Full Length Research Paper

The commercial viability of Tamarind (Tamarindus indica L) fruit based products for improved incomes among farmers in Northern and Eastern Uganda

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Abstract
Tamarind (Tamarindus indica L) is a multi-purpose tree that grows wildly in Uganda. Virtually every part of the tree is utilised in food preparations or medicines. However its economic potential in Uganda has not been fully established. A three year study from 2010 to 2013 was conducted to establish the commercial potential based on product development from its fruit in relation to market response and opportunities. Four products namely jam, marmalade, source and tam-chilli were developed from sweet and sour provenances of the fruit and organoleptically tasted by controlled taste panel. To test product acceptability and commercial viability, 437 potential consumers from two regions; North-Eastern (traditional tamarind area) and Western (non-traditional tamarind region) Uganda were engaged in the exercise. Results indicated that most consumers (76%) preferred sour provenances for culinary purposes as food enhancers. Among the new products, jam and marmalade were most preferred (87%) followed by sauce and tam-chilli at 34% and 23% respectively. Preference for jam and marmalade was reflected in the average willing price of UGX 5,760/= and 3,900/= for 250g-jars respectively. Generally, consumers in the Western region offered higher prices than their counterparts in North and Eastern region. The male buyers consistently offered 15% higher prices than their female counterparts. It was therefore concluded that tamarind fruit can be transformed into commercially value-added products and can be a source of income for farmers and processors in Uganda.

Key words. Tamarind pulp, value-addition, consumer preference, Uganda.

INTRODUCTION
Tamarind (Tamarindus indica L) a native plant of tropical Africa is best known for its fruits, which contain about 30% sticky, edible pulp (Singh et al., 2007). The acidic pulp is a common ingredient in culinary food preparations in countries where the tree grows naturally. In Uganda it grows wildly mainly in the Northern and Eastern regions of the country. It is known by various local names: Apedur (Ateso), Chwa-o (Luo), Kyimikhuwa (Lumasaba), Mukoge (Luganda), Mkwaju (Kiswahili). Tamarind is one of the many multi-purpose forest trees with a good economic potential because of its diverse uses (Jadhav et al., 2010; Gunasena and Hughes, 2000; Ishola et al., 1990). Virtually every part of the tree is utilised either as food flavouring or medicine portion (Gunasena and Hughes, 2000, Tsuda et al., 1994).

Tamarind pulp is a rich source of micro-nutrients like calcium, phosphorous, vitamin A, C and tartaric acid (El-Siddig et al., 2006). Owing to its chemical constituents, it is used as flavour, stabilizer and binder in food preparations (Tsuda et al., 1994). The seed is a rich...
The researchers conducted all research activities provided processing facility for product development and Processing (HFP) at Kawempe-Mbogo, Kampala District, development. The industrialist, HOMETECH Food supplied high quality raw materials for product regions of Uganda provided baseline information and three selected districts from Eastern and Northern roles based on their speciality and expertise. The FGs chain. Each of the value-chain actors had designated industrialist were the main actors involved in the value-chain. Ultimately the livelihoods of the resource poor in the regions of Uganda would improve.

**MATERIALS AND METHODS**

**General study design**

The study design used the value-chain approach which consisted of generating baseline information on traditional tamarind fruit production, post-harvest practices, consumer culinary tastes and on-farm utilization; developing pulp extraction process; developing new tamarind based-products from extracted pulp and fresh young fruit; product astringency; sensory and market testing of the developed tamarind products. Farmer groups (FGs), researchers and one cottage industrialist were the main actors involved in the value-chain. Each of the value-chain actors had designated roles based on their speciality and expertise. The FGs with access to tamarind trees in two sub-counties of the three selected districts from Eastern and Northern regions of Uganda provided baseline information and supplied high quality raw materials for product development. The industrialist, HOMETECH Food Processing (HFP) at Kawempe-Mbogo, Kampala District, provided processing facility for product development and the researchers conducted all research activities.

