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***Mutandabota*, a Food Product from Zimbabwe: Processing, Composition, and Socioeconomic Aspects**

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We evaluated processing technology, composition, and socioeconomic significance of mutandabota, a food product made by mixing cow's or goat's milk with dry baobab fruit pulp. Mutandabota production is a gendered activity dominated by women. Nutrient content was ($\text{g } 100 \text{ g}^{-1} \text{ w.b}$) protein 4.8 ± 1 , fat 2.8 ± 0.9 , fiber 1.1 ± 0.4 , ash 0.9 ± 0.2 , carbohydrates 20 ± 1.7 , moisture 70.4 ± 3.7 , and vitamin C $80 \pm 25 \text{ mg}/100\text{g}$. Microbiological load ($\log \text{ cfu ml}^{-1}$) was high, 4.7 ± 1.2 mesophilic bacteria, 5.3 ± 2.1 lactic acid bacteria, and 5.0 ± 1.3 yeasts and molds. The pH of milk was 6.7 and the final pH of mutandabota was 3.5 ± 0.1 . Mutandabota is a major source of proteins and vitamin C. Its microbiological quality needs evaluation.

KEYWORDS *baobab fruit, chemical composition, microbial load, milk, mutandabota*

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Research and development of underutilized foods in Sub-Saharan Africa provides a viable option to combat increasing hunger and malnutrition. According to FAO/WHO (1991) and Stevens and colleagues (2012), the Sub-Saharan population of Africa, notably women and children, suffer from insufficient intake of protein and energy, and a lack of micronutrients. The Food and Nutrition Council of Zimbabwe (2010) reported that 34% of children under five years of age in the country suffer from chronic malnutrition. The Council recommended scaling up nutrition, mainly by improving the nutritional quality of indigenous food products that are available to the community. *Mutandabota* or *umlondo* is one underutilized food product found in drier areas of Zimbabwe (Department of Research and Specialist Services 2001). It is made by mixing cow's or goat's milk and dry baobab (*Adansonia digitata* L.) fruit pulp. *Mutandabota* is consumed as a major protein source by both young and old, and is sometimes used as a supplementary food for infants. For generations, *mutandabota* has significantly contributed to people's livelihoods through subsistence use and as a safety net in drought periods. However, its consumption is limited to localized areas where the baobab tree occurs. The baobab tree is widely distributed throughout drier regions of Southern Africa (Sanchez, Osborne, and Haq 2010).

Milk and baobab fruit pulp are the major raw materials in *mutandabota* production. Quality of milk and proximate composition of pulp have a direct bearing on the nutritional status of *mutandabota*. Milk has been considered the most nearly perfect food known, endowed with nutritional and immunological components that positively influence human health (Wong et al. 2006; Millsa et al. 2011). Raw cow's milk from Zimbabwe contains approximately 12 g 100 g⁻¹ total solids, 3.2 crude protein, 3.5 fat, and 8.3 non-fat solids (Mutukumira et al. 1996). Proteins of milk contain all essential amino acids. All 22 minerals and vitamins considered essential to the human diet are also present in milk (Eckles, Combs, and Macy 2000).

Baobab fruits from Zimbabwe showed a pulp content of 24 g 100 g⁻¹ (range 10–57; Department of Research and Specialist Services 2001). Moisture content of fruit pulp was 11.6 g 100 g⁻¹ on product fresh weight basis. Proximate composition was found to be (g 100 g⁻¹ d.w.): crude protein 5.3, fiber 13.7, fat 3.6, carbohydrates 74.9, and ash 4.9 (Arnold, Wells, and Wehmeyer 1985; Chadare et al. 2009). Fruit pulp is acidic due to the presence of organic acids, including citric, tartaric, malic, succinic, and ascorbic acids. Vitamin C content in fruit pulp was reported as 160–337 mg 100 g⁻¹ (Ighodalo, Catherine, and Daniel 1991; Department of Research and Specialist Services 2001). Such high vitamin C content gives fruit pulp a particularly high antioxidant capability (Vertuani et al. 2002). Minerals in fruit pulp included (mg 100 g⁻¹): iron 9.3, calcium 295, magnesium 90, zinc 1.8, sodium 2.8, and potassium 1240 (Osman 2004).

