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Harvesting and Processing of *Balanites aegyptiaca* Leaves and Fruits for Local Consumption by Rural Communities in Uganda

[1]Clement Akais Okia, [1]Jacob Godfrey Agea, [2]James Munga Kimondo,
[3]Refaat Atalla Ahmed Abohassan, [4]Joseph Obua and [5]Zewge Teklehaimanot
[1]Collage of Agriculture and Environmental Sciences,
Makerere University, P.O. Box 7062, Kampala, Uganda
[2]Kenya Forestry Research Institute, P.O. Box 20412-00200, Nairobi, Kenya
[3]Faculty of Meteorology, Environment and Arid Land Agriculture,
King Abdulaziz University, P.O. Box 80208, Jeddah 21589, Saudi Arabia
[4]The Inter-University Council for East Africa, P.O. Box 7110 Kampala, Uganda
[5]School of Environment, Natural Resources and Geography,
Bangor University, Bangor, Gywnedd, Ll57 2UW, UK

Abstract: *Balanites aegyptiaca* (L.) Del. commonly known as desert date is an important multipurpose tree found in most African countries. Like in many parts of dryland Africa, Balanites leaves and fruits provide livelihood support to many rural households in the drylands of Uganda where other options are limited. The young succulent leaves are a dependable dry season vegetable while the seed kernel obtained after cracking the nut is a valuable oil source. Local methods for harvesting and processing of Balanites products were examined as a step towards promoting their wide use and development of improved processing methods. Harvesting and preparation of Balanites leaves in Katakwi district and fruits/nuts collection and oil extraction in Adjumani district, Uganda were documented. The results revealed that Balanites leaf harvesting involves cutting the young branches and twigs and plucking leaves under the tree. Leaves are boiled within 24 h after collection to avoid loss of taste and to shorten boiling time. Boiled leaves have a shelf life of 2 days only. On the other hand, Balanites oil production starts from the fruits or nuts mainly collected from beneath the parent trees. Oil processing entails cracking the nuts to extract seed kernels followed by pounding and roasting of kernels and oil extraction by hot water floatation method. Cracking the hard nuts to obtain seed kernels is a major challenge in oil extraction process. Oil produced is too little to meet the demand. Processing of Balanites oil is a promising option for improving rural livelihoods in the dryland areas of Uganda where Balanites trees grow naturally and are abundant. However, appropriate tools for cracking the hard Balanites nuts are required to increase oil production. Ways of increasing the shelf life of processed Balanites leaves should also be explored.

Key words: Balanites, desert date, livelihoods, nuts, oil, vegetable, Uganda

INTRODUCTION

Perennial tree crops play a fundamental role in the economies of many developing countries in the tropics where few alternative agricultural enterprises exist (Omont and Nicolas, 2006). Indigenous food plants can be a major factor in rural poverty alleviation because of their ever increasing local and international demand. According to Schreckenberg *et al*. (2006) a wide range of indigenous fruits can enable farmers to meet their varied household needs including food, medicines and income. Indigenous fruits and vegetables are often part of the traditional diet and culture and there is an accumulated time-tested local knowledge regarding their harvesting and processing. Collection, processing and marketing of these indigenous food plants can represent a significant portion of total household income particularly where farming is marginal (Scoones *et al*., 1992).

However, one of the bottlenecks in widespread use and management of indigenous food plants is the lack of access to information throughout the production to consumption pathways. For instance, there has been an increasing yearn for information on value chain of most indigenous fruits by farmers, small-scale entrepreneurs,

Corresponding Author: Clement Akais Okia, Collage of Agriculture and Environmental Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda

businesses and research institutions (Hughes and Haq, 2003). This is evidently reflected in the frequent participatory research and debates on indigenous fruit tree resources in Africa and elsewhere (Haq and Atkinson, 1999; Chikamai *et al*., 2004, 2005). Albeit, the information gaps, wild food plants provide a safety net against hunger and boost rural employment and income (Mithofer and Waibel, 2003) through processing and value addition (Saka *et al*., 2004). According to Singh and Roy (1984) one of the fundamental ways of alleviating poverty among the rural population is to add value to local edible wild plants by processing them into commercial products. In addition, the constraints and opportunities to harvesting and processing these food plants need to be analysed in order to increase their wide scale use and management.

