44. Processing and utilisation of indigenous fruits of the miombo in southern Africa

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Abstract

Over 50 indigenous fruit species from the miombo woodlands are important sources of food and constitute food reserves for people during famines or droughts in southern Africa. The SADC–ICRAF regional programme has concentrated its work on the four most promising fruit species *Uapaca kirkiana*, *Parinari curatellifolia*, *Strychnos cocculoides* and *Sclerocarya birrea*. The paper discusses processing and utilisation methods and the role of farmers and small-scale processors in overall development of the priority species during the last 10 years and emerging issues for future work. The edible pulp of indigenous fruits is rich in iron, zinc, vitamins A and C, and reducing sugars. The seed kernels are good sources of protein, fat and minerals. Various products such as juices, jams, dried pulp, wines, flavours and 'flitters' using a mixture of *S. cocculoides* and *U. kirkiana* have been made by farmers for home consumption and sale in urban markets. Small-scale processors such as Mulunguzi winery in Malawi, the Mukutu and Ntandabale Wineries at Lusaka in Zambia and farmers have produced wine from indigenous fruits. Training of farmers' groups and small- to medium-scale processors has been undertaken to increase their skills in quality assurance and business management.

Introduction

Forests and homestead farms are important sources of non-timber products including indigenous fruits (IFs), which are consumed by communities and also sold to generate income. These are essential for food security, health, social and economic welfare of rural communities (FAO 1989; Maghembe et al. 1998; Akinnifesi et al. in press a). For example, sheanut butter obtained from *Vitellaria paradoxa* in dry savanna forest and parklands of the Sudan is used by rural communities as culinary fat or oil, and for making soap, ointments and cosmetics (Boffa et al. 1996). The fat is used in pastries and confectionery as a cocoa butter substitute and it constitutes a base for cosmetic and pharmaceutical preparations. In the miombo region of southern Africa, indigenous fruits gathered from wild are largely a subsistence product. This necessitated ICRAF and its partners to identify priority fruit species and initiate a domestication programme for them in 1998 (Maghembe et al. 1998; Akinnifesi 2001). Domestication entails naturalisation of forest trees to managed conditions through human-induced changes in the genetics of the plant (Simons 1996).

Species priority setting involved six steps, team building and planning, assessment of client needs, assessment of species used by the communities, ranking of products, identification of priority species, their valuation and ranking, and fruit choices (Franzel et al. 1996). These exercises had resulted in identifying over 50 IFs from the niombo woodlands as important sources of food and constitute food reserves for people during periods of seasonal food shortage in southern Africa. Out of these 50 species, ICRAF and its partners identified *Uapaca kirkiana*, *Parinari curatellifolia*, *Strychnos cocculoides* and *Sclerocarya birrea* as the 'top bet' species for domestication (Maghembe et al. 1998; Kwesiga et al. 2000; Akinnifesi et al. in press a). The selection of these four species was based on several factors including their contribution to food security, income generation, and potential of being processed into various products. This paper provides a review of the regional efforts on local knowledge systems regarding IF processing and utilization, farmers' preferences for fruit products and product nutritional quality. The prospects for fruit processing and the role of farmer participation in fruit processing and marketing are also discussed.

Importance of IFs to human nutrition

Miombo indigenous fruits are rich in sugars, essential vitamins, minerals, oils and proteins necessary for human nutrition. For example, the edible pulp of *P. curatellifolia* and *U. kirkiana* contains vitamin C as much as 10.4 and 16.8 mg per 100-g fresh weight, respectively (Saka 1994). Improved nutrition increases immunity to HIV/AIDS, reduces its effect and arrests its progression (Rajabiun 2001). The rural areas are at the risk of HIV/AIDS, which affects food production and economic activities of people. IFs, therefore, constitute an important source of essential vitamins and minerals for the poor people. The four countries in the southern Africa region (Malawi, Tanzania, Zambia and Zimbabwe) are net importers of fresh fruits and products mostly from South Africa and Europe (FAO 2002).

The contribution of IFs to trade is nil. Therefore, efforts are underway to strengthen and improve processing of local fruits, including IFs as an important strategy to promote fruit export and create employment opportunities in the rural areas. Processing of IFs and their marketing would complement the efforts of governments to diversify product range in the local markets, improve nutrition and expand local processing industries.

