under beneficial rather than exploitative terms (Hellin & Higman, 2002; Vantomme, 2003b; Nicholls & Opal, 2005; Bennett, 2006).

Organic production Organic agriculture is a production system that sustains the health of soils, ecosystems and people, and relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects, such as synthetic fertilisers and pesticides (Hellin & Higman, 2002; Vantomme, 2003b; Bennett, 2006).

Although the potential of certification for natural products, the currently available information shows that experiences and data on NTFP certification are scarcely out of the egg (Vantomme, 2003b).

and/or strategies which will ensure that exploitation, processing, commercialisation and on-farm cultivation of indigenous trees does not pose a threat to their conservation (Shackleton *et al.*, 2002; Akinnifesi *et al.*, 2004). The policies required could be grouped as legislative and regulatory, marketing, extension en research issues, with considerable overlap between them (Schreckenberg *et al.*, 2006).

5.3 Recommendations and scenarios for intervention

5.3.1 Framework to develop marketing chains

Recommendations and scenarios for intervention will be formulated within the scope of two frameworks developed by the Royal Tropical Institute, namely chain participation (KIT *et al.*, 2006) and trading up (KIT & IIRR, 2008). Hereafter, both frameworks are shortly introduced in Boxes 5.4 and 5.5.

5.3.2 Local chain development: building linkages and enhancing trust

Prerequisites for all recommended interventions for local chain development are the will, motivation, or incentive of a chain actor to conduct a specific action, and the capacity to do so (Gruère *et al.*, 2007a). Hereafter some necessary interventions for chain participation, chain upgrading and trading up will be given that are relevant for the cases studied in the present PhD thesis. The intention of the author is not to give a review of all possible recommendations, but to make a selection of interventions that are considered to have the highest impact on the development of the commercialisation of baobab and tamarind products in Mali and Benin in order to better valorise these products and develop their markets.

Chain participation A necessary first step to chain development is to support smallholders to become crop specialists or chain actors by (i) ensuring that smallholders have the basic assets (*e.g.* financial, physical, human en social capital, and natural resources); (ii) improving their production and management skills; and (iii) building smallholders'

Box 5.4: Chain participation

Smallholders can participate in marketing chains in many different ways, which can be summarized into two broad dimensions (KIT *et al.*, 2006; Marshall *et al.*, 2006b):

- chain activities: being involved in various activities in the chain is called vertical integration; and
- chain management: having a high degree of control over chain management is known as horizontal integration.

These two dimensions can be combined into a chain participation matrix as shown in Figure 5.2. Upgrading as a chain actor, a prerequisite to be able to achieve any form of chain development, means becoming a crop specialists with a clear market orientation (KIT *et al.*, 2006). As a chain actor, a smallholder can add value through vertical integration and thus increase the involvement in a number of chain activities, *e.g.* moving into joint processing and marketing. It is worth to note that vertical integration will shorten the marketing chain by cutting out traders or other intermediaries. Another way in which smallholders can add value is to get involved in chain management and develop chain partnerships, *e.g.* cooperation with other chain actors undertaking similar roles. When combining both vertical and horizontal integration, chain actors can develop ownership over the chain, *e.g.* building direct linkages with consumers. This diagonal movement in Figure 5.2 will also enhance aspects as information management, quality management, innovation management, chain cooperation and marketing intelligence (KIT *et al.*, 2006).

It should be noted that there is no ideal chain position for smallholders as this depends on their specific situation and may change over time, whereby costs may outweigh benefits (KIT *et al.*, 2006). Whereas horizontal integration may increase the smallholders' negotiating power, vertical integration may facilitate and promote establishment of specialised niche marketing chains (Marshall *et al.*, 2006b). Vertical integration is often preferred by smallholders because they think that adding activities will also provide extra income. However, this is not always true as adding activities may also mean adding extra costs and risks. Moreover, increasing the number of activities often requires additional assets and skills, such as technology, finance, human resources and organisation (KIT *et al.*, 2006).