Harvesting and processing of indigenous tree products can enhance farmers incomes however, appropriate processing technologies for various products need to be developed. An understanding and support to local initiatives should form the basis of such efforts. In this respect, local knowledge on harvesting and processing of Balanites products needs to be harnessed and enhanced by small and medium-scale entrepreneurs before local people can adopt them. The aim of this study was to document the local methods of harvesting and processing Balanites products as a step towards promoting their wide use and development of appropriate processing methods. Two questions guided the study: how are Balanites leaves harvested and processed and how is oil extracted from Balanites nuts?

MATERIALS AND METHODS

Data were collected in Adjumani and Katakwi districts of Uganda. In each district, two villages (Nyeu and Egge in Adjumani and Apuuton and Acoite in Katakwi) were selected. The selection was based on prominence of *B. aegyptiaca* trees and reported processing and use of its products among households. Balanites leaves are mainly processed and eaten in Katakwi and other districts in Teso sub region while seed kernels are used for oil extraction in Adjumani and other neighbouring districts in the west Nile sub region. Katakwi district is located in north-eastern Uganda (33°48'-30°14'E and 1°38'-2°20'N) and it is dominated by the Iteso ethnic group. On the otherhand, Adjumani district is located in north-western Uganda (31°24'-32°4'E and 2°53'-3°37'N) and it is mostly occupied by the Madi people (Rwabwoogo, 1998).

Focus Group Discussions (FGDs) involving men, women and youth were conducted in the four villages. Key informants such as village leaders and community members with specialised knowledge on Balanites products collection and processing were interviewed. FGDs based on interview guide collected information on harvesting and processing of Balanites products. Information from various age groups and gender categories were synthesized to reveal methods of harvesting and processing of Balanites products. Information collected from key informants was used to triangulate data collected using FGDs. Fifteen focus groups each comprising 8-12 participants and 25 key informants were interviewed.

RESULTS

Balanites leaf harvesting, processing and storage: Balanites leaves were harvested for consumption as a vegetable in Katakwi district during the dry season (November-March). Women and children especially girls harvested the leaves using simple hand tools such as winnower, basket, basin or sack, machetes and sometimes an axe. Leaves from tall trees were collected with the help of an improvised ladder. Harvesters moved in groups of at least three people for security reasons, especially when collecting leaves from distant areas. Branches and twigs of trees with desirable leaves were cut and the leaves plucked under the tree or in a shade. Leaves and flowers from thorny branches and twigs were plucked with care to avoid injury. The branches and twigs were taken home or collected later for use as firewood.

Leaves were cooked without washing as they were presumed to be clean. The leaves were submerged in water and boiled preferably in clay pots for 2-3 h and within 24 h after collection. Clay pots were preferred to metallic saucepans because they retained heat for a long time thus reducing boiling time and amount of firewood used. Leaves that were stored without boiling for more than 1 day after collection hardened and became bitter. The leaves were turned at intervals to ensure uniform boiling and samples chewed to determine if they were properly cooked. Water was decanted at the end of boiling and the leaves left to cool before finally squeezing remaining water by hands. This process reduced the bitter taste in the leaves. The leaves were kept cool and moist by sprinkling some water before the final processing or transporting to the market.

The boiled leaves were pounded using a mortar and pestle or ground using a grinding stone before cooking. Pounded leaves were mixed with cold water (2:1 ratio) before groundnut paste or sour milk was added and again boiled on low fire for 5-10 min while being stirred. Little salt was added although the leaves still tasted good without salt. Older people preferred to eat the cooked

leaves without salt. In some cases, honey, milk, tamarind or mango fruit extract and sugar was added to the sauce and eaten with millet bread, sweet potatoes, maize meal and cassava. Boiled leaves were stored for one to two days after which they ferment and develop a bad smell and taste.

