A survey of the traditional processing techniques of *masau* was conducted using a questionnaire and two focus group discussions in Mudzi, Mt. Darwin, and Muzarabani districts in Zimbabwe. *Masau* fruits form part of the family diet and generate additional income by selling at local markets. Surplus fruits are sun dried and can be transformed into various products such as porridge, traditional cakes, *mahewu*, and also fermented to produce a spirit called *Kachasu*. The ethanol content of the fermented fruit pulp ranged from 2.1 – 3.7 mL $100mL^{-1}$, whereas the traditionally made distillate contained 23.8 – 45.6 mL 100 $mL^{-1}$.

**KEYWORDS** *masau* fruits, traditional processing, fermentation, organic acid

## INTRODUCTION

The *masau* (*Ziziphus mauritiana*) tree occurs in arid and semi-arid regions in the world. Its fruit is one of the most commonly utilized wild fruits in Zimbabwe. A significant rural population in arid regions derive various products such as wood fuel (firewood), fodder, fertilizer (organic manure, forest litter), building material, and herbs from *masau* trees (Morton, 1987). In some places, the *masau* tree is grown as a hedge with its spines creating effective live fencing. Its highly nutritious fruits provide a valuable source of energy, vitamins and also income (Bakhshi and Singh, 1974; Saka and Msonthi, 1994). Extracts from the fruits, seeds, leaves, roots and bark of the *masau* tree are used as traditional medicines to treat the effects of insomnia, skin diseases, inflammatory conditions and fever. For these reasons, the *masau* tree plays an important role in the integrated economy of arid regions (Morton, 1987).

In Zimbabwe, the fruit undergoes spontaneous fermentation and is then distilled into a potent spirit called *Kachasu* (Tredgold, 1986; Gadaga et al., 1999). The optimisation and control of the processing of indigenous fruit products such as traditionally fermented foods has the potential for multiple benefits, including the improvement of socio-economic status for rural communities through employment creation, augmenting family income and providing a non-seasonal supply of safe and quality beverages. In addition environmental rehabilitation, domestication of the fruit trees as well as retaining an important food source (Cavendish, 2000) are reasons to develop the utilisation of wild fruits. The rural people in Rushinga district in Zimbabwe collect *masau* fruits and grade them for a non-governmental organisation called Tulimara Speciality Foods for Africa. NGO's such as the Southern Alliance for Indigenous

Resources (SAFIRE) ensure that fair prices are paid to the communities and that the highest quality fruit is used for processing.

The objective of this study was to document the traditional processing techniques of *masau* fruits in Zimbabwe, and to study the properties of the fruit, the fermented pulp and its distillate.

## MATERIALS AND METHODS

### Survey of the Traditional Processing of *Masau* Fruits

A survey to document the handling and processing of *masau* fruits and products thereof was conducted in Muzarabani (16° 20′ S, 31° 21′ E), Mudzi (17° 17′ S, 32° 35′ E), and Mt. Darwin (16° 27′ N, 31° 53′ E) districts of Mashonaland Central Province, Zimbabwe. A semi-structured questionnaire was administered to 30 randomly selected households in Muzarabani, 10 in Mudzi, and 10 in Mt. Darwin. Focus group discussions were also performed with women who sold *masau* fruits in Harare (two groups of 10 and 8, respectively).

### Sample Collection and Preparation

During the survey, 2 kg samples of fresh ripe and dried *masau* fruit were harvested from villages in Muzarabani district. Fermented *masau* pulp and the distilled product (200ml samples) were collected from seven households that had been identified as brewers of *Kachasu* in the same area. Police clearance was sought since *kachasu* is an illicit beverage.

Fermented pulp and distilled product were collected in 250 ml sterile bottles (Schott Duran, Elmsford, NY) from brewers in Muzarabani communal area. Samples were transported in a cooler box and kept at 5°C on arrival at the laboratory, and analysed the following day.

Samples of fermented fruit pulp were centrifuged at 1207 x g (MSE Super Minor Centrifuge, Sussex, England). The supernatant was collected and then frozen at –18°C until further analysis. The distillate was also kept at –18°C until further analysis.