The objectives of the present study were to monitor the technology used to process milk and baobab fruit pulp into *mutandabota*, to evaluate

the chemical and microbiological composition, and to assess the socio-economic significance of *mutandabota*. This was meant to enable formulation of a research agenda for developing practices to improve the quality and safety of *mutandabota* under local conditions, and to ultimately increase the contribution of this food product in the fight against malnutrition.

MATERIALS AND METHODS

Study Area

The study was conducted in Siyanzyundu (17° 36' S, 27° 32' E), Binga district, Zimbabwe, a communal farming area with a rich *mutandabota* tradition. The abundance of baobab trees and the widespread consumption of *mutandabota* in Binga (Department of Research and Specialist Services 2001) determined the choice of this community as the study site. *Mutandabota* is believed to have originated here and is considered a food cultural heritage in this community.

Field Data Collection

The field research was conducted from August 2010 to July 2011. Permission to carry out the research was obtained from the headmen and councilor of the area. Informed consent was obtained from all participants and respondents. Data were collected through focus group discussions (FGD), formal interviews, practical observation, and demonstrations.

FOCUS GROUP DISCUSSIONS AND INTERVIEWS

Siyanzyundu is made of eight villages. The names of villages and their population size is shown in table 1. Seven of the villages are relatively close to each other. One village, Chilisegele, is relatively isolated from others and bigger, with a population of 280 inhabitants. From each of the eight villages, at least 5% of the inhabitants were randomly selected to make a sample size of 40. Boyd and colleagues (1981) recommend a sample size of at least 5% of the total population. Based on this, the number of participants picked from each village, as shown in table 1, was considered to be representative.

Discussions and interviews were conducted in the local Tonga language that was best understood by all informants. Semi-structured interviews (Bernard 2006) were used for FGDs. FGDs were held with two groups. The age of participants ranged from 24 to 65 years (mean = 45). The first group consisted of participants from seven villages. The number of participants from each village and their gender is shown in table 1. The second group consisted of 15 participants from one village, Chalisegele. Four of the participants were men and 11 were women. The age range was 23–70 years

TABLE 1 Number and Gender of Participants in Focus Group Discussions in Siyanzyundu, Zimbabwe

Village name	No. participants	Women	Men
Siabwande	5	5	0
Siantebele	8	8	0
Siamudele	2	2	0
Ndwani	1	1	0
Ngandu	2	2	0
Siamugwandu	5	3	2
Siabukoko	2	1	1
Chilisegela	15	11	4
Total	40	33	7

(mean = 43). The headmen, as community leaders, were excluded from FGD to enable spontaneous and free flow of information.

Formal interviews were held individually using semi-structured questionnaires (Bernard 2006) to understand people’s perceptions on preferences, availability, and consumption of indigenous tree-food products. This was important for comparison purposes and in judging whether the baobab tree was more or less important as a food resource than other indigenous fruit trees. The following people were interviewed: (1) the two headmen in Siyanzyundu (headmen are traditional leaders in Zimbabwe and are considered as the custodians of traditional knowledge and culture; Mupunga and Dube 1992), (2) the councilor for the area, and (3) two elderly women recommended to us for their knowledge of *mutandabota*. None of these interviewees participated in the previous FGDs.