Balanites fruit and nut collection: Balanites fruits ripened during the dry season (December-February). They were collected after falling beneath the mother tree or when the branches are shaken. Hooked sticks were used to shake branches and twigs to dislodge ripe fruits. Fruits were mainly collected by women and children and carried in saucepans, basins, baskets and bags. Nuts for oil production were also collected from under parent trees, public places where fruits had been eaten and in animal resting places. Goats and sheep spat the nuts after stripping the epicarp and mesocarp while cows regurgitated them. As a result, animal resting places were convenient nut collection points.

Fruits were first sorted by removing small sized, immature and diseased ones. Fresh Balanites fruits exhibited a shelf life of 5 days under ordinary house conditions or up to 10 days under fairly cool conditions improvised by dampening the storage sack. However, during this study both whole and shelled fruits were stored in a laboratory under refrigeration for up to 3 months without any noticeable deterioration in taste and colour. Communities in Adjumani district reported that shelled fruits were dried and stored for 2-4 months under ordinary conditions. Such fruits were however, soaked for 5-10 min to soften the pulp before eating.

The fruits were occasionally de-pulped while others were dried with the pulp. De-pulped nuts were reportedly easier to crack than those dried with the pulp. When nuts are collected they are further dried to make cracking easier and to store for a long period. Dried nuts were stored for 3-4 months under ordinary conditions or up to 12 months in air-tight containers. Mixing with ash increased storability of nuts to over 6 months. In the event that any of the Balanites nuts was found with a hole (sign of borer damage), they were separated from the good batches because it was assumed that the kernel had already been damaged by insects.

Balanites oil processing: During the course of the study, we met six groups of women that were actively involved in Balanites oil processing in Adjumani district and they produced oil for both home consumption and sale. They generally used one method for oil processing through seven steps (Fig. 1).

The first step involved sun drying the nuts on bare ground for about 3-7 days. Nuts collected from animal resting places took 3-5 days while those obtained by manual de-pulping took 4-7 days to dry. Well dried nuts were easy to crack. Dried nuts were sorted by removing damaged or inferior nuts which were believed to lower the quality of oil.

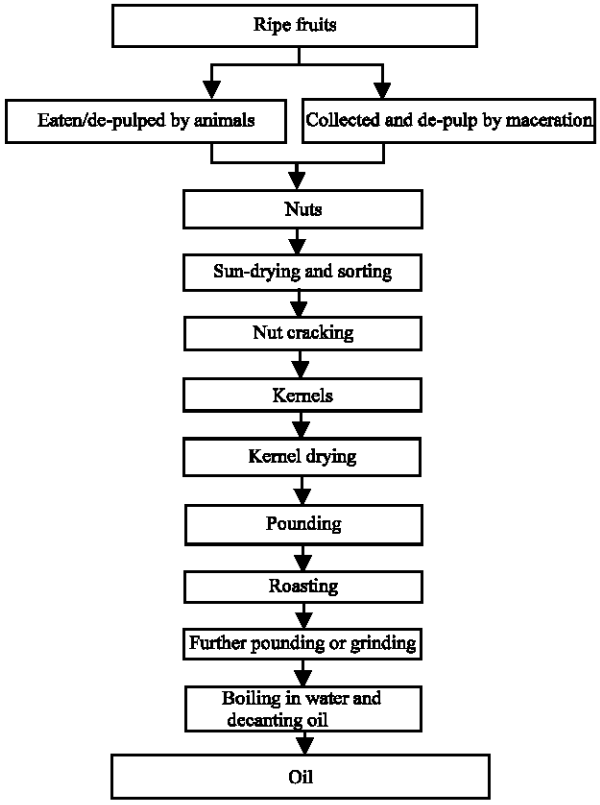

Fig. 1: Flow diagram for local processing of Balanites kernel oil

The second step involved cracking nuts to obtain seed kernels. Nuts were cracked by hitting with two stones, a bigger stone was placed below and a smaller one used as a hammer. A nut was first hit horizontally to create cracks along its lines of weakness separating the five flagella then vertically with the smaller pointed end up to split-open. The hard shell (endocarp) also referred to as stone due to its extreme hardness was removed and the kernel extracted. If opening proved difficult, a knife was used.