Composite samples of each set of fresh and dried fruit *masau* samples were prepared. The seed was extracted from the fruit pulp and skin by cutting open the fruit using a knife. The fruit pulp and skin (100 g) were homogenised using a blender (Waring® Commercial blender, Torrington, Connecticut, USA). A juice was made by mixing 100 g of the

homogenate with 100 ml of distilled water. The juice was then centrifuged at 1207 x g and the supernatant was stored at –18°C until further analysis.

### Determination of pH

pH of the fermented fruit pulp and fruit juice was performed using a Metrohm model 744 (Metrohm Ltd, Herisau, Switzerland) pH meter, with a combination glass electrode and calibrated using commercial buffers (Merck, Darmstadt, Germany) at pH 4 and 7.

### Titratable Acidity

A portion of the fruit juice (10 ml) was titrated against 0.1 M NaOH (Soyer et al., 2003). The results were expressed as g of citric acid $100g^{-1}$ of fruit juice dry matter.

### Determination of Sugar, Ethanol, and Organic Acids

Fermented pulp, fruit juice, and the distillate were analyzed by high performance liquid chromatography (HPLC), fitted with Refractive Index and UV/VIS detectors (Spectra System Thermo separation products, Reviera, Florida, USA). The separation was done on an Aminex HPX-87H ion exclusion column ($300 \times 7.8$ $mm^2$) at an oven temperature of 40°C and a flow rate of 0.6 ml $min^{-1}$. Juice and fermented fruit pulp were filtered through a 0.45 μm Millipore filter (Schleicher & Schuell GmbH, Dassel, Germany). Standards for the organic acids (tartaric, malic, citric, succinic and oxalic) were obtained from ALDRICH Co. (Sigma-Aldrich Chemie, Steinheim, Germany) and sugars (sucrose, fructose and glucose) were obtained from Merck (Damstardt, Germany). The standard solutions were prepared individually by dissolving in double distilled water. The mobile phase was 5 mM degassed $H_2SO_4$.

### Statistical Analysis

The analytical data were analyzed using the statistical program SPSS 13.0 for Windows (Apache Software Foundation, USA) and the one-way ANOVA model was used applying the LSD test to evaluate significant difference among means.

## RESULTS AND DISCUSSION

### Survey of the Traditional Processing of *Masau* Fruits

*Masau* fruits ripen from mid June and are available until the end of September in the districts covered. The fruit is first green (Figure 1), turning yellow to brown as it ripens, and it is generally considered to have a sweet-sour taste. Two varieties, sweet and sour, of the *masau* fruit are distinguished by the communities. Fruit sizes range from 1–2.5 cm in diameter and are influenced by location of the tree. The trees that grow in river banks have relatively larger fruits with a small stone, compared to those that grow in drier areas. Most respondents (96%, n = 50) consume fresh *masau* fruits everyday during the season. Women and children usually gather the fruits in the morning, and most families (92%) spend at most two hours per day in gathering *masau*. About 2–4 buckets of 20-liter capacity (approximately 30–60 kg in total) of *masau* fruits are collected per day per family depending on the number of persons gathering the fruit. Occasionally the *masau* fruit trees are located at homesteads and in fields belonging to particular families. The harvested fruits are consumed fresh by the locals, and also sold at rural and urban markets. Most respondents (80%) gather *masau* fruits for sale to retailers in urban markets. The prices of *masau* fruits range from approximately € (Euro) 1–3 per 15 kg depending on the market. The fruits can also be exchanged for

**Figure 1.** The *masau* (*Ziziphus mauritiana*) fruit tree found in Zimbabwe, showing ripe (yellow/ orange) and unripe fruits (green).

soap, salt, sugar, clothes, kitchenware and tea leaves. Saka and Msonthi (1994) reported that indigenous fruits play a role in people's diet and contribute to the economy of the rural communities in Malawi, and we observe a similar situation in Zimbabwe.