**Study area**

The study covered nine districts of Uganda; one from the North, two from East and five from the West. The first three core districts were; Apac, Soroti and Katakwi were selected based on availability of tamarind trees, utilization trends and familiarity with tamarind fruits. In each of these districts, two sub-counties were selected based on presence of vibrant farmer groups and their accessibility to tamarind trees. In each sub-county, one hundred trees were tagged based on the sweet or sour culinary properties and they were sampled regularly for phenological and fruit production studies. The selected districts had to demonstrate intent to commercialize tamarind products for income generation. They were also required to show willingness to enact by-laws to ensure protection of the environment through tamarind tree propagation. The other five districts Mbarara, Ibanda, Kasese, Kibaale and Kabalore were selected to represent the greater western Uganda. The western districts are unfamiliar with tamarind tree and its products. They were therefore selected to test the potential of marketing tamarind based products beyond the traditional tamarind producing regions of Uganda. Whereas the core districts participated in all study activities, districts in western region and Kampala participated in consumer test survey only.

**Tamarind fruit production and postharvest practices and on-farm utilization**

Information on traditional tamarind fruit production, post-harvest handling practices, consumer culinary tastes and on-farm utilization was generated using focus discussion group. A structured questionnaire was first pre-tested in Apac district prior to its administration in core districts. The purpose of this tool was to capture data on production, utilization trends, sales and profitability, types of provenances, seasonality, harvesting practices and other quality parameters like colour, taste and astringency. Data collection was through direct interviews with the 50 farmers of whom 45% were women and 5 key informants that consisted of three local council members and two extension staff in each district. A farmer in this context was that individual who had access to tamarind trees and harvested their fruits either ex-situ or in-situ trees, either sold or consumed from home or both. Descriptive statistics was used to analyse the data.

**Extraction of tamarind pulp**

50kg of high quality and freshly harvested ripe fruits from each of the two provenances; sweet and sour were open-sundried by FGs. Upon arrival at HFP unit, it was weighed and soaked in 100 litres of hot water at a temperature of 40 – 45°C for one to two hours to increase the pulp recovery yield. The soaked fruit was stirred regularly after every 20 minutes with a wooden stick.
Table 1. Utilization of tamarind pulp expressed in percentage (%) response

<table>
<thead>
<tr>
<th>District</th>
<th>Flavour enhancer</th>
<th>Unpasteurized juice</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apac (n= 45)</td>
<td>65</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Soroti (n=56)</td>
<td>95</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Katakwi (n=60)</td>
<td>76</td>
<td>20</td>
<td>4</td>
</tr>
</tbody>
</table>

during the period of soaking. Pulp from the soaked fruit was extracted using local food grade tamarind pulp extractor developed by Agricultural Engineering Appropriate Technology Research Centre – Namalere, which automatically removes seeds and unwanted fibre.

Formulation of new tamarind-based products

The hygienically extracted pulp was used in development of new tamarind-based products. The Broomfield (1996) recipes for tomato sauce, chilli sauce, jams and marmalade were adapted to design formulae of the new tamarind-based products: paste/sauce, tam-chilli, jam and marmalade. Both sweet and sour tamarind provenances were used to produce two versions of each product. Several prototypes were formulated and the most acceptable provenance(s) for a particular product was used to develop the final product. The different product prototypes were processed by HFP.

Sensory evaluation of the newly formulated prototypes

Sensory evaluation was conducted using a controlled taste panel of 24 individuals (50% females and 50% males) from National Agricultural Research Laboratories (NARL), Kawanda. Their task was to assess the acceptability of the products based on hedonic scale of 1-9 as well as products culinary attributes. To avoid taste panel bias, Rand-between Excel function was used to code samples. Thereafter, samples were served to a controlled panel. Using a designated score sheet, product preferences were recorded. A simple T-test of preference was used to determine statistical differences between the choices made by the taste panel.