Nut cracking was said to be a delicate process and was performed with extra caution. Use of excessive force could shatter the kernel leading to low recovery. The first hitting (horizontal) is supposed to be light to avoid breaking the kernel while the second (vertical) is heavier but made directly at the pointed tip. This way, two leading lines of rupture would run along the flagella thus facilitating opening of the nut and consequently removal

of the kernel. As a result, women and children dominated the process because of their tender care. The thin layer covering the kernel (testa) was not removed. Experienced women extracted 2-3 kg of kernel per day.

The third step involved drying kernels. Unlike the nuts that were dried on bare ground, extracted kernels were dried on a clean material such as winnower, polyethylene sheet, cow dung-smeared floor or a mat. Contact with water was avoided as it lowered the quality of oil by reducing its shelf life. Under normal sunny conditions, kernels took 2-3 days to dry. Well-dried kernels were easy to pound or grind. The fourth step in oil processing entailed pounding the kernels into a rough powder using mortar and pestle. Pounding facilitated roasting of the kernels which was the fifth step in the oil processing. Roughly pounded kernels were roasted for 20-40 min until they changed colour from yellow to brown.

Roasting was said to improve oil yield and flavour. It was noted that roasting changed colour of oil from light yellow to brown. The roasted and pounded kernels were spread on a clean material such as a winnower and left to cool for about 5-10 min. The sixth step was grinding or further pounding of kernels. The coarse pounded and roasted kernels from stage five above were ground into powder or paste using a traditional grinding stone or further pounded with mortar and pestle. The resulting paste/powder was very oily. Grinding was most preferred because it was said to produce a fine paste/powder in a shorter time.

The last step was oil extraction. Oil was immediately extracted from the kernel powder in boiling water (hot water floatation) in a saucepan. The oil processors (women) stated that the paste was not stored as this reduced oil yield. The paste was added to boiling water while stirring in a ratio of about 1: 3/4. Once most of the oil settled on top of the water, the saucepan was removed from the fire and the oil decanted into a clean container. The oil extraction process, done in one only round, took about 1-2 h. About 2.5 kg of Balanites kernels produced 1 L of oil representing 40% recovery.

Storage of balanites oil: Extracted oil was stored in glass or plastic bottles, jars, jericans and bowls. Some households however, stored the oil in saucepans, pots and tins. The use of a particular container depended on availability but clear or transparent ones are generally preferred for easy viewing. Oil was stored in cool and dry places in a kitchen or main house. The oil shelf life was reported to be about 4-6 months. Oil deterioration was detected through change in smell and taste.

During the processing stages, quality of the oil was reportedly affected by exposure of kernels to water, delayed processing of kernels into oil after extraction from the nuts, over-roasting (burning) of kernels use of inappropriate ratio of water to paste during boiling, inadequate stirring while mixing kernel paste with boiling water, poor pounding or grinding (failure to change into powder or paste), poor decanting (water droplets remaining in the oil), prolonged boiling and repeated decanting.

On the other hand, the extracted oil quality was said to be affected by dirty containers, uncovered containers resulted in infestation by insects especially small ants, storing the oil near paraffin-gave the oil bad smell, prolonged oil storage (>7 months), storing close to cooking place-led to contamination by smoke (affecting smell and taste) and the presence of water droplets in the storage container.

DISCUSSION

Leaf harvesting, processing and storage: Balanites leaves were only harvested and processed in Katakwi and other districts in Teso sub-region. The high coppicing ability of the Balanites trees facilitated repeated cutting of the young branches. This makes the trees with good or sweet leaves to be easily recognised by community members and thus conserved in the landscape. Leaf harvesting was mostly done by women and children using simple tools such as a machete and axe. This is different from the case of some wild food plants such as the baobab in Ghana where men play an active role in leaf harvesting while women process and market the products (Kranjac-Berisavljevic *et al*., 2009).