Data collected in FGDs and interviews included sociodemographic characteristics (e.g., age, gender), farming activities, cattle head and goat characteristics (e.g., numbers, composition, and uses), cattle and goat feeding management (e.g., sources of feed and grazing management), cattle and goat health management, and milking practices. The importance of the baobab as compared to other fruit trees as a food resource was evaluated by asking participants to rank fruit trees in their area from the most important (ranked 1) to the least important (ranked 5). Data was collected on preparation of *mutandabota*, challenges encountered, fruit and pulp storage conditions, as well as *mutandabota*’s socioeconomic and nutritional significance.

MILKING AND PREPARATION OF MUTANDABOTA

The milking of cattle and goats was observed. Three households prepared *mutandabota* in duplicate at their homesteads on separate days. The households prepared *mutandabota* using raw cow’s milk according to their traditional technical knowhow. Household members were observed while carrying out the operations. Quantitative data was collected on inputs (i.e.,

raw materials, labor, utensils), time, temperature of preparation; and outputs (yields and by-products). Samples were collected during preparation for biochemical and microbiological analysis.

Biochemical and Microbiological Analysis

BIOCHEMICAL ANALYSIS

The pH of milk and *mutandabota* were determined immediately on sampling in a 5 ml subsample using a combined glass electrode pH meter. Moisture, crude protein, fat, ash, and crude fiber content of *mutandabota* were determined according to AOAC (2005) methods. Total carbohydrate content of *mutandabota* was estimated by difference. Temperature of *mutandabota* was determined on sampling by inserting a thermometer into a 100 ml sample.

MICROBIOLOGICAL ANALYSIS

Microbial load was evaluated and the type of bacteria was determined in cow's milk and *mutandabota*. From milk, a subsample (1 ml) was aseptically drawn from the preparation dish just before addition of pulp, and made into 10^{-1} dilutions using peptone physiological saline (PPS) solution (8.5 g NaCl and 1 g neutralized bacteriological peptone (Oxoid, LP0034) in 1 L demineralized water). At the end of *mutandabota* preparation, a subsample (1 ml) of *mutandabota* was aseptically drawn from the preparation dish and made into 10^{-1} dilutions using peptone physiological saline (PPS) solution. Immediately, in each case, from PPS serial dilutions, 100 μ l of the appropriate diluent were inoculated onto selective media in duplicate. Lactic acid bacteria (LAB) were enumerated on de Man, Rogosa, and Sharpe Agar (MRSA: 1.5% Technological Agar Oxoid, LP0013 added to de Man, Rogosa and Sharpe broth (Merck, VM986641), mixed and sterilized), supplemented with 100 mg 100 g^{-1} natamycin (2 g Delvocid (50% natamycin, DSM). MRSA plates were stored in air-tight jars and incubated under a modified atmosphere (80% N_2 , 10% CO_2 , and 10% H_2) at 30 °C for 48 ± 4 h. Colonies were checked microscopically to confirm presence/absence of yeasts. Presumptive LAB were confirmed by oxidase and catalase tests, and confirmed counts were reported as LAB. Aerobic mesophilic bacteria were enumerated on plate count agar (PCA, Oxoid CM0325). PCA plates were incubated at 25 °C for 48 ± 4 h, and reported as total viable count. Yeasts and molds were enumerated on oxytetracycline glucose yeast extract agar (OGYEA, Oxoid CM0545) supplemented with oxytetracycline). OGYEA plates were incubated under aerobic conditions at 25 °C for 3 d. All colonies on respective plates were counted and results expressed as colony forming units (cfu) per ml of milk or *mutandabota*, taking into account the dilution factors.

Statistical Analysis

Statistical analysis was done using SPSS 13.0 for windows (Apache Software Foundation, USA) and Microsoft Excel. Descriptive statistics such as means, percentages, frequencies, and variances were computed and used to describe the data.