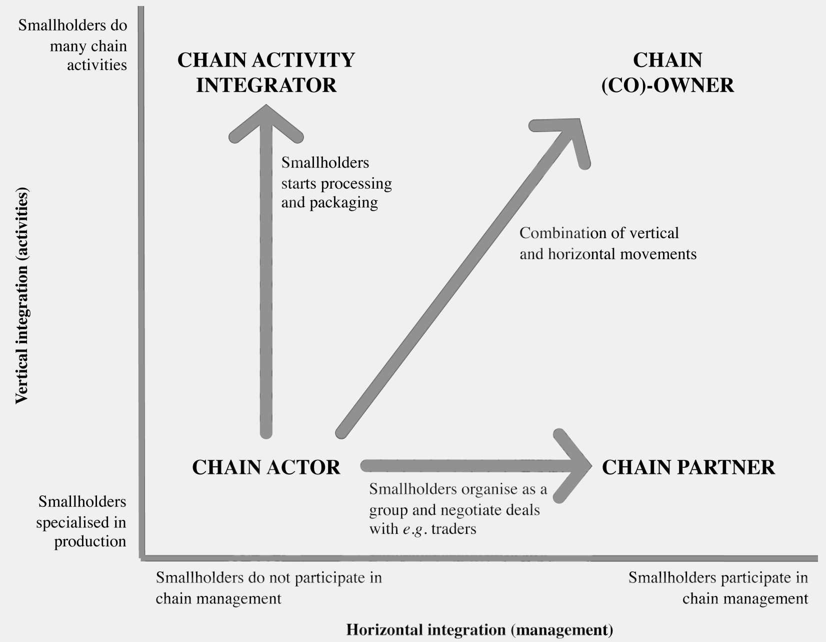


Figure 5.2: Different forms of chain participation by smallholders and how smallholders can improve their position in the chain (adapted from KIT *et al.*, 2006)

Box 5.5: Trading up

There are two basic types of strategies for improved trading relations (KIT & IIRR, 2008), creating:

- stronger chain relations: create well-organised business relations between the various actors in the value chain; and
- stronger market institutions: establish standards, regulations, policies and services to coordinate and support trading activities.

Whereas the first type of strategy seeks to improve the conditions for trading within the value chain, the latter seeks to improve the conditions in the business environment around the value chain (KIT & IIRR, 2008). Stronger chain relations can be achieved by organising chain actors, creating mutual understanding, specialising on certain roles and services, developing a chain partnership and coordinating the chain (KIT & IIRR, 2008). Stronger market institutions can be achieved by developing market information systems, standardising quality, weights and measures, developing contract enforcement mechanisms, providing financial services, and using policy leverage or advocacy (KIT & IIRR, 2008).

The market interactions matrix in Figure 5.3 gives insights in possible ways to organise trading relations between smallholders and traders in a beneficial way, a process also known as trading up. Successful case studies have demonstrated that to accomplish sustainable improvements in trading or trading up, there needs to be simultaneous attention for improved chain relations and stronger market institutions (KIT & IIRR, 2008).

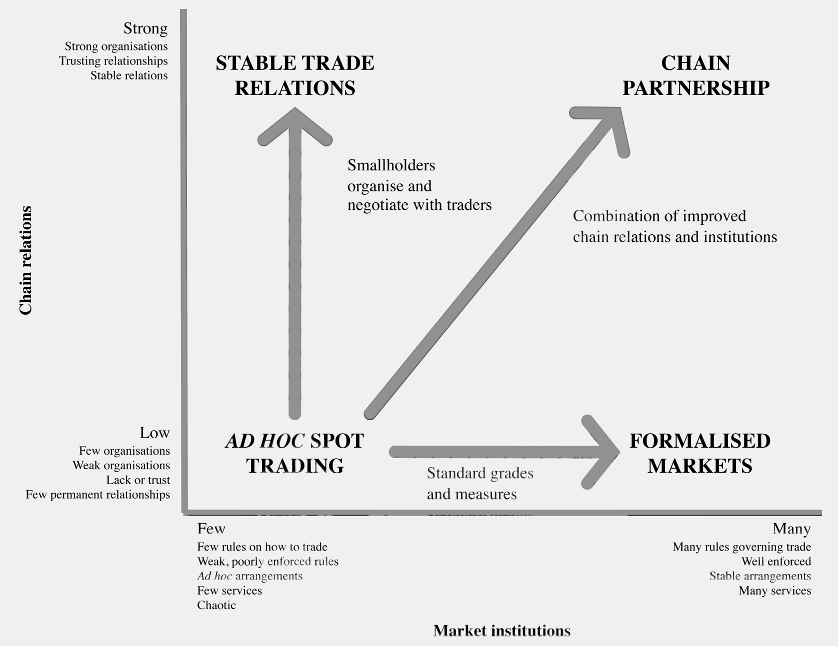


Figure 5.3: Market interactions matrix (adapted from KIT & IIRR (2008))

understanding of market chains, competition, consumer demands, farmers organisations and contracts (KIT *et al.*, 2006).