Determination of safety of the new products

Astringency in all developed products was determined by assessing the tannin levels using AOAC (1990) method based on catechin equivalence. The microbiological safety of product was determined by standard method derived from ICMSF (1978) used for enumeration of yeasts and moulds in tamarind kernels and products. However, the aflatoxin contamination; toxic products of mould growth in new tamarind products were determined by a flatest quick fluorometer procedure (VICAM L. P, USA) in the four tamarind products developed from the two provenances.

Market testing of new tamarind-based products

A market survey using a structured questionnaire was conducted to evaluate the market potential of the newly developed tamarind-based products. The study was conducted in the core project districts of Apac, Soroti and Katakwi and districts unfamiliar with tamarind products; Mbarara, Ibanda, Kasese and Kabarole. Several protocols varying according to product were prepared to serve the newly developed products to the respondents. Whereas tamarind sauce and tam-chilli were put on steamed rice, jam and marmalade were applied as spread on purposely baked tasteless bread to enhance the taste of tamarind products. In each district, 60 potential consumers (30 females and 30 males) were targeted and each product was served to the potential consumer with zero interference from other consumers. A simple question was asked whether they liked the product or not and the responses were recorded and analysed using t-test.

RESULTS

Tamarind fruit production, postharvest handling practices and on-farm utilization

The findings of the survey confirmed the traditional use of tamarind pulp as flavour enhancer (Table 1) in various foods like millet porridge/bread and amukeke (dried sweet potato chips) in the Eastern and Northern regions of Uganda. Farmers reported that both the ripe fruit pulp and two months old unripe fruit pulp were used as flavour enhancers in food preparations. Other uses for ripe tamarind pulp included locally made unpasteurized juice, roots, bark and leaves as medicine for various ailments.

Farmers reported that on average, each mature tamarind tree had the potential to yield 5,000Kg per fruiting season which occurred from June to August. The yield depending on location, variety and level of pest infestation. Accessibility to tamarind trees varied with districts (Table 2). However, accessibility did not necessarily translate into increased yield. For example, 50.5% of Soroti farmers harvested less than 50Kgs and yet almost the same number harvested over 300Kgs in Apac district. On the contrary, farmers in Katakwi, could hardly harvest 5 basins per individual. The amount of fruit
Table 2. Average quantity of fruit harvested every time a farmer visited accessible tamarind trees

<table>
<thead>
<tr>
<th>District</th>
<th>1-5 trees</th>
<th>&gt;5 trees</th>
<th>Quantity harvested (Kgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apac (n= 45)</td>
<td>90.3</td>
<td>9.7</td>
<td>50</td>
</tr>
<tr>
<td>Soroti (n=56)</td>
<td>100</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>Katakwi (n=60)</td>
<td>60</td>
<td>40</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 3. Percentages of farmers applying different storage practices for dried tamarind fruit

<table>
<thead>
<tr>
<th>District</th>
<th>Propylene bags</th>
<th>Jerry-cans</th>
<th>Others (open air)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shelled</td>
<td>Unshelled</td>
<td>Shelled</td>
</tr>
<tr>
<td>Apac (n= 45)</td>
<td>29.0</td>
<td>9.7</td>
<td>10.34</td>
</tr>
<tr>
<td>Soroti (n=56)</td>
<td>0</td>
<td>22.7</td>
<td>0</td>
</tr>
<tr>
<td>Katakwi (n=60)</td>
<td>60</td>
<td>40</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4. The level of tamarind trade in selected Urban Centres