Indigenous knowledge on fruit utilisation and processing

Local knowledge of indigenous communities and its inventory is a key to domestication of trees and commercialisation of their products (Kwesiga et al. 2000). Fruit collectors include children, who have a wealth of information on the relative quality of fruits in terms of taste, size and availability (Maghembe et al. 1998; Simon et al. 1999). This helps to identify local preferences and product diversity, which are necessary for relevant domestication programme (Maghembe et al. 1998). For example, in Burkina Faso, local knowledge systems indicate that IFs are used as fats, spices, soups and other meal preparations (Ladipo et al. 1996). Farmers preferred and prioritised products based on fruit contribution to food security and income generation potential (Table 1) (Kwesiga et al. 2000).

IFs are used as fresh fruits, juices, 'chiminimini', powder, yoghurts and jams (Figure 1)(Simon et al. 1999; Saka et al. 2002). To raise income for the rural and peri-urban households, fresh fruits, 'chiminimini' and spirits appear the most important products. Preference for some products made from *Uapaca* and *Parinari* appear area specific. For example, in Tanzania, juice making is the most preferred by women processors followed by jams and wines (Simon et al. 1999; Swai 2002). This is because juice processing is simple and prices are affordable by common people in rural and urban areas. Fruits of *Adansonia digitata, Vitex mombassae, V. doniana, Syzygium guineense, S. cocculoides* and *P. curatellifolia* are the most frequently used for processing into different products. The dry form of *A. digitata* fruit is easier to store for longer periods than fresh fruits.

Farmers prefer simultaneous exploitation of indigenous and exotic fruits for product development in order to expand product range and meet market needs (Saka et al. 2002; Schomburg et al. 2002). Consequently, average ranking by farmers of indigenous and naturalised (exotic) fruits for both income generation and household food security in decreasing priority is *U. kirkiana, P. curatellifolia, Zizyphus mucronata, Z. mauritiana, S. cocculoides, Adansonia digitata, Pachystea breripes, Annona senegalensis, Tamarindus indica, Ficus indica* and *Xymalos monospora* (Table 1).

Fresh fruits are processed in order to (i) provide palatable products, (ii) preserve the product, and (iii) obtain products that can be converted into other by-products. The advantage of dried fruits is that they can be stored for over 18 months and thus enhance food security in times of hunger (Akinnifesi et al. in press b). Therefore, dried fruit is an important product in southern Africa (Kadzere et al. 2002; Saka et al. 2002). Farmers' generally learn about processing from their parents and/or grand parents (Kadzere et al. 2002; Saka et al. 2002). About 26% of the technical knowledge is learnt from agricultural and community services programmes. Empowering the community with appropriate processing techniques is thus very essential.

Traditional fruit processing in Zimbabwe is most common in the drier parts of the country (Zambezi Valley, Chipinge and Gokwe) to supplement food requirements (Kadzere et al. 2002). The major fruits processed in the Zambezi Valley are *Z. mauritiana* and *A. digitata* and to a lesser extent *S. birrea*. *Tamarindus indica* is used as an additive in processing *Z. mauritiana*. In Chipinge, the major fruits processed include *S. madagascariensis, A. digitata* and *S. birrea*, while in Gokwe the fruits are *P. curatellifolia* and *S. cocculoides*. Fruits of *P. curatellifolia* and *S. birrea* are also fed to livestock wastage. The derived products are presently produced by traditional practices using locally available utensils. Increasing the product value through better post-harvest technologies and local competition is necessary. Farmer participation in enhancing research and development work on fruit processing, marketing and utilization is critical. To expand utilisation and marketing of the IFs, quality assurance is also essential. Therefore, concerted research and development efforts should address:

- Updating and documenting farmers' emerging priorities and indigenous knowledge regarding processing methods and utilisation of fruit products;
- Improving marketing opportunities to enhance the utilisation of IFs and derived products;
- Development of appropriate processing techniques and diversifying product range for priority IFs;
- Participatory assessment of the needs of rural population with regard to subsistence and cash income opportunities;
- Post-harvest handling and storage methods and their effect on fruit and product quality;
- Cost–benefit analysis of the current and improved post-harvest handling methods for IFs;
- Reducing post-harvest losses due to pests and diseases of IFs, and
- Training of farmers and intermediate buyers in fruit processing and business management.