RESULTS

Siyanzyundu: The Study Area

Siyanzyundu, in Binga district, Zimbabwe is a communal farming area in a very arid and marginal agro-ecological zone in the country. The baobab tree does very well in the area due to its adaptation to hot, dry areas (Arnold et al. 1985). Table 2 shows the importance of the baobab tree as a food resource for the community in Siyanzyundu in relation to other fruit bearing trees. The baobab tree was ranked first, mainly because of its use in *mutandabota* preparation, and also because different parts of the tree are processed into different foods. Fruits are sucked and chewed. Leaves are used as a sauce ingredient. Fruits are sold to generate income and can also be used in barter trade in exchange for the staple millet grains (*Pennisetum glaucum*). Second ranked was the *nyii* tree (*Berchemia discolor*), followed by *mateme* (*Strychnos cocculoides*) then *musika* tree (*Tamarindus indica*). The remaining trees (table 2) were the least ranked as food resources.

The average head of cattle per homestead in Siyanzyundu was 9 (range 2–30). The predominant breed in Siyanzyundu was the small, hardy Sanga type with a small proportion of cross-bred Jersey, Friesian, and Brahman. The goat breed was the indigenous Mashona type. Of the 40 farmers, 26% reared cattle only, 39% had cattle and goats, while 17% had goats only. A few farmers (18%) had neither goats nor cattle. Of those who had goats, the average number of goats per farmer was 19. Farmers stated that their cattle and goats were healthy. Veterinary extension services provided treatment and vaccinations against important diseases, among them anthrax, and foot-and-mouth

TABLE 2 Ranking of Trees as Food Resources by Local Farmers in Siyanzyundu, Zimbabwe

Rank	Local name of tree	English name	Botanical name
1	<i>Muuyu</i>	Baobab	<i>Adansonia digitata</i>
2	<i>Nyii</i>	Mountain date	<i>Berchemia discolor</i>
3	<i>Mateme/Mkemeswane</i>	Corky monkey-orange	<i>Strychnos cocculoides</i>
4	<i>Musika</i>	Tamarind	<i>Tamarindus indica</i>
5	<i>Mutsuvvu/Mutswankela</i>	Chocolate berry	<i>Vitex payos</i>
5	<i>Mkambo</i>	Monkey orange	<i>Strychnos innocua</i>
5	<i>Mbubu/Umviyo</i>	Velvet wild medlar	<i>Vangueria infausta</i>
5	<i>Zakalanda/moringa</i>	Horse-radish tree	<i>Moringa oleifera</i>

disease. The Ministry of Agriculture considers extension and veterinary services in these areas satisfactory (Agricultural Extension Services 2005). All farmers ($n = 40$) reported that their cattle and goats grazed on communal rangelands throughout the year, with goats additionally browsing bushes. The principal grasses in the area are *Aristida*, *Eragrostis*, and *Hyparrhenia* species. While cattle and goats in this community, like anywhere else in the country, are kept for a number of purposes (Feresu and Muzondo 1989), the provision of meat and production of milk are the most important benefits, thereby providing the family with a protein source.

Milking in Siyanzyundu

When milking, cow hind legs along with the tail were tied and the udder region was washed with clean water using bare hands. Holding the teats diagonally, milking was done quickly, silently, and completely with dry hands (figure 1). Foam formed on milking in the milking jar was used to lubricate the teats. It was observed that farmers' milking practices were deficient in basic sanitary techniques like disinfection of the milker's hands before milking, or teat dipping. The effects of teat dipping, according to Dodd and Phipps (1994), is to lower the level of microorganisms in milk as well as to help the healing of teat skin injuries.

Milk yield per cow was on average 2 liters per day, depending on farm-management practices and season. Higher milk yields were recorded during the rainy season, when the pasture is plentiful. In the dry season,

FIGURE 1 Cow milking in Siyanzyundu, Zimbabwe (color figure available online).

yields are much lower. Most farmers (70%) said they milked 1 or 2 cows per year, 30% milked 3 or more cows per year. According to Empson (1992), generally levels of milk production from the communal farming sector are low. The figures in Siyanzyundu compare well with the country average in the communal sector. These are 1–3 liters per day (150 lactation days) for indigenous breeds; 4–10 liters per day (average 240 lactation days) for crossbreeds; and more than 10 liters per day (300 lactation days) for purebred exotic cows (Mupunga and Dube 1992). Milk yield per 9 goats was 2.5 liters (on average 278 ml per goat) per day.