In the study districts, surplus fruits are sun dried and processed later into various products such as porridge, traditional cake, *mahewu* and instant powder drink. The porridge for children and adults is made by mixing water and *masau* powder followed by boiling while stirring. The traditional cake (Figure 2) is made from *masau* powder by mixing it with a small quantity of water to enable it to be moulded into desired shapes, ready to be consumed as a snack. For *mahewu*, the dried *masau* fruits together with the seeds are pounded using pestle and mortar, and mixed with water to make slurry. This is left in the sun for a few hours and then consumed as a beverage. In Western Sudan (Egceling, 1951), cakes resembling gingerbread are made from a mixture of dried and fermented pulp. In India, the ripe fruits are mostly consumed raw, but sometimes candied fruits are made after pickling in a salt solution for 1–3 months (Morton, 1987). Products of the latter type were not encountered during our survey.

The practices of producing a fermented *masau* beverage in Muzarabani, Mudzi and Mt. Darwin are the same. The dried *masau* pulp is mixed with water (approximately 1:10 ratio of pulp: water) and left to ferment spontaneously for 6–7 days. The fermented pulp (Figure 3) is not consumed as such because of its unattractive exterior and smell. The fermented pulp is transferred to a drum and distilled to obtain the spirit called *Kachasu* using a set up shown in Figure 4. An outline of the fermentation and the distillation procedures is presented in Figure 5. The

**Figure 2.** Traditional *masau* (*Ziziphus mauritiana*) cake made by rural communities in Muzarabani, Zimbabwe. Scale: 1: 1.5.

**Figure 3.** Mass of fermented *masau* (*Ziziphus mauritiana*) fruits from a rural community in Muzarabani, Zimbabwe.

**Figure 4.** Women distilling fermented *masau* (*Ziziphus mauritiana*) pulp to produce *Kachasu.*

sour type of *masau* is preferred for making *kachasu* because it is considered to give the spirit a better taste. Although *kachasu* can be made from other wild fruits such as *Adansonia digitata*, *Tamarindus indica* and *Ziziphus mucronata,* the respondent brewers preferred *kachasu* from *masau* because it had a better taste and flavor.

*Kachasu* can be made from other substrates including maize meal, bulrush or finger millet meal, various fruits, and banana peels. Usually other non-food ingredients such as the bark of the *masau* tree are added

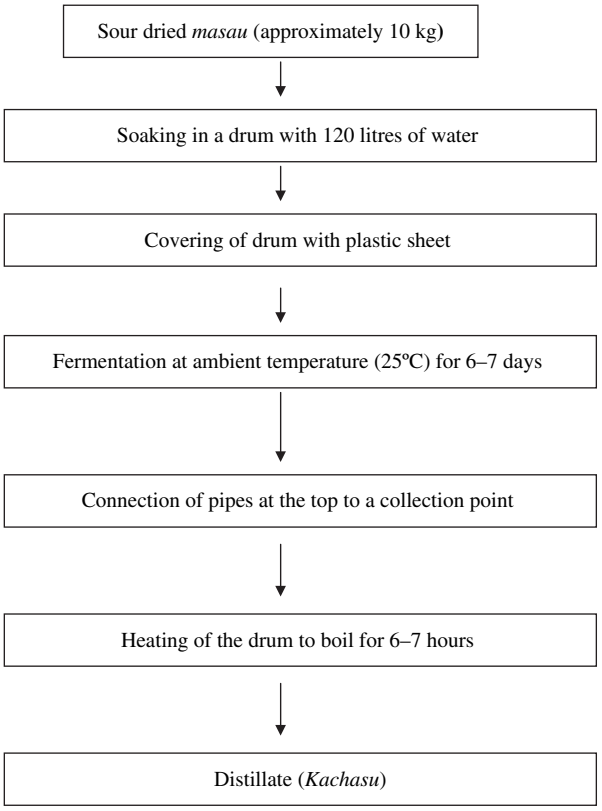


**Figure 5.** Flow diagram for the fermentation and distillation process of *masau* (*Ziziphus mauritiana*) pulp to produce *Kachasu* liquor.

to make the distillate more intoxicating and this is one of the reasons this product was banned in 1971 (Brett et al., 1992). *Kachasu* is similar to *waragi* (Mwesigye and Okurut, 1995) and *chang'aa* (Nout, 1979; Mwesigye and Okurut, 1995) which are produced in Uganda and Kenya, respectively. We observed that the production of *kachasu* is done in private by certain families for income generation and livelihood. However, in other countries, e.g., Malawi, spirits made from indigenous fruits have been promoted. For instance, distilled alcoholic liquor and wine called *mlunguzi* are produced at an industrial scale from a combination of *Uapaca kirkiana* and *Ziziphus mauritiana* fruits (Maghembe and Seyani, 1992). In Venezuela, a jujube liqueur is made and sold as *Crema de ponsigue* (Morton, 1987). And in Uganda, spirits are produced by licensed

communities and then sent to the main distillery where it is then triple-distilled to produce a bottled spirit (Mwesigye and Okurut, 1995).