- Recommended interventions: domestication of baobab and tamarind, and training of smallholders.
- Goal: smallholders become specialised in producing baobab and tamarind, offer fairly attractive products, become organised among themselves and develop basic assets, management skills, understanding of markets and willingness to innovate.

Domestication of baobab and tamarind should be based on the principles developed and adopted by the World Agroforestry Centre and documented by *e.g.* Kalinganire *et al.* (2007) and Tchoundjeu *et al.* (2006, 2007). Hereby, domestication, product development and commercialisation should be seen as a cyclic process without a clear starting or ending point (Leakey & Izac, 1996; Akinnifesi *et al.*, 2004) rather than separate interventions. If domestication and commercialisation of agroforestry tree products occur in parallel problems regarding seasonality and reliability of supply, diversity and inconsistency of fruit quality will be overcome throughout the market chain (Akinnifesi *et al.*, 2006; Nevenimo *et al.*, 2007). This is, however, a long-term investment that may require years to translate into profits for chain actors (Akinnifesi *et al.*, 2006). Domestication and commercialisation projects of baobab and tamarind in West Africa should start/continue in collaboration with the World Agroforestry Centre. One of the advantages is that, in the pilot villages selected by the World Agroforestry Centre, gaining confidence and building-up truthful relationship with the local community will be facilitated due to an existing long-term collaboration.

Chain upgrading: horizontal integration When chain actors want to exercise greater influence in the chain and aim at becoming a chain partner, they need to develop abilities such as negotiating prices, developing technologies and setting quality standards. Therefore, they may opt for a partnership strategy, *i.e.* horizontal integration, based on shared interests and mutual growth (KIT *et al.*, 2006). Farmer organisations or producer groups can play a key role in organising economic activities, as they might – unlike individual smallholders – benefit from market information, capital and skills, volume and quality (KIT *et al.*, 2006; Jaenicke & Lengkeek, 2008). By linking up with a buyer, farmer organisations or producer groups can increase their business security and gradually improve and expand their businesses.

- Recommended interventions: supporting smallholders to associate, collaborate and coordinate, enhancing trust, exchanging information, and communication and bargaining with a focus on shared interests.
- Goal: specialised and organised farmer groups of baobab and tamarind products cooperating with processors or traders.

Many authors acknowledge that collective action plays an essential role in creating market access for smallholders (Gruère *et al.*, 2007b; Will, 2008; Kruijssen *et al.*, 2009; Jaenicke, 2010; Kwaschik *et al.*, 2010) as it increases the bargaining power and economies of scale of small-scale producers and processors (Biénabe & Sautier, 2005; Marshall *et al.*, 2006b). The formation of community-based organisations, whereby smallholders can pool resources and market their products collectively, could overcome the high transaction costs resulting from their small size (Will, 2008; Kruijssen *et al.*, 2009). Moreover, it can improve their access to resources (such as inputs, credit, training, transport and information), increase bargaining power, and facilitate certification and labeling (Biénabe & Sautier, 2005; Will, 2008; Kruijssen *et al.*, 2009). Information is needed on markets (demand, end-uses, supply), marketing factors (products, distribution channels, promotion and prices), competition and marketing environment (including social, economic, technological, regulatory, legal, cultural and infrastructural environments) (Lintu, 1995).

Chain upgrading: vertical integration When chain actors sell their produce as raw material at low prices, while at the end of the chain the consumer pays a price that is many times higher, they may feel that they get little return from the market. These smallholders may increase their income by adding business activities usually together with other smallholders, *i.e.* vertical integration (KIT *et al.*, 2006). The easiest way is by investing in higher productivity, better quality and specialisation; marketing is best left to traders (KIT & IIRR, 2008).

- Recommended intervention: grading of the (primary, processed) product into homogeneous quality grades, each with a different price, each eventually for a different market segment.
- Goal: quality management assures that the product can find its way into the market, and that both the product and the production processes satisfy the consumer.

In addition, commercially viable processing enterprises require product uniformity and consistently good quality, availability of new and improved processing technologies to meet market requirements, necessary machinery and equipment, and adequate and easy access to the necessary information on processing, packaging, marketing, product preservation, etc. (Ham *et al.*, 2008; Haq *et al.*, 2008). Successful processing stories, such as those of PhytoTrade Africa (Welford & Le Breton, 2008; Lombard & Leakey, 2010) and BFCS (BFCS, 2011), may be inspiring in how to achieve product research and development, and how to develop markets and market awareness.