To support the growth of this sector, ICRAF and its partners including the private sector should develop and implement a master plan that will lead to the

- Development of a modern food processing industry, meeting national and regional food needs in conformity with modern hygiene standards;
- Establishment of export-oriented as well as import substituting products; and
- Establishment of industries, which utilise more IFs and substitute for imported raw materials.

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Table 4. Some experiences with fruit processing using two fruit species

Fruit species	Ripeness of fruits	Technology	Outcome	Comments
Parinari curatellifolia				
Jam	Fully ripe Soft pulp	Heating up to boiling point	Good consistency, nice/fruity smell, Extreme astringency	*Parinari* products should not be heated above 65°C, as it will lead to extreme astringency.
Juice	Fully ripe Soft pulp	Soaking in syrup (40%), filtration and heating to 75°C	Fruity juice, clear and light red in colour, extreme astringent	Need for further improvements. The technology used for Parinari should be tested.
Sweets	Fully ripe Soft pulp	Same as for Juice, drying in direct sun	Preserved whole fruits, extreme astringency	Drying the whole fruit is possible after they have been soaked in syrup.
Uapaca kirkiana				
Juice	Fully ripe Soft pulp	Soaking mashed fruits in syrup (40%), filtration, heating up to 65°C	Fruity, sweet juice, light red in colour, clear product,	The juice has no astringency. The shelf life is under observation.
Fruit leather	Fully ripe Soft pulp	By-product of juice making. Drying of pulp in oven at 60°C.	Bron, cake-like fruit leather. Sweet and fruity.	The shelf life is under observation.

IFs (Akinnifesi 2001). Farmers need training in several areas including processing, maintaining standards, business management and marketing (Dietz 1999; Schomburg et al. 2002). ICRAF in collaboration with partners has trained 198 farmer trainers on processing of IFs into juices, jams and wine in four districts in Tabora region (Table 3).

In Malawi and Tanzania, recipes based on IFs have been developed and farmers trained in preparing them (Figure 2) (Swai 2002; Saka et al. 2002; Schomburg et al. 2002). Farmers have also undergone training in basic management skills in quality assurance, entrepreneurship, marketing including marketing research, costing and pricing, stock control, record keeping and business planning. Quality assurance and management of the fresh and finished products will increase utilisation and acceptance by urban and more affluent communities.

Farmers have acquired some experiences in making various products such as jams, juices, sweets and fruit lathers (Table 4). The results indicate that processing of *Parinari* products should not be heated above 65°C, as this leads to increased astringency. The sweets seem to show potential for drying while *Uapaca* juices and lather have limited shelf life. The methodology requires further improvement and evaluation. Efforts are continuing to develop a range of recipes that provide wholesome and quality products.

Conclusions and future outlook

Miombo IFs are an important source of human nutrients especially vitamins and minerals. They contribute to daily nutrition, meeting household food security and generating cash income for family welfare. These fruits can be transformed into various products to increase shelf life, add value and reduce

Juice making

- Peel thoroughly washed and cleaned fruits separating the pulp from seeds
- Add 3 full (300 ml) cups of the pulp to 1 litre (2 pints) of water contained in a previously hot washed mortar
- Mix the mash thoroughly with a wooden mortar for some 20 to 30 minutes until consistently
- Filter the mash into a clean pot using a muslin cloth, add sugar (a quarter of a cup) and freshly squeezed lemon juice (25 ml) and stir until the sugar is completely dissolved.
- Add a preservative (e.g. sodium benzoate 5 mg per 1 litre of liquid mixture)
- Heat the mixture to simmering for 5 to 10 minutes and cool to room temperature and serve.

Jam making

- Peel thoroughly washed and clean fruits, separating the pulp from seeds
- Mix 1 cup full (300 ml) of the pulp, 1 cup of sugar and 3 cups of water in a frying pan to consistency
- Add some lemon juice (30 ml)
- Add a preservative (e.g. sodium benzoate 5 mg per 1 litre of liquid mixture)
- Heat slowly using a charcoal stove until the jam sets
- Transfer the jam into 330 ml jar, which was previously sterilized
- Allow the jam to cool to room temperature and serve.