Young leaves and flowers of Balanites have also been reported to be harvested and processed in Burkina Faso though gender roles were not mentioned (Guinko and Pagso, 1992). In this study, harvesters improvised ladders to access tall trees with straight boles. Tree climbing was noted to pose a serious problem to harvesters and cases of accidents, though rare were reported. The thorny nature of the Balanites tree and presence of small black ants on stems increases risks associated with Balanites tree climbing. Harvesters, therefore, expressed a need to grow shorter trees to make leaf harvesting easier. Research is needed to explore this possibility.

Whereas one could view Balanites leaf collection as a labour demanding activity, the collectors reasoned that it was beneficial and economically viable considering that it took place during the peak of the dry season with few alternative vegetables and with minimal agricultural activities. This meant that leaf collection took place when most family labour was available thus justifying its use in

leaf collection to provide leaf for home consumption and excess for sale. The women also indicated that leaf collection for sale did not require any capital hence it was viewed to be an attractive option for the poor to earn income during the dry season when alternatives are few.

Children were also involved in Balanites leaf collection as a way of raising money to buy clothing and scholastic materials. It has been noted that since many Non Timber Forest Products (NTFPs) are seasonal, they are important to household subsistence when they appear in the diet. In Benin, Schreckenberg (1996) reported that NTFPs were available during the dry and early rainy season or hunger period when cultivated crops are in short supply. This therefore makes their collection worthwhile.

Women were skilful in leaf preparation and this knowledge has often been passed from mothers to children though boys were always reluctant to learn the process. According to the boys, leaf preparation is the work of women and girls. This may be explained by the traditional set up of the Iteso people where cooking is generally considered to be a woman's role. Squeezing of excess water from leaves after boiling was considered important because leaves and flowers are always collected from several trees. Although, there is selection for sweetness in the field, some of the bitter leaves could still get mixed up with the sweet ones thus squeezing helps to minimize any bitterness which may have resulted from collection of leaves from various trees.

Many previous studies on Balanites have reported about edible leaves with no explanation of how they are collected and/or prepared (Von Maydell, 1990; Cook *et al*., 1998; National Research Council, 2008; Teklehaimanot, 2008). In the present study, local methods of Balanites leaf collection and processing among the Iteso people in north eastern Uganda have been documented. Leaf processing involves two stages pre-boiling which prepares the leaves for marketing as well as shortening the final cooking process and pounding and final short cooking where pasted groundnuts or milk is added.

Cooking leaves without salt was a better option since one can always add some salt when eating. Therefore, only very little amount of salt should be added in the boiling process. Balanites leaves were eaten with variety of local foods making it an integral part of the dry season diet. There was minimal storage of leaves and this limited their use to within 2-3 days after boiling. It also meant that leaves could not be stored for later use during the early rain season when other green vegetables were still rare. Leaf storage that was practised to a limited extent in the past is being abandoned probably due to decreasing quantities of leaves collected, increasing family size, increased market demand and changing social setup.

Whereas Baobab leaves are reported to be processed and stored in powder form for use in dry season in West Africa (Maranz *et al*., 2008), Balanites leaves in Uganda are only partially boiled and used or sold within 2-3 days. In northern Nigeria, Cassius *et al*. (2000) reported that the leaves of aduwa Balanites were sun-dried, pounded into a fine powder and used to thicken soups. Such innovative processing and use of Balanites leaves is lacking in Uganda and yet this could help in extending product shelf life and facilitate access to distant markets. This example could be borrowed so that rural women in Uganda can store Balanites leaves over an extended period thus ensuring food security and earning more income through selling in markets outside the production areas.

Fruit and nut collection: Fruits are mainly collected from under trees after fruit fall. Whereas most collectors consider such fruits to be clean, they are susceptible to insect attack, especially in cases where collection is delayed. This method of commercial collection calls for more work in sorting the fruits since in most cases both fresh and old fallen fruits are all collected. In areas with more livestock, there is competition for fruits between animals and humans. Much as this is not currently a serious problem, it is likely to create a conflict if the collectors were to increase the scale of their activities in the event of market expansion. Cases of these conflicts were witnessed in Nyeu village, Adjumani district where herdsmen did not allow women to collect fruits from Balanites trees close to their kraals.