Trading up: stronger trade relations Smallholders and traders will benefit if they manage to make their chain relationships more stable, more transparent and better organised (KIT & IIRR, 2008).

- Recommended intervention: organising chain actors, creating mutual understanding, and specialising in certain roles and services.
- Goal: create stronger and stable trade relations between smallholders and traders.

Trading up: stronger market institutions Market institutions are norms, rules, regulations, policies or services that shape the way in which farmers and traders interact. They give structure and support to trade activities, thereby reducing the costs and risks that farmers and traders face in their businesses. They form the business environment that surrounds the trading activities in the market chain. Improving market institutions is a basic strategy to improve trading (KIT & IIRR, 2008).

- Recommended interventions: developing transparent market information systems, standardising quality, weights and measures, and providing basic infrastructure and financial services.
- Goal: create formalised markets with, on the one hand, accurate information on the availability, price and quality for making good decisions as to where, when, to whom, and at what price to buy or sell, and, on the other hand, standardisation of quality features, size, weight and/or packaging of a product.

The aim of all these interventions should be that baobab and tamarind products are better valorised and find their way into the market. Therefore, all recommended interventions must be tailored to market demands (KIT *et al.*, 2006). As a result, there is a strong need to study consumer behaviour, needs and preferences that underpin existing consumption (Jordaan *et al.*, 2008) as a better understanding of consumer preferences is essential to market development (Mishili *et al.*, 2009). Another important issue is that the focus on developing market outlets for baobab and tamarind products needs to be kept in balance with the use of these products to meet subsistence needs (Arnold & Ruiz Pérez, 1998; Buchmann *et al.*, 2010).

Successful implementation of these strategies for developing the market chain of baobab and tamarind products will need the implication and collaboration of the private sector, NGO's, governments and research institutes (GFU, 2003).

5.3.3 ... and beyond?

Once the major domestic limitations have been tackled, commercialisation of baobab and tamarind products on regional scale should be developed and expanded in West Africa. Simultaneously, international markets should be targeted. In Europe, a dynamic and increasing demand for various tropical fruits is manifesting itself. This rising demand can be explained by increased consumers' health consciousness and interest in fruit consumption in general, as well as by population growth of ethnic minorities in Europe and international travel and global communication (CBI, 2006). Hereby, quick gains can be made by strengthening collaboration and knowledge exchange with other countries or continents, where the same species (or varieties) are better valued or are already extensively commercially utilised (Jama *et al.*, 2008; Fandohan *et al.*, 2010a). Key examples for production practices and marketing potential of tamarind can be found in Asian countries, such as India and Thailand. Commercialisation of the products of the African baobab can be inspired by the development of a marketing chain for the roots of the Australian boab (*Adansonia gregorii*) as a novel vegetable into a gourmet vegetable market (Johnson *et al.*, 2002, 2006).

A combination of strong domestic, regional, and international markets seems the best option allowing for diversification, and thus increased livelihood resilience against fluctuations in any one of these markets (Buchmann *et al.*, 2010).

6
General conclusions

This final chapter gives the overall conclusions of this PhD research based on the objectives and formulates directions for future research.

6.1 Main results per objective

Most aspects of the market chains of baobab and tamarind products in Mali and Benin studied in the present research have – according to the author's knowledge – not yet been studied and published elsewhere. Therefore, this research should be considered as a pilot case study in obtaining insight in the structure and functioning of the markets of baobab and tamarind products.

6.1.1 Chain actors and their activities

Gatherers

Gatherers of baobab and tamarind products can be categorised as smallholders according to the definition of Davis (2006). Additionally, gatherers in Mali and Benin are involved in primary processing of baobab and tamarind products. After harvesting, they transform fresh baobab leaves into dry baobab leaves and/or baobab leaf powder, baobab fruits are processed into baobab fruit pulp, tamarind leaves are dried, and tamarind fruit pods are stripped from their shell. In the present study, the portion of cash income obtained from baobab and tamarind products is about 4 % for the poorest and 5 % for the richer households in Mali, whereas, in Benin, a contribution of up to 11 % is reported for the poorest group of smallholders. These results show thus that baobab and tamarind cash income can be supplementary to the more important crop cash income. Moreover, marketing of baobab and tamarind products happens principally in the dry season, which is also the period during which other agricultural products are becoming scarce and thus more expensive. This suggests that commercialisation of baobab and tamarind products may provide cash income complementary to other income generating activities, and thus act as a financial buffer. This confirms that baobab and tamarind products fall into the gap-filling income category as defined by Marshall *et al.* (2006b). The present study showed also that gatherers in Mali harvest baobab and tamarind products mainly for home consumption, whereas, in Benin, most of the produce is sold by gatherers and may thus provide an income.