Goats were milked with one person holding the hind legs, a second holding the head, and a third person extracting the milk (figure 2). As with cow milking, the udder region was washed with clean water using bare hands. Holding the teats diagonally, milking was done quickly, silently, and completely with dry hands. Foam formed on milking in the milking jar was used to lubricate the teats. Milk produced per homestead is pooled together before use, keeping goat's and cow's milk separate.

Milk was filtered using a clean (non-sterile) cloth to remove any physical contaminants such as animal fur, manure, and pieces of grass, before consumption and/or processing. There are no refrigeration or other cooling facilities in Siyanzyundu. Therefore, milk is consumed immediately after milking or processed into *mutandabota* for immediate consumption. Some

FIGURE 2 Goat milking in Siyanzyundu, Zimbabwe (color figure available online).

of the farmers (60%) sell some of their cow's milk within local communities to raise some income.

Post-Harvest Storage of Baobab Fruits

Villagers store baobab fruits in cribs (huts specially designed to ensure a dry, non humid internal environment). Fruits can be stored for six months or more without loss of quality in such cribs. If exposed to a humid environment, fruits are said to absorb moisture and this affects the quality of pulp. Farmers reported the problem of fruits being weevil or insect damaged. Damage is detected by the presence of holes, a floury dust, or tiny pinkish crystal-like structures in the pulp—a criterion to which villagers pay special attention—when choosing fruits for processing. Pulp from such fruits is considered unsuitable for processing. Chadare et al. (2008) also observed pulp-storage problems in Benin, such as insect larvae infestation and color changes.

Extraction of Fruit Pulp and *Mutandabota* Preparation

In the method of preparing *mutandabota* employed in Siyanzyundu, as recorded in this study, mature dry baobab fruits were collected from the wild. Baobab fruits ripen and dry while they are still on trees. Large quantities (two to five sacks, each sack containing on average 120 fruits) were brought to the homestead. Farmers mentioned that they preferred less-bitter fruits from good trees identified over the years. Such fruits are said to produce better *mutandabota*. Fruits were graded according to size (small, medium, and large). Fruits of the same size were processed together, which was a way of ensuring homogeneity in terms of color, flavor, and aroma of the final product. The illustration of process stages used for the preparation of *mutandabota* is shown in figure 3. In this method fruits were cracked by hitting them against a rock or log. Naturally dehydrated pulp together with seeds was separated from the pericarps. Pericarps were stored for later use. After removal of the pericarp, pulp and seeds were separated by sieving, pulp was collected in a winnowing basket. The seeds were pounded in a mortar with a pestle to completely separate the pulp adhering to the seeds. A second sieving was done and the collected pulp was added to the main portion of the pulp in the winnowing basket. This was repeated three times or until the seeds were free of pulp. Seeds and some fibrous matter were put aside for later use. Pulp was gradually added to milk, while continuously stirring, in an 8-liter plastic bowl. Crystalline sugar was also added to the mixture. Stirring was continued for approximately 7 minutes or until a homogeneous mixture was achieved. The preparation temperature was 30 °C.

Table 3 shows a summary of the raw materials and their quantities used in preparing *mutandabota* and the resultant product yield. Average yield

FIGURE 3 Flow chart of *mutandabota* preparation in Siyanzyundu, Zimbabwe.