Wine making

- Extract pulp (2 kg) from ripe fruits using hot water
- Dissolve sugar (2 kg) in water (6 litres), add rind and strain through cheese cotton or muslin cloth
- Prepare wine yeast
- Boil 4 tablespoons of sugar until it melts and add it to the fruit juice
- Pour all the ingredients into a plastic container and cover. Store the container in a place where it will not be disturbed
- Stir every day for 8 days
- Filter the mixture and transfer juice into a fermentation vessel with plastic tube connected to the lid and the other end immersed in water allowing carbon dioxide to escape while preventing oxygen from entering the vessel
- Store for 10–14 days and decant, fill pre-sterilized bottles and cork
- Store the wine yeast aside for possible re-use
- Peel thoroughly washed and clean fruits, separating the pulp from seeds
- Mix 4 cup of maize flour with 4 cups of the indigenous fruit pulp.
- Add salt and sugar according to taste.
- Beat the mixture to consistency
- Fry small portions in cooking oil
- Serve the flitters

Figure 2. Making recipes of juices, jams and wines and flitters using indigenous fruits.

pH values lower than 5 were obtained (Table 2). Mixing the juices with guavas or mangoes decreased pH further. The *Strychnos*-mango juice gave the lowest pH, consistent with high acidity of the *Strychnos* (Saka 1994). The high acidity (2.83 ± 0.53%) of *S. cocculoides* accounts for astringency and low pH (Saka et al. 1992).

The viscosities of IFs are significantly lower than those of exotic fruits ($P < 0.05$). The low viscosities (10 cP) are due to very low total dissolved solids. Increasing the edible pulp beyond 40% w/v had resulted in a more viscous product, which was difficult to filter. The similarity ($P > 0.05$) of refractive indices of IF juices to those of exotic fruit products would also be affected. The edible pulp of *P. curatellifolia* contained higher iron, copper, calcium and magnesium levels than *U. kirkiana*. This is consistent with previous results, which indicated that the former is a better potential source of trace and major elements (Saka 1994). *Parinari curatellifolia* juices have the potential to contribute 5.5–7.5% of iron, 3.5–7.0% of zinc and 30–45% of copper to the recommended dietary allowances (RDAs), respectively. These levels reflect about 10–30% of the initial values for fresh fruits. The iron, copper and zinc levels of the juices are higher than those obtained from fresh *S. birrea* (Thiong'o et al. 2000). Further chemical analysis of the nutritional value of the fresh fruits and edible kernels is necessary to complete the gaps in knowledge.

Making juices using a mixture of guava and *Uapaca* increases iron levels, while the *Strychnos*-mango contains high zinc levels. Copper levels are highest in the *Strychnos*-mango juice. Thus, the consumption of indigenous fruits and when mixed with tropical fruits (e.g. mangoes and guava) would contribute the recommended daily amounts of these trace elements. Guava and mangoes are rich sources of these elements (Williamson 1975).

Wines from indigenous fruits

IFs are available at different times of the year (Maghembe et al. 1998; Schomburg et al. 2002). Proper storage and post-harvest handling are generally lacking in Africa due to the absence of storage or fruit processing facilities. To address this constraint, wine has been made from various fruits including palms, sour cheery, *Rosa rosburgii* and cashewnut. In southern Africa, wine has been made with the fruits of *U. kirkiana, S. birrea, Z. mauritiana,* and *P. curatellifolia* and the wines from these fruit tree species were of good and acceptable quality (Ngwira 1996). Ngwira (1996) reported that *Syzygium owariense* fermented and cleared faster (3.5 months) than *Mangifera indica*, which took 5 months. The alcohol contents of wines prepared from the fruits of *S. owariense, Psidum guajava, Tamarindus indica* and *M. indica* were usually in the ranges of 12–16, 12–18, 12–14 and 12–16%, respectively. In contrast, the alcoholic content of wines from *Z. mauritiana* and *P. curatellifolia* reported from Zambia was much lower at 7.4 to 8.3% (Mkonda 2002). This is due to the non-use of wine yeast, yeast nutrient and pectin, which are not readily available. While efforts in Zambia and Tanzania are continuing, the Mulunguzi winery in Malawi unfortunately stopped production. It is, therefore, important to ensure that the quality of wine is comparable to those in the markets (Dietz 1999) and that consumer preference studies should be included to ensure acceptability. These initiatives also constitute an important strategy to utilise excess fruits, improve palatability and provide an opportunity for increased income generation for rural households (Dietz 1999; Schomburg et al. 2002).