The majority of surveyed gatherers in Mali and Benin reported to sell their baobab and tamarind products at the farmgate. Baobab and tamarind fruits and leaves are harvested using traditional harvesting techniques, which only require manual labour and low-cost tools. According to field observation and also substantiated by some authors (Assogbadjo, 2006; Buchmann *et al.*, 2010), leaf harvesting practices, in the case of baobab, may negatively impact on fruit production. Therefore, in general, sustainable harvesting practices need to be developed and proposed to promote the species' conservation and avoid overexploitation. Particularly for baobab leaves, baobab market gardens as developed by the World Agroforestry Centre and its partners (ICRAF, 2003) can be recommended. At last, surveyed gatherers in Mali and Benin mentioned dangerous harvesting techniques, seasonality and limited availability of baobab and tamarind products, time-consuming processing practices, product quality and a lack of market information as their major problems.

Traders

Traders of baobab and tamarind products fulfil different and varying functions, which points to a lack of functional specialisation. Therefore, the term trader in the present study encompasses collectors/assemblers, wholesalers, retailers and petty traders. Moreover, next to baobab and tamarind products, traders sell a great variety of other food products. Traders of baobab and tamarind products are mainly women, which confirms that NTFPs are generally traded by women (Ndoye *et al.*, 1998; Fafchamps & Gabre-Madhin, 2001; Ahenkan & Boon, 2010). Findings in the present study revealed three possible price setting processes: (i) fair negotiation, usually when the produce is sold at the market place; (ii) traders have more bargaining power, especially when the produce is sold at the farmgate; and (iii) collecting gatherers in Benin have more influence in the price setting than traders. The latter shows the beneficial impact of collective action strategies in increasing the bargaining power of smallholders. Additionally, the present study identified distinct trade centres for baobab leaf powder, baobab fruit pulp and tamarind fruit pods in Mali and Benin. The surveyed traders reported the following principal problems: variable product quality, limited storage space, transport difficulties due to poor roads, lack of market information and no access to formal financial services.

Processors

Processors in Benin reported to make juice from baobab and tamarind fruit pulp, whereas in Mali, processors use baobab and tamarind fruits in the preparation of juice, syrup, jam and instant juice powder. Additionally, baobab fruit pulp is used in Mali for the preparation of millet cream (locally called *dégué*). This shows that surveyed processors are solely involved in secondary processing. Additionally, processing is generally not reported as a one-man's business and processing (family) enterprises were found to transform a whole range of different products. The present study reported that traditionally processing practices are widely adopted in Mali and Benin, however, several authors found that local processing techniques may have a negative impact on the product quality (Sidibé *et al.*, 1996, 1998b; Scheuring *et al.*, 1999; Hell *et al.*, 2009). Notwithstanding the manual processing techniques and simplicity of equipment used, the portion of efficient processors identified by means of a data envelopment analysis is 63 % in Mali and 49 % in Benin. Thus, processors appear to be efficient under the given circumstances in Mali and Benin. The major cost that processors in both countries face is the cost of packaging material, which has also been mentioned in literature as the main barrier for small-scale processors (Fafchamps & Gabre-Madhin, 2001; Gabre-Madhin, 2001; Fafchamps, 2004; Abeyrathne & Jaenicke, 2006; Shepherd, 2007). Moreover, surveyed processors in Mali and Benin reported inappropriate and expensive packaging material, limited availability of adequate processing equipment, bad transport due to poor road infrastructure, lack of financial means and limited market information as main constraints.

Consumers

The present study showed that both rural and urban consumers buy and use baobab and tamarind products on a regular basis. Baobab fruit pulp is reported to be used in porridges and/or juices, whereas baobab leaves are used in sauce preparations. Most surveyed consumers use tamarind leaves and fruits in the preparation of juices and/or for souring meals. Substitution products for all baobab and tamarind products are reported in the present study and confirmed by literature. The main problems recorded by consumers are seasonality of supply, price fluctuations and unreliable product quality.

6.1.2 Market chains

In total, six different baobab and tamarind products are reported in this study to be traded in Mali and Benin. Based on the market maps drawn for these products, three different market chains were identified.