In the drylands of Uganda, animals (cattle, goats and sheep) are usually left to roam during the dry season since there are no cultivated crops at this time. At night, ripe Balanites fruits fall to the ground and in the morning, women and children often compete with animals for ripe fallen fruits. Women expressed a desire to have control over Balanites and other fruit trees, especially shea (*Vitellaria paradoxa*) and Tamarind (*Tamaridus indica*). They argued that control of such tree resources which contribute to their livelihoods would increase tree products and generate more income.

Unlike Balanites leaves which can only be stored for 2 days, Balanites fruits have shelf life of 5 days under ordinary conditions which can be extended to seven days by dampening the storage conditions. Refrigeration extends shelf life to over 3 months. However, storage of fruits under both ordinary and refrigerated conditions makes peeling difficult. In the latter case, the outer covering becomes more brittle while in the former it becomes hardened and sticks to the pulp. Under these circumstances, it becomes difficult to separate the shell from the pulp, hence affecting the quality of the pulp. Therefore, only short-term storage of 4 and 7 days of unpeeled fruits is advisable under ordinary and refrigerated conditions, respectively. If long-term storage

is required, the fresh fruits should be peeled, sun-dried and kept in air-tight containers or kept under cold conditions.

In cases where fruits are collected mainly for production of kernels used in oil extraction, they are immediately macerated in water. This requires soaking the unpeeled fruits for 10-15 min and rubbing then between hands or with aid of rough surfaces. The resulting nuts are then rinsed with water and sun-dried. This is only done in cases where large quantities of nuts are required within a short time. The common method is to collect nuts from animal resting places or areas where they have been disposed after eating the pulp. In a few instances, fruits burnt by bush fire (nuts un-burnt) beneath the mother trees are also collected and used for kernel extraction. Processing of Balanites fruits in Nigeria involves soaking them in cold water for 3 days or hot water for a day and washing off the pulp to obtain the nut. The nut is sun dried for 2 days if cold water is used and for 8 h if hot water is used to soak the fruit (Mamman *et al*., 2005).

In this study animals (cows, goats and sheep) are heavily relied upon to de-pulp Balanites fruits leaving nuts that are used to obtain kernels. Nut storage is constrained by borers that damage the kernels thus, lowering their storage time to between 2-4 months. However, treatment of nuts with ash and keeping them in airtight containers increases their storage time to about 6 months. Similar storage time has been reported for Balanites nuts elsewhere (Von Maydell, 1990).

Oil processing: Processing of Balanites oil is dominated by elderly women in Adjumani district. The steps in oil processing are more or less similar to those used for local shea oil extraction (Mbaiguinam *et al*., 2007; Omujal, 2008). After nut collection, the steps used in oil processing included: drying and sorting nuts, manual cracking of nuts to obtain seed kernels, sun drying kernels, pounding kernels, roasting kernels, grinding or further pounding of kernels and oil extraction in boiling water.

However, some of the exceptions in Balanites oil processing are: unlike the shea nuts that can be cracked by light beating with a stick or even pressing between thumb and fingers, Balanites nuts are reported to be much harder thus requiring use of two stones after sun-drying, Balanites kernels are immediately pounded unlike shea kernels that can be stored or even marketed in this state (Omujal, 2008). Storage of Balanites kernels for >5 days was reported to cause rancidity and decrease in oil yield.

Lack of appropriate equipment for cracking Balanites nuts to obtain the oil-rich kernels has been widely documented as a major limitation to their use and popularity (FAO, 1992; Mamman *et al*., 2005; Aviara *et al*., 2005; National Research Council, 2008), In Nigeria, the manual method used for Balanites nut cracking is similar to that used in Uganda. It involves cracking nuts with stone on top of another stone or metal and it is very slow and risky (Mamman *et al*., 2005). Likewise, the process used in local extraction of Balanites oil in Nigeria appears to be similar to that used in Uganda (Mamman *et al*., 2005). The kernel meal is heated in a pan or pot containing some water over an open fire. While the manual crackers in Uganda regard the operation as delicate because it requires extra care to avoid damaging the kernel Mamman *et al.* (2005) reported damage of kernels if cracking force used in the prototype machine was too high.