TABLE 3 Ingredients Used in Producing a Batch of *Mutandabota* ($n = 6$) in Siyanzyundu, Zimbabwe

Ingredients	Minimum	Maximum	Mean ($n = 6$)	<i>SD</i>
Pulp (g)	280	394	334	57.4
Cow's milk (g)	1,691 (1,742 ml)	1,973 (2,032 ml)	1,814 (1,868 ml)	141
Sugar (g)	112	189	151	38.5
<i>Mutandabota</i> (g)	1,943	2,380	2,180	220.8
Yield (%)	91	96	94	2.5

was 2,180 g of *mutandabota* from 334 g of pulp, 151 g of sugar, and 1,814 g of milk. The average percentage yield was 94% based on total ingredient weight. *Mutandabota*, shown in figure 4, had an appetizing cream color with a thick yogurt-like consistency.

FIGURE 4 *Mutandabota* being served for lunch in Siyanzyundu, Zimbabwe (color figure available online).

Chemical Composition

The nutrient content of *mutandabota* was (g 100 g⁻¹ fresh weight) crude protein 4.8 ± 1 , fat 2.8 ± 0.9 , crude fibre 1.1 ± 0.4 , ash 0.9 ± 0.2 , carbohydrates 20 ± 1.7 , moisture 70.4 ± 3.7 and vitamin C 80 ± 25 mg 100 g⁻¹. *Mutandabota* is a major source of protein in the Siyanzyundu community, which depends, as is the case with most rural Sub-Saharan communities, on millet, sorghum and maize grains for food (Oniang'o, Mutuku, and Malaba 2003). The content of vitamin C (80 ± 25 mg 100 g⁻¹) makes *mutandabota* an attractive natural source of vitamin C for pregnant and lactating women as well as for children and the elderly.

Microbiological and Biochemical Properties

Microbiological load of raw cow's milk on processing to produce *mutandabota* was high. On average, mesophilic bacterial counts were $8.9 \log \text{cfu ml}^{-1}$, lactic acid bacterial counts were $5.1 \log \text{cfu ml}^{-1}$ and yeasts and mold counts were $3.6 \log \text{cfu ml}^{-1}$. Identification of 131 single-colony isolates from the raw milk and *mutandabota* showed the absence of potential pathogenic microorganisms (unpublished results). Mesophilic bacterial counts exceeded the regulatory limit of $5.7 \log \text{cfu ml}^{-1}$ for milk intended for processing (Ministry of Agriculture 1992). Possible causes for such high bacterial counts could be contamination by the milker, hands of the milker,

environment at the milking site, milk filter cloth, and/or the milking vessels that may harbor microorganisms. Moreover, the environmental temperatures of 30 ± 1.2 °C during processing and a time lapse of approximately 2 hours before processing to *mutandabota* could also have contributed to bacterial growth. The International Dairy Federation (1990) and Walstra and Jenness (1984) reported that the high temperatures in raw milk in tropical conditions favor mesophilic bacterial growth. While there are antimicrobial substances in milk, such as lysozyme, lactoperoxidase, lactoferrins, and immunoglobulins (Harding 1999; Silanikove, Merin, and Leitner 2006), these substances usually inhibit bacterial growth only for some minutes after milking (Fonteh, Grandison, and Lewis 2002; Zhang et al. 2008).

On preparing *mutandabota*, the pH of cow's milk was 6.7 ± 0.4 , a pH value within the biological variation described by Walstra et al. (2006). Milk pH is affected by a number of factors that include farm-management practices, type of feed, and stage of lactation. The pH of the resulting *mutandabota* was 3.5 ± 0.1 , at a temperature of 30 °C. The low pH of *mutandabota* could be attributed to the acidic nature of dry baobab fruit pulp. Airan and Desai (1954) first highlighted the presence of organic acids in baobab fruit pulp. Later reports by Nour and colleagues (1980) and Vertuani and colleagues (2002) confirmed the presence of citric, tartaric, malic, succinic, and ascorbic acids in baobab fruit pulp.