Market chain of fresh baobab leaves and tamarind leaves

The market chain of fresh baobab leaves in Mali and Benin and tamarind leaves in Mali is short as only two to four different chain actors are involved, namely gatherers, retailers, petty traders and consumers. Direct on-farm sales and rural primary markets are the most important market types, whereas rural and urban retail markets play a minor role. This market chain is characterised as locally important and has thus a domestic potential.

Market chain of dry baobab leaves and baobab leaf powder

The number of actors involved in the market chain of dry baobab leaves and baobab leaf powder varies between two and six in Mali, and may include gatherers, collectors/assemblers, wholesalers, retailers, petty traders and consumers. In Benin, up to five actors take part in the market chain of baobab leaf powder, namely gatherers, collecting gatherers, retailers, petty traders and consumers. Thus, two differences in chain actors between Mali and Benin have been surveyed. First, no wholesalers were identified in Benin. Secondly, the collecting and bulking function is done by collecting gatherers in Benin, whereas in Mali this is the task of collectors/assemblers. Most transactions take place in rural primary markets, and rural and urban retail markets. When collectors are involved in the chain, assembly/(semi-) wholesale markets and on-farm sales become also important. Additionally, in Mali, direct selling at the farmgate was reported. The market chain of dry baobab leaves and baobab leaf powder have a clear local, provincial and national importance. Moreover, regional trade in baobab leaf powder has been reported. As a result, this market chain is characterised as important on domestic level with a regional potential.

Market chain of baobab and tamarind fruits

In the market chain of baobab and tamarind fruits, up to seven different actors may be involved in Mali and include gatherers, wholesalers/collectors, retailers, petty traders, processors, caterers/retailers and consumers. In Benin, ten different actors can be identified, namely gatherers, collecting gatherers, collectors/assemblers, wholesalers, retailers/collectors, retailers/petty traders, petty traders, processors, caterers/retailers and consumers. As not all these different chain actors are interlinked with each other, a maximum of six actors have been reported to be linked in the chain. Moreover, some of the actors have similar tasks and are consequently competitors of each other. All four market types are important, namely on-farm sales, rural primary markets, assembly/(semi-) wholesale markets, and rural and urban retail markets. Besides a clear national importance of the market chain of baobab and tamarind fruits in Mali and Benin, regional trade have been recorded, whereas international market potential has been reported in literature. Thus, this market chain is characterised by its domestic and regional importance with international potential.

6.1.3 Market chain analysis

Nevertheless the importance of baobab and tamarind products in local West African markets has been recognised (Gustad *et al.*, 2004; Assogbadjo *et al.*, 2008; Buchmann *et al.*, 2010; Fandohan *et al.*, 2010a; van der Stege *et al.*, 2011), only a few authors have reported about marketed quantities and prices. The present study is the first that has recorded quantities bought and sold, and purchasing and selling prices for different actors involved in the commercialisation of baobab and tamarind products in Mali and Benin. Based on the quantities and prices recorded, baobab fruit pulp is traded in larger quantities in Benin than in Mali, whereas baobab leaf powder and tamarind fruit pods are marketed in larger quantities in Mali than in Benin. Prices are lower in Benin for baobab fruit pulp and baobab leaf powder than in Mali, while tamarind fruit pods are cheaper in Mali when compared to Benin. Prices surveyed for baobab leaf powder and fruits are in the same order of those found in literature, whereas tamarind fruit pods in the present study were found to be more expensive than the prices reported in literature. Based on both own figures and FAO estimates, an extrapolation shows that the commercialisation of baobab fruit pulp in Mali involves more than 400,000 gatherers, about 165 wholesalers, and at least 5,000 petty traders. Moreover, at least 35,000 gatherers, about 440 wholesalers and more than 9,000 petty traders take part in the market chain of tamarind fruit pods in Mali. In conclusion, commercialisation of baobab and tamarind products creates a lot of employment opportunities. In addition, added values for baobab and tamarind products were calculated in the present study and show that processors and gatherers tend to have the highest added values. This trend is found to be more pronounced in Mali than in Benin. As added value does not take into account any costs, it is impossible to give a decision about which actor has the highest margins.