Training of farmers in processing

Capacity building is critical at all levels for the successful domestication and commercialisation of

Table 3. Numbers of first- and second-generation farmers trained in processing of indigenous fruits in Tanzania, Zambia and Malawi.

Country	First generation	Second generation	
	Farmers (numbers)	Groups (numbers)	Farmers (numbers)
Tanzania	198	43	2045
Malawi	120	150	1875
Zambia	115	5	77
Total	433	198	3997

Table 2. Mineral content of some indigenous fruit juices (at 10% w/v sugar).

Fruit juice	pH (26°C)	Ca	Mg	Zn	Fe	Cu
		(μg ml^{-1})				
Masuku, Zomba	4.5 ± 0.01	36.6 ± 0.4	53.4 ± 0.2	4.8 ± 0.2	1.4 ± 0.3	1.2 ± 0.2
Masuku, Phalombe	4.7 ± 0.01	60.5 ± 2.3	52.3 ± 3.8	2.5 ± 0.3	0.6 ± 0.12	1.3 ± 0.2
Parinari curatellifolia	5.0 ± 0.05	91.7 ± 6.2	75.1 ± 3.6	3.5 ± 0.2	4.5 ± 0.3	1.8 ± 0.2
Nkhata Bay						
Uapaca, mix (cloth filtered)	3.9 ± 0.01	8.2 ± 0.8	54.1 ± 3.0	2.8 ± 0.02	40.1 ± 1.2	2.0 ± 0.1
Uapaca–guava (cloth filtered	3.8 ± 0.01	3.4 ± 0.2	38.3 ± 0.1	4.9 ± 0.13	87.1 ± 4.4	4.0 ± 0.1
Uapaca–guava (sieve filtered	3.9 ± 0.01	6.0 ± 0.2	41.3 ± 1.9	8.2 ± 0.23	117.2 ± 4.2	6.7 ± 0.2
Strychnos–mango (sieve filtered)	3.4 ± 0.01	4.8 ± 0.2	48.4 ± 3.1	34.0 ± 1.9	49.5 ± 2.2	79.4 ± 4.5
Guava (sieve filtered)	3.7 ± 0.01	5.2 ± 0.4	29.4 ± 2.5	39.7 ± 1.2	61.8 ± 2.6	2.9 ± 0.01
Recommended daily amounts (RDA) (children 10 to 12 years) / 100 g^{-1}		400–1200	40–170	5–10	6–110	0.4–0.6

Values following ± are standard deviations, n= 4

trees of single provenance from Kasungu *S. cocculoides* provenance were not significantly different ($P > 0.05$) except in sweetness and taste. The difference in these two attributes may be due to variation in sugar levels (Ennis et al. 1979).

Consumer evaluation of fruit jams made with the fruits of *S. cocculoides* and *U. kirkiana* indicated significant differences between them (Saka et al. 2001). Consumers preferred the *Strychnos* jam over *Uapaca* jam in all attributes such as appearance, taste flavour, mouth feel texture, and sweetness. Differences in quality attributes and ease of spreading on bread accounted for variations in consumer preferences for the fruit products (Ennis et al. 1979). The lower acceptance of the *Uapaca* jam was largely due to the bad taste probably resulting from the inclusion of an inner peel. Further study was planned to modify the jam preparation to enhance acceptability and commercial value. When left at room temperature or under refrigeration, the *Strychnos* jam remains unspoiled for over 3 months while the *Uapaca* preparation exhibits fungal growth within a week at room temperature and after four weeks under refrigeration. The longer shelf life of the *Strychnos* jam was attributed to its higher acidity (Saka et al. 1992).

Filtering *U. kirkiana* juice through cotton cloth increased consumer acceptability compared to filtering through sieve (Saka et al. 2002). Preference for the cloth-filtered fruit juices was because of clear appearance. Mixing *Uapaca* fruit with guava pulp lowered the ranking due to reduction in the indigenous fruit flavour and taste.