In *mutandabota*, mesophilic bacterial counts were, on average 4.7 ± 1.2 log cfu ml⁻¹; lactic acid bacteria were 5.3 ± 2.1 log cfu ml⁻¹; yeasts and molds were 5.0 ± 1.3 log cfu ml⁻¹. The drop in bacterial load, when compared to microbial load in milk on processing (8.9 log cfu ml⁻¹ mesophilic bacteria, 5.1 log cfu ml⁻¹ lactic acid bacteria, and 3.6 log cfu ml⁻¹ yeasts and molds), was probably due to the acidic nature of baobab pulp and the resulting pH of *mutandabota*, which is not very conducive to microbial proliferation and probably inactivated or killed many microorganisms. The lactic acid bacteria seem to have been affected less by the acidic nature of *mutandabota* because of their inherent tolerance of acidic environments (Hyronimus et al. 2000). Yeast and molds increased in numbers, probably because, in addition to yeasts and molds from milk, some yeasts and molds came from dry baobab pulp. Yeasts and molds have been isolated from baobab fruit pulp (Saka et al. 2007).

Socioeconomic Significance of *Mutandabota*

Mutandabota is of social, economic and nutritional significance in the livelihoods of people living in Siyanzyundu and many other Zimbabwean communities. This is the case with other fruit based products in Zimbabwe (Nyanga et al. 2008). The whole family is involved in production of *mutandabota* from fruit harvesting, milking and mixing of ingredients. This brings the family together, fostering family and community cohesion,

especially if *mutandabota* is shared with neighbors. The dominance of women in focus groups (87.5% in the first group and 73.3% in the second group) indicates that *mutandabota* production is a gendered activity dominated by women. Women are responsible for fruit harvesting and *mutandabota* preparation. *Mutandabota* is consumed by all members of the family and is a major component of the diet. On average an adult consumes a serving of 400 g *mutandabota* per day. This makes economic sense in that *mutandabota* is made from locally available resources and can be consumed as either breakfast or lunch.

DISCUSSION

The climatic conditions in the study area Siyanzyundu, in Binga, Zimbabwe, could have influenced the inhabitants to exploit the baobab fruit as their main forest-food resource. Siyanzyundu is a very arid and marginal agro-ecological zone in the country. Rainfall is too low (<600 mm/annum) and erratic for the reliable production of even drought-resistant fodder and grain crops (Ndebele et al. 2007). Vincent and Thomas (1960) noted that extensive cattle or game ranching is the only sound farming system for this region. Farming in Siyanzyundu is based on minimal dry-land cropping and grazing natural pasture. All farmers in Siyanzyundu grow sorghum (*Sorghum bicolor*) and millet (*Pennisetum glaucum*) as their staple food crops, providing most of the carbohydrates to the diet. Processing milk and baobab fruit to produce *mutandabota* ensured a constant supply of proteins, vitamin C and minerals to the diet throughout the year, since the raw materials, milk is always available and the baobab fruit pulp can be stored for use throughout the year. However pulp preservation needs improvement. Pulp storage can be improved by the use of sodium metabisulphite as a preservative against molds (Ibiyemi, Abiodun, and Akanji 1988). *Mutandabota* provides additional fibre to the diet, which evidently has potential health benefits, in particular for preventing diabetes, cardiovascular diseases, various cancers and functional constipation in children (Smith 2010).

The practice of milking both cattle and goats in the cattle kraal and goat pens, respectively, in an open environment, raised a hygiene concern for the reason that, while milk is immediately poured into a container and closed, there is a high contamination risk during milk extraction from the teats, because at this time the container is not closed and foreign materials like manure blown by the wind can contaminate the milk (figures 1 and 2). Milk has many times been identified as a source of food-borne diseases (Adesiyun, Webb, and Rahaman 1995; Arslan and Ozdemir 2008). Control of bacterial content in raw milk is very important for public health, because consumption of dairy products processed from milk with high microbial counts increases the risk of ingestion of toxins or infective organisms. However,

microbiological quality is not only dependent on bacterial count, but on the specific bacterial types. A high count of lactobacilli, for example, may actually be beneficial. Lowering of milk pH from 6.7 to 3.5 in *mutandabota* within the 7 ± 2 minutes preparation time, through natural means, can be considered a major benefit to *mutandabota* in the enhancement of microbiological safety and shelf life.