<table>
<thead>
<tr>
<th>Urban Centre</th>
<th>No. Traders</th>
<th>Percentage of traders (%)</th>
<th>Period of time in trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katakwi</td>
<td>3</td>
<td>51.7</td>
<td>&gt; 10 years</td>
</tr>
<tr>
<td>Soroti</td>
<td>20</td>
<td>60</td>
<td>&gt; 10 years</td>
</tr>
<tr>
<td>Lira</td>
<td>5</td>
<td>100</td>
<td>&lt; 3 years</td>
</tr>
<tr>
<td>Apac</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jinja</td>
<td>4</td>
<td>50</td>
<td>&gt; 10 years</td>
</tr>
<tr>
<td>Kampala:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• St.</td>
<td>3</td>
<td>66.7</td>
<td>&gt; 10 years</td>
</tr>
<tr>
<td>Bakiuddembe</td>
<td>9</td>
<td>33.3</td>
<td>&gt; 5 years</td>
</tr>
<tr>
<td>• Nakawa</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

harvested was demand driven according to 99.9% of the respondents. The mode of harvesting also varied with district although the majority climbed the tree to harvest the fruit as evidenced by 68.2% in Soroti, 77.4% in Apac and 100% in Katakwi. The other methods of harvesting included hitting the fruit with long sticks or plucking it off from the low hanging branches and shaking the tree. Generally the mode of drying was similar in the three project districts. Fruit was left in-shell and dried on bare ground. This was done by 72.7% Soroti 80% in Katakwi and 98% in Apac and remaining percentage dried fruit on mats or polythene sheets. After drying most farmers (85%) stored fruit in sacks or containers like tins or pots.

All respondents reported that during storage, the fruit developed moulds. They gave various reasons for mould growth including coldness/ moisture (90.9%) and poor storage (2%). As an intervention measure, some farmers re-dried the fruit (12.9% in Apac). Otherwise, most farmers discarded mouldy fruits. In Soroti, 86.4% of the respondents harvested fruit for marketing purposes and a notable 50% of these sold as much as three quarters of the harvest. The number of traders and their involvement in tamarind fruit trade varied with urban centres (Table 4). About 70% in Soroti and 47.6% of the respondents in other market outlets reported that dealing with tamarind was quite lucrative. About 52.4% of the traders described the trade as insignificant. The major constraint for most of the traders was ready market and its sustainability through establishment of tamarind plantations. When asked about willingness to establish tamarind plantations and participate in tamarind-based businesses, 96.8% of the respondents in Soroti, 90.9% in Apac and 100% in Katakwi responded in affirmative. Despite the abundant tamarind trees, all respondents in all main districts reported that neither government nor Non-governmental organizations had had deliberate interventional programmes to promote the tamarind fruit within the region until the present study. In terms of provenances, 75% of the respondents in Soroti sold the sour provenance and 25% sold the sweet one. In Katakwi, 33.3% of the respondents sold the sour provenance and 66.7% sold both. A similar trend was observed in all other markets surveyed.

However, all respondents said that the sour provenance had a higher demand of 76% than sweet at 24%. In Soroti, the demand for the sour provenance was linked to the final use. Preference varied with districts although some respondents could utilize
whatever provenance was available as evidenced in Apac (Table 5).

The choice of the variant was related to the utilization option. In Soroti, respondents who preferred the sweet provenance based on chewing properties (11.1%) while in Katakwi the choice was based amount used to enhance the desired taste. For instance, when sweet provenances were used, little sugar was required to obtain the desired taste. The sour provenance apparently tasted better in millet bread or porridge (33.3%) than the sweet one. About 78.6% of the total respondents in Katakwi used tamarind as food flavouring while the 14.3% did not.

Generally, most of them used tamarind as a food flavour in their foods (94.4%) in Soroti, 69.4% in Katakwi. In Apac 73.9% used tamarind food flavouring, 26.1% transformed pulp into juice and 4.3% sucked the fruit pulp. With regard to other tamarind based products, 75% of the respondents in Soroti, 96.4% in Katakwi were not aware of any tamarind based products on the market while 3.6% and 25% respectively knew of only juice. In Apac, 78.3% of the respondents knew about fruit juice while 21.7% had not seen any tamarind-based product on the market.