We observed several variations in the use and pre-treatment of the ingredients used for the fermentation of *masau*. Whole *masau* is occasionally added to the pounded *masau* fruits before fermentation. In addition, other ingredients such as salt, the bark of the *masau* tree, crushed *usika* (*Tamarindus indica*) fruits, and malted millet and sorghum meal are added to the mixture. We observed that in some cases, the fermented mixture is first sieved to remove the solid particles prior to the distillation process.

From 10 kg of dried *masau* fruits, the distillation process of its fermented pulp yields about 15 liters of alcoholic spirit. The spirit is collected in three batches according to their alcoholic strength. During consumption of the spirit, the last batch collected is often used to dilute the first batch. Soft drinks or water are also used to dilute the spirit. Male adults aged from about 20 years and older are the chief consumers although some women aged about 40 and older also consume the spirit. Most respondents (98%) produce the spirit as a source of family income. A 750 ml bottle of spirit sells at approximately €1 – 2 depending on the demand.

The survey also reveals that besides providing food to the rural community, the *masau* tree and its fruits are also important as traditional medicine and livestock feed. Of the 50 respondents, 65% reported that the bark of the tree is used to cure scorpion bites and the roots are traditionally used to cure colic problems in babies. The roots can also be boiled and the extract is ingested to reduce high blood pressure. The *Kachasu* was also reported to be a good remedy for persistent cough. The fruits are traditionally used to treat cold, flu and indigestion and also to stimulate appetite.

## Composition of *Masau*, Fermented Pulp, and Distillate (*Kachasu*)

The levels of titratable acidity, pH, sugars, organic acids, and ethanol in *masau* fruits, fermented pulp and distillate are shown in Tables 1 and 2. The values are reported on a dry matter basis.

The predominant acids in both fresh and dried fruits are citric, malic, oxalic, and succinic acids (Table 1). Tartaric and acetic acids occur at considerably lower levels. Morton (1987) also detected the presence of citric, malic, and oxalic acids in *Z. mauritiana* but did not quantify them.

**Table 1.** Sugars, organic acids, pH, and titratable acidity of *masau* fruits in Zimbabwe

| Parameter | Sample | |
|---|---|---|
| | A[1] | B |
| Sugars (g 100 $g^{-1}$)[2] | | |
| Glucose | 6.7 ± 0.14[a] | 7.5 ± 0.4[a] |
| Fructose | 6.8 ± 0.6[a] | 7.9 ± 0.7[a] |
| Organic acids (g 100 $g^{-1}$) | | |
| Citric | 3.8 ± 0.5[a] | 4.9 ± 0.5[a] |
| Tartaric | 0.5 ± 0.02[a] | nd[b] |
| Malic | 3.4 ± 0.13[a] | 4.8 ± 0.6[b] |
| Succinic | 2.6 ± 0.11[a] | 2.4 ± 0.02[a] |
| Acetic | 0.2 ± 0.11[a] | 0.3 ± 0.06[a] |
| Oxalic | 4.6 ± 0.8[a] | 4.6 ± 0.5[a] |
| pH | 3.6 ± 0.3[a] | 3.8 ± 0.5[a] |
| Titratable Acidity (as g 100 $g^{-1}$ citric acid) | 5.6 ± 0.3[a] | 6.6 ± 0.02[b] |

[1]A – Fresh *masau* composite, B – Dried *masau* fruit composite used for the fermentation process. nd – not detectable.

[2]Means ± standard deviation, means in the same row having the same letter are not significantly different according to the LSD at the 0.05 level.

Muchuweti et al. (2005) detected citric, malic, and malonic acids but did not quantify their concentration. The citric acid content we found in fresh *masau* fruits is comparable to that of lemons and lime (4.2–8.3 g 100 $g^{-1}$) (Nielsen, 1998). The sour taste of *masau* fruits is thus explained by presence of these organic acids.