In the Lower Shire of Malawi, the dominant fruit, *Z. mauritiana*, is sun-dried for 3 months and stored for future use (Saka 1994). The dried product is brewed to produce a spirit known as 'Kachasu'. Zizyphus seed kernels are roasted, pounded and added to cooking vegetables. The seed kernels of *Trichilia emetica* are pounded and the powder mixed with milk and warmed and served as a baby food (Williamson 1975). In Zaire, attempts were made to produce fruit juices from edible portions of *Aframomum stipulantum* and *S. cocculoides* (Mbiyangandu 1985). The fruits of *S. birrea* make high value liquor, 'Amarula' in South Africa and it is marketed worldwide (Kwesiga et al. 2000).

Effect of processing on physicochemical characteristics of fruit products

The fresh fruits and juices of *S. cocculoides* are acidic;

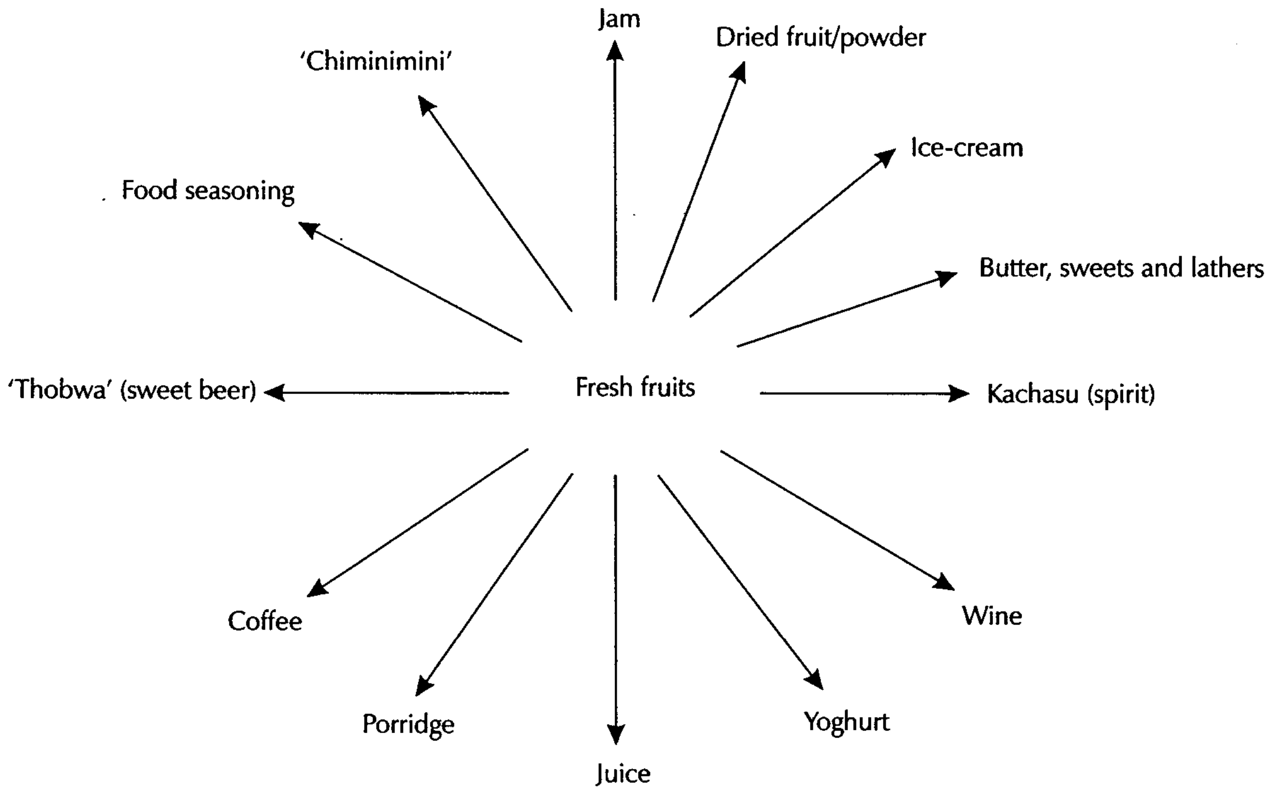

Figure 1. A summary of some products from indigenous and exotic fruits in Southern Africa.