On average, an adult consumes a serving of 400 g *mutandabota* per day. According to the World Health Organization (2007), the recommended level of protein intake (RLPI) for a toddler (1–3 years old) is 0.83 g per kg of body weight. A serving of 300 g *mutandabota* would provide 60% of the RLPI, if consumed twice a day, as is often the case, then 120% of RLPI is covered. A 300 g serving of *mutandabota* will provide more than 100% of the recommended vitamin C daily intake for a toddler.

Mutandabota production is a gendered activity dominated by women. In recognition of the prominent role of women in the whole process, it is envisaged that any technological intervention has to prioritize the role of women, and the effect of the technology on their livelihoods. Pulp extraction and pulp preparation appear to be the most difficult processing operations. They are tedious manual operations mainly handled by women. A mechanical pulp extractor, as wished for by the local population, would significantly contribute to a sustainable solution in improving the livelihoods of processors. Finding solutions for such operations through research activities will result in a semi-mechanized process which will ultimately save time for women involved in this activity. The saved time can be invested in other remunerative activities, resulting in higher incomes that can be spent on child education and development. Pulp preparation also faces problems. It requires pounding in a mortar with a pestle, and a sieving process for removal of fiber and seed. These two operations are made difficult by air currents that take away part of the product or introduce dust particles. It would be beneficial to investigate how the operations can best be facilitated for a rural population. *Mutandabota* is gaining interest and its production has expanded beyond its area of origin (Department of Research and Specialist Services 2001). We can thus foresee further increase in consumption of *mutandabota*.

CONCLUSIONS AND RECOMMENDATIONS

Mutandabota is part of the food cultural heritage of Zimbabwe and the community of Siyanzyundu in particular. The high protein content of *mutandabota*, in addition to nutrients, vitamins, and minerals, as recorded in this study, gives it potential usefulness as a food protein source in Sub-Saharan Africa where child malnutrition needs to be combated and eradicated. *Mutandabota* complements well an otherwise nutrient-poor, staple

cereal-based diet in rural communities. *Mutandabota* is acceptable to the people and this forms a firm basis for promoting its consumption beyond the current scope and makes it an affordable and readily available source of nourishment for all groups considered to be nutritionally at risk, such as children, pregnant woman, lactating mothers, rural communities, and urban poor. Nutritional research on *mutandabota* focusing on digestibility and bioavailability of nutrients is necessary.

It is beneficial to perform research on cumbersome processing operations and appropriately mechanize them to save time and improve safety considerations to enable wider distribution and contribution to reduce malnutrition. Storage conditions for the baobab fruit are indeed very poor and need to be studied and improved to increase the shelf life of the fruit. Increasing the shelf life of the fruit will add value to pulp for production of a standardized *mutandabota*.

The high microbial load of milk used for *mutandabota* processing and the correspondingly high microbial load in *mutandabota* pose a potential hygiene challenge. General hygienic practices should be investigated and improved, from milking through all the processing stages. Lowering of milk pH from 6.7 to 3.5 in *mutandabota* within the seven minutes' preparation time, through natural means, can be considered a major benefit to the product in the enhancement of microbiological safety. Introduction of fermentation technology in *mutandabota* production could be beneficial, since it contributes to improvement of nutritional value, digestibility of food, and microbiological safety and is an inexpensive technology that can be applied successfully in rural situations. In addition, we recommend determining the feasibility of incorporating probiotics with suitable characteristics to improve the health benefits of *mutandabota*. The ultimate goal would be to end up with a safe, healthy, optimum-quality product of relevant nutritional value.

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