In the fermented pulp, the major organic acids were citric acid and lactic acid ranging from 1.2–3.6 g 100 $mL^{-1}$ and 1.5–3.3 g 100 $mL^{-1}$, respectively (Table 2). Acetic and malic acids were found in lesser amounts, along with traces of oxalic acid. Lactic acid was found only in fermented pulp indicating that it is produced during fermentation. Malic acid levels were lower in fermented pulp than in *masau* fruits. Probably malic acid is assimilated or converted during the fermentation.

Glucose and fructose but not sucrose were identified in *masau* fruits. The equal amounts of glucose and fructose found in the fruits suggest the presence of invert sugar, which is found naturally in fruits and honey. The ethanol content of the fermented pulp ranged from 2.1–3.7 mL 100$mL^{-1}$. The distillate (*kachasu*) had alcohol levels ranging from 23.8–45.6 mL 100$mL^{-1}$.

**Table 2.** Sugars, organic acids, ethanol, pH, and total acidity of fermented *masau* fruit pulp

| Sample | Sugars (g 100mL$^{-1}$) | | | Ethanol (mL 100mL$^{-1}$) | | Organic acids (g 100mL$^{-1}$) | | | | | pH | Titratable acidity as (g 100$^{-1}$ citric acid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | sucrose | glucose | fructose | pulp | distillate | citric | malic | acetic | lactic | oxalic | | |
| F1[1] | 0.27$^{a}$[3] | Nd[2]$^{a}$ | Nd$^{a}$ | 3.7$^{a}$ | 29.6$^{a}$ | 2.4$^{c}$ | Nd$^{a}$ | 0.17$^{a}$ | 1.5$^{a}$ | 0.11$^{a}$ | 3.66$^{a}$ | 5.25$^{a}$ |
| F2 | 0.37$^{b}$ | 0.12$^{b}$ | 0.64$^{b}$ | 4.0$^{b}$ | 31.1$^{b}$ | 3.6$^{a}$ | 1.31$^{b}$ | 0.12$^{b}$ | 3.3$^{b}$ | Nd$^{b}$ | 3.56$^{b}$ | 5.47$^{a}$ |
| F3 | Nd$^{c}$ | Nd$^{a}$ | 0.19$^{c}$ | 2.9$^{c}$ | 25.7$^{c}$ | 1.5$^{b}$ | 0.45$^{c}$ | 0.20$^{a}$ | 2.6$^{c}$ | Nd$^{b}$ | 3.92$^{c}$ | 4.45$^{b}$ |
| F4 | 0.01$^{c}$ | Nd$^{a}$ | 0.05$^{a}$ | 2.1$^{d}$ | 23.8$^{d}$ | 1.4$^{b}$ | Nd$^{a}$ | 0.14$^{b}$ | 2.4$^{c}$ | Nd$^{b}$ | 3.67$^{a}$ | 4.60$^{b}$ |
| F5 | Nd$^{c}$ | Nd$^{a}$ | 0.05$^{a}$ | 3.2$^{e}$ | 27.7$^{e}$ | 3.6$^{a}$ | 0.53$^{d}$ | 0.12$^{b}$ | 2.1$^{c}$ | Nd$^{b}$ | 3.66$^{a}$ | 5.33$^{a}$ |
| F6 | 0.23$^{d}$ | Nd$^{a}$ | 0.53$^{d}$ | 3.6$^{a}$ | 31.4$^{b}$ | 1.2$^{b}$ | 0.13$^{e}$ | 0.20$^{a}$ | 2.2$^{c}$ | Nd$^{b}$ | 3.55$^{b}$ | 5.29$^{a}$ |
| F7 | Nd$^{c}$ | Nd$^{a}$ | 0.02$^{a}$ | 4.0$^{b}$ | 45.6$^{f}$ | 3.6$^{a}$ | 0.61$^{f}$ | 0.18$^{a}$ | 2.1$^{c}$ | Nd$^{b}$ | 3.51$^{b}$ | 5.17$^{c}$ |
| Mean | 0.13 | 0.2 | 0.21 | 3.4 | 30.7 | 2.5 | 0.4 | 0.16 | 2.3 | 0.06 | 3.65 | 5.08 |
| STDEV | 0.15 | 0.04 | 0.26 | 0.7 | 7.0 | 1.1 | 0.5 | 0.04 | 0.5 | 0.04 | 0.14 | 0.39 |

[1]F1 – F7 fermented *masau* samples from seven different households.