### Development of new tamarind-based products

Prototypes of jam, marmalade, sauce and tam-chilli were developed from both sour and sweet tamarind provenances in partnership with HFP. Products were packaged in plastic bottles or jars and appropriately labelled with nutritional information caption. Although HFP production was on request, a day’s production varied with type of product (Table 6). Commercial viability of a product is dependent on consumer acceptability and production cost among other variables like competition with similar products or other firms. The HFP unit production inputs included cost of raw materials, power, labour, water and fixed costs (Table 6).

The new products were then subjected to sensory evaluation for consumer acceptability and the showed that about 87.25% and 76.45% of the controlled panel preferred jams and sauces respectively made from sweet tamarind provenances while 67.48% and 82.27% preferred marmalade and tam-chilli made from the sour provenances respectively. Consumers normally perceive culinary attributes of various products differently (Table 7). Generally, preference with regard to applicability of the preserves (jams/marmalades) in descending order...
Table 8. Nutritional information of tamarind-based products (Expressed in %)

<table>
<thead>
<tr>
<th>Product</th>
<th>Provenance</th>
<th>Protein</th>
<th>Dry matter</th>
<th>Fibre</th>
<th>Fat</th>
<th>P</th>
<th>Ca</th>
<th>Energy (Kcal/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jam</td>
<td>Sweet</td>
<td>0.68</td>
<td>58.15</td>
<td>0.22</td>
<td>0.43</td>
<td>0.24</td>
<td>0.44</td>
<td>2.51</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>0.78</td>
<td>61.96</td>
<td>0.35</td>
<td>0.48</td>
<td>0.17</td>
<td>0.41</td>
<td>2.80</td>
</tr>
<tr>
<td>Marmalade</td>
<td>Sweet</td>
<td>0.47</td>
<td>55.68</td>
<td><em>1.46</em></td>
<td>0.39</td>
<td>0.31</td>
<td>0.43</td>
<td>2.49</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>0.56</td>
<td>58.62</td>
<td>1.85</td>
<td>0.42</td>
<td>0.28</td>
<td>0.49</td>
<td>2.55</td>
</tr>
<tr>
<td>Sauce</td>
<td>Sweet</td>
<td>0.81</td>
<td>25.09</td>
<td>0.21</td>
<td>0.15</td>
<td>0.25</td>
<td>0.43</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>0.82</td>
<td>28.97</td>
<td>0.25</td>
<td>0.15</td>
<td>0.26</td>
<td>0.44</td>
<td>0.94</td>
</tr>
<tr>
<td>Tam-chilli</td>
<td>Sweet</td>
<td>0.83</td>
<td>21.44</td>
<td>0.21</td>
<td>0.15</td>
<td>0.25</td>
<td>0.56</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>0.82</td>
<td>20.71</td>
<td>0.18</td>
<td>0.14</td>
<td>0.45</td>
<td>0.61</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Table 9. Quantitative analysis of yeasts, moulds and aflatoxin levels in tamarind products

<table>
<thead>
<tr>
<th>Product</th>
<th>Provenance</th>
<th>Yeast and Mould Count (CFU/g)</th>
<th>*Aflatoxin Level (µg/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marmalade</td>
<td>Sweet</td>
<td>&lt;10</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>&lt;10</td>
<td>0.04</td>
</tr>
<tr>
<td>Jam</td>
<td>Sweet</td>
<td>&lt;10</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>&lt;10</td>
<td>0.04</td>
</tr>
<tr>
<td>Sauce</td>
<td>Sweet</td>
<td>&lt;10</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>&lt;10</td>
<td>0.03</td>
</tr>
<tr>
<td>Tam-chilli</td>
<td>Sweet</td>
<td>&lt;10</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>&lt;10</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*WHO and UNBS general allowable limits for foods = 20ppb (20 µg/Kg).