The availability of baobab and tamarind products is determined by the phenology of the trees. Baobab bears only leaves during the rainy season, whereas tamarind leaves are available throughout the year. The fruiting period of both baobab and tamarind coincides with the dry season in Mali and Benin. As a result, harvesting of baobab and tamarind fruits, and baobab leaves is highly seasonal. This is further reflected in the commercialisation of baobab and tamarind products which is found to occur chiefly during the dry season in Benin. In Mali, marketing of baobab and tamarind products is observed to be less seasonal. However, no seasonal storage has been surveyed in Mali and Benin due to a lack of storage infrastructure, space and financial means. Most surveyed chain actors typically purchase a certain volume of produce, which is stored until it is sold, after which they replenish their stock. As a result, storage duration is observed to be very variable. In the present study, dry baobab and tamarind products are mainly stored in recycled rice bags which are kept in the house or in a storehouse or granary, in respectively Benin and Mali. Even though humidity and bug, mice and fungi attacks were reported as main problems during storage, the informants rated overall storage conditions as good. But some authors pointed out that these traditional storage practices may negatively affect the quality of the produce (Sidibé & Williams, 2002; Cisse *et al.*, 2009; Chadare, 2010).

In the present study, all baobab and tamarind products are not graded nor standardised. Direct inspection is the only method reported by which quality is assessed. Moreover, it has been observed that different actors use different quality criteria. All chain actors in Mali and Benin attach great importance to processing and storage techniques for baobab and tamarind products, and expect a well-dried or finely ground product without impurities, which has not been exposed to humidity. Additionally, colour and taste are important quality parameters in Mali, whereas taste is only a criterion in Benin for baobab and tamarind fruits. Maturity, freshness and size, together with the absence of insects or insect lesions are important quality criteria used to assess quality of tamarind fruits and leaves in Mali. The same criteria are used in Benin to inspect the quality of fresh baobab leaves.

Lack of market information is commonly recognised to be a major constraint in the commercialisation of NTFPs (Neumann & Hirsch, 2000). This was confirmed in the present study as the majority of surveyed chain actors stated that market information is lacking. Information is particularly lacking about harvesting and processing techniques, price, quality and demand. Chain actors in Mali particularly need more information about demand and they reported not to be satisfied about the access to information. In contrast, surveyed actors in Benin need especially information about quality and say to be rather satisfied with overall information flow. Incomplete or non-transparent market information leads to market failure (KIT & IIRR, 2008).

SWOT analysis

In Mali and Benin, both baobab and tamarind are multi-purpose indigenous tree species which are well-known and often used by local populations because of their nutritional value and health benefits, and have the potential to generate income on existing domestic markets. Besides, both species have been identified by local people as priority species for domestication and they are included in research and development programmes of many international research organisations to improve food and health security and alleviate poverty. On international level, baobab and tamarind products are interesting candidates to enter promising market segments, such as functional foods and nutraceuticals. Additionally, the novel food approval of baobab fruit pulp may boost the international trade of this product. Next to this international market potential, also regional trade has been reported to be important. Baobab and tamarind seeds are often regarded as by-products of fruit processing. However, their potential is significant in the marketing of edible and cosmetic oils (Akinnifesi *et al.*, 2005; Bennett, 2006).

But, domestic markets are characterised by a lack of organisation, poor storage facilities, limited market infrastructure and weak linkages, whereas chain actors have undeveloped entrepreneurial skills, limited access to formal financial services and a lack of market information. Moreover, there is a great variation in product quality due to wild harvesting from undomesticated trees (Akinnifesi *et al.*, 2006; Belcher & Schreckenberg, 2007; Nevenimo *et al.*, 2007) and rudimentary processing techniques, and grading or standardisation are non-existent in Mali and Benin. Governments in SSA fail to provide basic market infrastructure. Due to a lack of official recognition and national regulations, the inclusion of indigenous species in national research programmes is limited. On international level, baobab and tamarind products may, on the one hand, be so exotic in taste that this may act as a barrier to consumption (Sabbe *et al.*, 2009b), and, on the other hand, face competition with similar products from other countries, regions or continents.

Impact analysis

Baobab and tamarind are widely used to supplement the largely cereal-based diets of many of the rural populations in Mali and Benin and have thus the potential to play a pivotal role in achieving the target set by FAO and WHO, namely a daily consumption of 400 g fruits and vegetables. Moreover, baobab and tamarind products are rich in minerals and vitamins which makes them interesting candidates to combat hidden hunger. However, up till now, no studies have been done to assess the bioavailability of essential nutrients in these species.