In an attempt to develop an appropriate machine for cracking Balanites nuts, Mamman *et al.* (2005) investigated the effect of moisture content and loading position on the mechanical properties of Balanites nuts. They reported a decrease in the mechanical properties of the nuts with increase in moisture content. This was attributed to the fact that Balanites nut is spongy and being a biological material, it becomes weaker and easier to fail as its moisture content increases. This suggests that, to save energy, the nuts should be cracked at high moisture content. However, nut cracking at high moisture content crushed 40% of the kernels into small pieces. Since product quality is very important, the nuts should be cracked axially at low moisture content so that intact kernels can be obtained.

Despite this study, no machine has so far been successfully designed for improved cracking of Balanites nuts. National Research Council (2008) noted that a design of such a machine still awaits discovery for the benefit of dryland communities who depend on Balanites oil processing. The techniques used in local processing of Balanites oil in Uganda are consistent with the principles of oil extraction reported by FAO (1992), involving: decortication or dehulling to separate the oil bearing part; breaking of the oil bearing part (kernel) into smaller pieces by pounding in a pestle and mortar or by manual or motorized grinding; heating the oil bearing material, sometimes with addition little water to assist in the rupture of oil bearing cells and in the liberation of oil and oil extraction.

Hot water floatation is the simplest method used in oil extraction stage and is used in many rural areas (FAO, 1992). In this study, oil processors placed ground Balanites kernels in boiling water and the contents were boiled while being stirred until the oil floats and settles on top. On removing from the fire and cooling, the floating oil was skimmed off. However, the final stage of heating the

oil in a shallow pan to drive off the last traces of water was not performed by Balanites oil processors in Uganda. This is reported to improve the quality of the oil as water has a catalytic role in the development of rancidity in oils (FAO, 1992).

Balanites processing communities in Uganda should therefore be made aware of the need to add this last step so as to improve the shelf life of locally processed oil. Despite the generally low extraction efficiency of the hot water floatation method due to the formation of oil-water emulsions which makes the final separation difficult (FAO, 1992), experienced Balanites oil processors in Adjumani reported 40% recovery. For the case of shea butter in Uganda, this traditional method has been improved with use of a manual oil press. If Balanites nut cracking is improved, it is possible that the shea oil press can be used or adapted for its oil processing.

CONCLUSION

Balanites leaves are a traditional dry season vegetable among the Iteso people in north eastern Uganda. Leaf collection involves cutting the young branches and twigs and plucking the young succulent leaves under a tree. Leaves must be boiled within 24 h after collection. The boiled leaves have a short shelf life of only 2 days and this limits their storage and marketing.

RECOMMENDATIONS

There is a need to explore ways of increasing the shelf life of leaves for instance by drying and storing in pounded form. Though rural communities in Uganda are currently not used to dry and powdered Balanites leaves, it is possible to change attitudes over time through awareness campaigns. Communities in Adjumani district have specialised knowledge and skills on Balanites oil processing.

The key stages in Balanites oil processing include nut cracking to extract seed kernels, pounding and roasting kernels and oil extraction by hot water floatation. The most difficult task in Balanites oil processing is the cracking of nuts to obtain the seed kernels thus very little oil is currently produced despite its high demand. Oil processing has been left to elderly women as other family members regard it as having lower returns to labour.

There is therefore, a need to develop appropriate tools for cracking the hard nuts to increase oil production. Furthermore, there is need to evaluate the oil quality produced using both local and improved methods. Generally, a breakthrough in nut cracking could unlock the potential of the Balanites in improving rural livelihoods in the drylands of Uganda and other similar areas where these trees are abundant.

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