Table 10. Prices (UGX) at which producers were willing to pay for every unit of respective products.

<table>
<thead>
<tr>
<th>Product</th>
<th>N</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jam</td>
<td>432</td>
<td>50,000</td>
<td>1,500</td>
<td>5,701.39</td>
<td>4,480.12</td>
</tr>
<tr>
<td>Sauce</td>
<td>427</td>
<td>40,000</td>
<td>700</td>
<td>3,908.67</td>
<td>3,427.23</td>
</tr>
<tr>
<td>Tam-chilli</td>
<td>398</td>
<td>60,000</td>
<td>500</td>
<td>3,411.06</td>
<td>4,154.55</td>
</tr>
<tr>
<td>Marmalade</td>
<td>424</td>
<td>50,000</td>
<td>1,000</td>
<td>5,762.03</td>
<td>4,534.36</td>
</tr>
</tbody>
</table>

Exchange rate; 1US$ = 2,650 UGX

was sweet jam, sweet marmalade, sour jam and sour marmalade. However there was no significant difference (p>0.05) in overall preference of preserves. Sweet jam had the highest while sour marmalade had the lowest preference score across most culinary attributes (preserves) and the difference was particularly significant from the respective sour provenance in terms of colour and astringency.

The most preferred among the sauces was sweet sauce followed by sweet chilli, sour sauce and sour chilli. Preference for sweet sauce was significantly different (p<0.05) from all other products made from sweet varieties with the exception of sweet chilli. Sweet sauce and sour chilli were significantly different in their taste, astringency and consistency.

Nutrient composition varied with the different tamarind based products developed from sweet and sour provenances (Table 8). Since the base material for all products was the tamarind pulp, the variance in nutrient content was due to other ingredients such as sugar, pectin, spices and stabilizers.

Microbiological safety of tamarind-based products

The results of the microbiological analyses shown in Table 9 indicated that regardless of the tamarind provenance, the developed products complied with World Health Organisation (WHO) as well as Uganda National Bureau of Standards (UNBS) allowable limits for aflatoxin in foods for human consumption.

Market testing of new tamarind-based products

Willingness to pay for the tamarind products

The amount of money potential consumers were willing to pay for 250 g of tamarind jam, 250g for marmalade; 400 g sauce and 200 g tam-chilli varied with product (Table 10). Whereas the maximum willing price for all products was way above the production costs highlighted in Table 6, the minimum prices were ridiculously low (Table 11). This may be indicative of the socio-economic status and exposure of some potential consumers in the rural areas...
who may not have seen or tasted the products previously. As such, they could not attach a high monetary value to an alien product to them. Tam-chilli had the least number of observations (N) because some respondents and especially females declined to taste it due to past experience with local chillies.

The mean willing price for each product irrespective of the type was appreciably above the production cost (Figure 1) which may be indicative of the profitability and commercial viability of any of the products when put on the market.

The mean willing price varied across districts (Figure 2). Evidently, potential consumers in districts where tamarind consumption was unfamiliar were willing to offer slightly higher prices for jam and marmalade than consumers in Apac and Soroti where tamarind was part of their diet. The mean willing prices for sauce and tam-chilli were persistently below the willing prices of jam and marmalade.

The mean willing price also varied by gender (Table 11). The women constantly offered lower prices than their male counterparts by a margin of 13.71% for jam; 14.21% marmalade and 16.04% for tam-chilli. This may be attributed to the low disposable income among women. Besides, women have to balance their meagre incomes between items considered priority and others deemed luxury. Probably, they considered tamarind based products to be luxuries compared to other domestic necessities.

Table 11. Willing-prices (UGX) by potential consumers for products disaggregated by gender

The exception was sauce where female consumers offered 3.78% more than the males. The difference between the two sexes with regard to maximum willing price was more evident. Even for sauce where they had offered more than the male counterparts, their maximum offer was still less by 50%. The willing price also varied by region (Table 12).