Increased urbanisation may expand the size of domestic and regional markets for baobab and tamarind products. Due to globalisation, ethnic food markets as well as international demand for exotic and novel food products will grow. This opens perspectives for baobab and tamarind products to enter new market segments, such as niche markets and functional foods.

In West Africa, increasing population and a high rate of land use intensification are resulting in the degradation of the Sahelian parklands and thus a decrease in the most important indigenous trees, such as baobab and tamarind. Additionally, local leaf harvesting techniques may reduce the number of fruits per tree. Therefore, domestication and conservation of baobab and tamarind should be promoted.

6.1.4 Recommendations and scenarios for intervention

Local chain development should build linkages and enhance trust between actors in the market chain. This can be achieved by interventions formulated within the frameworks of chain participation, chain upgrading and trading up. Recommendations are formulated in many fields: (i) parallel domestication and commercialisation of baobab and tamarind; (ii) training of smallholders to improve their production and management skills; (iii) supporting smallholders to associate, collaborate and coordinate to achieve economies of scale in their transactions with buyers; (iv) making channels of information and market intelligence accessible to all chain actors;(v) enabling chain actors to understand and better satisfy product, process or delivery standards required by buyers; and (vi) improving market institutions. The aim of all these interventions should be that baobab and tamarind products are better valorised and find their way into the market. Therefore, all recommended interventions must be tailored to consumer preferences.

Once the major domestic limitations have been tackled, commercialisation of baobab and tamarind products on regional scale should be developed and expanded in West Africa. Simultaneously, international markets should be targeted as, in Europe, a dynamic and increasing demand for various tropical fruits is manifesting itself. A combination of strong domestic, regional, and international markets seems the best option allowing for diversification, and thus increased livelihood resilience against fluctuations in any one of these markets (Buchmann *et al.*, 2010).

6.2 Limitations and directions for future research

The present study combined various research methods and tools, both quantitative and qualitative, to obtain a holistic view of the structure and functioning of baobab and tamarind markets and trade channels in Mali en Benin. The results of this research are undoubtedly invaluable to obtain insights in how baobab and tamarind products can be valorised in Mali and Benin. Nonetheless, there are some limitations on this study.

The semi-structured interviews were long, sometimes too long to keep the respondents' attention and consisted of a wide range of questions, which might have hindered respondents to stay focused. As a consequence, the author had to cope with missing, incomplete and inconsistent data. In turn, this lead, during data analysis, to numerous estimates, assumptions and/or simplifications, which probably had an influence on the accuracy of results.

Although a great population was sampled, an even greater sample size would have been better in order to explain quantitative differences and/or similarities reported between individual respondents. This is the reason why the author was sometimes unable to give a(n) (clear) explanation of the results found. In addition, the data sampling plan was rather complex as two countries, six food products and different chain actors were taken into account. Although this allowed for many results, it made data analysis difficult.

Another challenge was the – by the author so-called – 'snapshot' technique, which means that one single field research was performed in each country. As no repetitions in time occurred, seasonal fluctuations could not be evidenced and data were assumed to be mean figures. In some cases, the latter might have led to under- or misestimations. Additionally, the period during which field research was performed, did not coincide in both countries, *i.e.* in Mali data were collected during the wet season, whereas in Benin data collection took place during the dry season. This might have biased the information given by the respondents.

Finally, and additionally to the limitations mentioned above, the multidisciplinary and at the same time holistic character of the present study restricted some in-depth interpretation of results. However, this leaves scope for future research.

According to the author, three types of further research and action are needed. Primarily, a follow-up in-depth market chain analysis is required for each baobab and tamarind product taking into account the quantitative assessment of (i) marketing costs and margins (per kg, per labour day, per €invested) of each chain actor; (ii) price fluctuations between seasons, regions and market types (rural, urban, wholesale, retail, etc.); and (iii) post-harvest practices such as processing, storage and transport. Secondly, a detailed study of each chain actor is recommended. Such a single actor study should aim to identify roles and needs, and empower competences of each actor implied in the market chain in order to formulate tailored strategies to improve each stakeholder's competitive role within the chain. Hereby, special attention should focus on the consumer as more emphasis is needed on assessing demand and getting to know consumers' preferences in order to promote specific market segments. Finally, the results of the two preceding studies should feed into an integrative strategic action plan to build linkages and enhance trust in order to develop the market chain of baobab and tamarind products.

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Publications

Articles published in international peer-reviewed journals included in the Science Citation Index (A1 publications)

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Articles published in conference proceedings (C1 publications)

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Conferences: oral and poster presentations (C3 publications)

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