for harvesting, handling, storage, and processing practices of fruits results in the loss of micronutrients (Kordylas 1990). IF producers/collectors encounter post-harvest problems such as rapid deterioration of ripe fresh fruits, which particularly is the case with *U. kirkiana* and *Z. mauritiana* (Kadzere et al. 2002; Schomburg et al. 2002). Fruits of *Z. mauritiana* are also susceptible to compression and pest damage. Fruit marketers, consumers and vendors also experience similar problems to those of producers. The major causes of losses include mechanical damage (cracking, compression, bruising and others) during harvesting and transportation, insect and pest damage, and over-ripening. Mechanical damage accounts for the highest loss in *U. kirkiana* whilst insect pests and rots in *Z. mauritiana* and *P. curatellifloia* (Schomburg et al. 2002; Kadzere et al. 2002). To overcome these problems, producers/collectors, marketers, consumers and vendors should be trained in proper harvesting and post-harvest techniques.

Product development and farmer participation

The case for domestication of IFs is largely determined by the usefulness of the trees to the community for food or cash. The choice of products or fruit trees is therefore dictated by the consumer acceptability and potential impact on the nutritional security and income generation (Kwesiga et al. 2000). The importance of farmer preference of fruit products to achieve greater impact is well known (Maghembe et al. 1998; Munoz 2000). Consumer evaluation and ranking of processed products has been studied to a limited extent in the region.

The organoleptic testing of eight juices sweetened with different sugar levels has been undertaken in Malawi (Saka et al. 2001). Although a sixteen-member panel largely preferred juices with 10% w/v sugar content, differences in individual consumer scores are not significantly different ($P > 0.05$). Taste and sweetness appear to be significantly different; the latter is a component of taste. This is not surprising because of the different sugar levels added to the juices. A comparison of juices made with Zomba (Malosa) and Dedza provenances of *U. kirkiana* indicates that the juice of Dedza provenance is more preferred than that of Zomba in terms of mouth feel. Otherwise, the two provenances were not significantly different ($P > 0.05$). Similarly, appearance, flavour, mouth feel and texture of juices obtained from two

Table 1. Fruit utilization, processing and average ranking of fruit products in Malawi.

Fruit product	Importance of fruit products		Fruit used
	Food security	Income generation	
'Chiminimini'	√	√	Bananas
Sweet beer ('thobwa')	√		*Zizyphus mauritiana*
			Parinari curatellifolia
			Anonna senegalensis
Alcoholic beverage ('kachasu')		√	*Uapaca kirkiana*
			P. curatellifolia
			Strychnos cocculoides
			Z. mauritiana
			Strychnos spinosa
Fresh	√		*U. kirkiana*
			P. curatellifolia
			Sclerocarya birrea
			S. cocculoides
			Z. mauritiana
Juice	√		*P. curatellifolia*
			Adansonia digitata
			Tamarndus indica
			U. kirkiana
Yoghurt	√	√	*A. digitata*
Powder	√		*P. curatellifolia*
			U. kirkiana
Jam	√	√	*S. cocculoides*
			Ficus indica
			P. curatellifolia
			Paw paws, oranges
Porridge	√		*U. kirkiana*
			P. curatellifolia
Dried	√		*U. kirkiana*
			Z. muaritiana
			P. curatellifolia
Oil	√		*P. curatellifolia*
Nut extraction	√		*P. curatellifolia*

while the former is also an important part of household food security.

Local processing and commercial production of IF-based products in southern Africa is limited because of lack of sustainable supply of IFs, inadequate information on technologies, market potential of the products and potential benefits to farmers (Ennis et al. 1979; Saka1994; Dietz 1999). More recently, the Wild Life Society of Malawi at Kamwamba, Mwanza district, started producing fresh juices from *A. digitata* and *T. indica* (Wildlife Society of Malawi, pers. comm.).

Post-harvest handling of IFs

Fresh fruits are perishable and incur loss of quality and nutrients from the time of their harvest until they reach the consumer. Post-harvest losses in fresh fruits are estimated to be 5 to 25% in developed countries and 20 to 50% in developing countries (Kordylas 1990). This is due to lack of knowledge in handling and marketing of fruits, poor flavour/taste, astringency, and pests and diseases. Direct and indirect losses in fruits mean reduction in the quantity and quality of food available for family consumption and sale. Limited knowledge on the appropriate stage

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