Respondents, who were actually farmers with access to tamarind trees in the Northern and Eastern region where tamarind trees grow either naturally or planted, offered lower prices for tamarind products than their counterparts in the Western region who had never seen tamarind trees. The difference was bigger with jam and marmalade whereas with sauce and chillies, non-tamarind Districts offered slightly lower prices than
Table 11. Willing-prices (UGX) by potential consumers for products disaggregated by gender

<table>
<thead>
<tr>
<th>Product</th>
<th>Gender</th>
<th>N</th>
<th>Willing Prices by Potential Consumers (UGX)</th>
<th>Mean</th>
<th>Std-deviation</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>Std-deviation</td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Jam</td>
<td>Male</td>
<td>318</td>
<td></td>
<td>5,915.41</td>
<td>4,872.117</td>
<td>50,000</td>
<td>3,500</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>114</td>
<td></td>
<td>5,104.39</td>
<td>3,078.368</td>
<td>15,000</td>
<td>1,500</td>
</tr>
<tr>
<td>Sauce</td>
<td>Male</td>
<td>313</td>
<td></td>
<td>3,868.05</td>
<td>3,499.359</td>
<td>40,000</td>
<td>2,500</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>114</td>
<td></td>
<td>4,020.18</td>
<td>3,233.157</td>
<td>20,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Tam-chilli</td>
<td>Male</td>
<td>293</td>
<td></td>
<td>3,561.77</td>
<td>4,681.358</td>
<td>60,000</td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>105</td>
<td></td>
<td>2,990.48</td>
<td>3,283.871</td>
<td>10,000</td>
<td>1,500</td>
</tr>
<tr>
<td>Marmalade</td>
<td>Male</td>
<td>313</td>
<td></td>
<td>5,984.66</td>
<td>4,869.847</td>
<td>50,000</td>
<td>10,000</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>111</td>
<td></td>
<td>5,134.23</td>
<td>3,355.552</td>
<td>20,000</td>
<td>3,500</td>
</tr>
</tbody>
</table>

Exchange rate: 1US$ = 2,650 UGX

Table 12. Willing prices (UGX) for tamarind products per region

<table>
<thead>
<tr>
<th>Product</th>
<th>Region</th>
<th>N</th>
<th>Willing prices by potential consumers (UGX)</th>
<th>Mean</th>
<th>Std (sd)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jam</td>
<td>Northern &amp; Eastern</td>
<td>216</td>
<td></td>
<td>5337.96</td>
<td>3853.243</td>
<td>1500</td>
<td>30,000</td>
</tr>
<tr>
<td></td>
<td>Western</td>
<td>216</td>
<td></td>
<td>6064.81</td>
<td>5012.335</td>
<td>2000</td>
<td>50,000</td>
</tr>
<tr>
<td>Sauce</td>
<td>Northern &amp; Eastern</td>
<td>216</td>
<td></td>
<td>3926.85</td>
<td>3063.168</td>
<td>500</td>
<td>20,000</td>
</tr>
<tr>
<td></td>
<td>Western</td>
<td>211</td>
<td></td>
<td>3890.05</td>
<td>3770.985</td>
<td>700</td>
<td>40,000</td>
</tr>
<tr>
<td>Tam-chilli</td>
<td>Northern &amp; Eastern</td>
<td>212</td>
<td></td>
<td>3427.83</td>
<td>3732.479</td>
<td>1000</td>
<td>35,000</td>
</tr>
<tr>
<td></td>
<td>Western</td>
<td>186</td>
<td></td>
<td>3391.94</td>
<td>4598.871</td>
<td>400</td>
<td>60,000</td>
</tr>
<tr>
<td>Marmalade</td>
<td>Northern &amp; Eastern</td>
<td>213</td>
<td></td>
<td>4948.83</td>
<td>3553.746</td>
<td>1000</td>
<td>25,000</td>
</tr>
<tr>
<td></td>
<td>Western</td>
<td>211</td>
<td></td>
<td>6582.94</td>
<td>5226.589</td>
<td>2000</td>
<td>50,000</td>
</tr>
</tbody>
</table>

Exchange rate: 1US$ = 2,650UGX

Tamarind Districts. The explanation to this difference would be derived from the fact that, being utilized overtime, in both raw and semi-processed forms, consumers in the east and north where tamarind is abundant perceived it to be a free resource that should not fetch a high premium.