[2]Nd – not detected.

[3]Means ± standard deviation, means in the same column and with the same letter are not significantly different according to the LSD at the 0.05 level.

## CONCLUSIONS

M*asau* fruit plays an important role in the livelihood of the rural communities in Zimbabwe. The fruit is consumed fresh and also sold at local markets. The sweet-sour taste of *masau* fruits is attributed to the presence of glucose and fructose, citric, malic, oxalic, and succinic acids. Surplus fruits are preserved by sun drying. Dried fruits can be transformed into various products such as porridge, traditional cake and *mahewu*. The dried fruit pulp can be spontaneously fermented and distilled to produce *kachasu*. The fermented *masau* pulp is not consumed because it smells and looks unattractive. However, it may be of interest to improve the fermentation process in order to produce a consistent and attractive quality product. Further studies of the microbiological properties of the fruit and the fermented pulp are needed to select and possibly develop starter cultures for improved fermentation processes.

## ACKNOWLEDGEMENTS

The authors thank the Royal Netherlands Academy of Arts and Sciences (KNAW) and the International Foundation for Science (IFS Grant no. C/3737) for financial support. We also thank Julius Mutseka, Ernest Nyanga, and Mr. Mutemeri for their concerted efforts during the survey. We are also grateful to Birgit Hasenack for assistance with the HPLC analyses.

## REFERENCES

Bakhshi, J. C. and P. Singh (1974). The ber - a good choice for semi-arid and marginal soils. *India Horticulture*, 19, 27–30.

Brett, T. R. L., E. N. Nyamupingidza, and R. C. Gurira (1992). The analysis, identification and determination of toxic substances in *Kachasu*. *Transactions of the Zimbabwe Science Association*, 66, 25–29.

Cavendish, W. (2000). Empirical regularities in the poverty-environment relationship of rural households: Evidence from Zimbabwe. *World Development*, 28, 1979–2003.

Egceling, W. J. (1951). *The indigenous trees of the Uganda protectorate*. Harare (Salisbury): The Government Printer.

Gadaga, T. H., A. N. Mutukumira, J. A. Narvhus, and S. B. Feresu (1999). A review of traditional fermented foods and beverages of Zimbabwe. *International Journal of Food Microbiology*, 53, 1–11.

Maghembe, J., and J. Seyani (1992). Multipurpose trees used by small-scale farmers in Malawi. Results of an Ethnobotanical Survey, Rep. No. AFRENA 42. ICRAF, Nairobi.

Morton, J. F. (1987). Indian jujube. in J. F. Morton, (ed.), *Fruits of Warm Climates*. Florida: Miami, pp. 272–275.

Muchuweti, M., G. Zenda, A. R. Ndlala, and A. Kasiamhuru (2005). Sugars, organic acids and phenolic compounds of *Ziziphus mauritiana* fruit. *European Food Research and Technology*, 221, 570–574.

Mwesigye, P. K. and T. O. Okurut (1995). A survey of the production and consumption of traditional alcoholic beverages in Uganda. *Process Biochemistry*, 30, 497–501.

Nielsen, S. S. (1998). *Food Analysis Second Edition*. Gaitersburg, Maryland: A Chapman and Hall Food Science Title, Aspen Publishers, Inc.

Nout, M. J. R. (1979). The manufacture and composition of Chang'aa (Nubian Gin). *Lebensmittel Wissenschaft und Technologie*, 12, 212–216.

Saka, K. J. D., and J. D. Msonthi (1994). Nutritional value of edible fruits of indigenous wild trees in Malawi. *Forest Ecology and Management*, 64, 245–248.

Soyer, Y., Koca, N., and F. Karadeniz (2003). Organic acid profile of Turkish white grapes and grape juices. *Journal of Food Composition and Analysis*, 16, 629–636.

Tredgold, M. H. (1986) *Food Plants of Zimbabwe*. Gweru: Mambo Press.