DISCUSSION

Considering that the majority of respondents used tamarind as a flavour for food enhancement which is also widely practiced elsewhere (Lakshmi et al., 2005; Khurana and Ho, 1989), provides a viable opportunity for exploitation of tamarind fruit in Uganda. The development of tamarind-based products including jam, marmalade, sauce and tam-chilli diversified utilization base and enhanced economic potential for tamarind fruit and its products. With rigorous marketing there is a huge potential for these products in areas previously unaware of this wild tree. To illustrate the envisaged economic potential; if 500 potential consumers purchased tamarind jam at the willing mean price of UGX 5,700 per 250 g jar of product every month, it is possible for the manufacturer to earn UGX 17,414,000 (UGX 34,200,000 gross minus UGX 6,786,000 production cost + UGX10,000,000/= ascribed to market fluctuations and current 6% inflation in the economy) per year which is equivalent to US$ 7,000. However, with expanded consumer and product base, the profit margin can easily reach US$ 10,000. Through the trickle-back effect, the current impoverished economic status of the rural folk in the Eastern and Northern part of Uganda can be transformed albeit marginally. Since the quantities of tamarind fruit was harvested on demand by the market, creation of demand at the tail-end of the value-chain inevitably increases quantities of tamarind fruits harvested. According to Blanchard (2010), the most ideal practice for creating demand is to rigorously market the product as a strategy to increase its consumption. For a product to be consumed, it has to be accepted and affordable by consumers. Sensory evaluation greatly influences the acceptance and purchasing intention of products (Sabbe et al., 2009). The exposure of products to the Western and Central regions of the country was an attempt to expand the market for the new tamarind products. Since the new market niches were willing to pay at least 15% more than their counterparts in either East or North of the country, they would provide a lucrative market for the tamarind products. As such, the potential for Uganda to earn comparable incomes with India and Thailand (Gunasena and Hughes, 2000) exists as demonstrated by the profit margin above. India and Thailand earned the equivalent of US $.11 million and US$ 15.23 million annually respectively from the export of tamarind-based products in 1998. For sustainability and simultaneous compliance to consumer culinary demands, HFP has to increase production of value-added tamarind products substantially. On the other hand, farmers have to improve their handling practices, increase harvested quantities...
that meet the requirements of the expanded market and closely network with industrialists. This calls for
domestication of tamarind trees to ensure sustainable
supply of quality raw materials. According to Leakey
(1999), domestication of agroforestry trees alleviates
poverty and rehabilitates the environment within the
tropics and this approach depends on the expansion of
the market demand for non-timer forest products like
jams and marmalades.

India and Thailand have benefited immensely from the
tamarind based products because of the export market.
For Uganda to equally benefit from her tamarind resource
she needs to export and to do so, exportable products
have to comply with quality and safety standards.
Relevant results attained during the present study
indicated that all products developed complied with
quality and safety standards. This is in compliance with
an ever-increasing global demand from consumers for
high-quality foods with major emphasis on quality and
safety attributes (Ma et al., 2014; Verde et al., 2013) and
natural quality attributes like flavour and taste
(García-Parra et al., 2011). Lapses in safety standards do
not only adversely impact the health of consumers but
may ruin the reputation and financial health of offending
company (Bates et al., 2001). Undoubtedly, ruined
reputation for a food company undermines marketability
of the product(s). As such, food processing plants like
HPF have to invest in mechanisms that ensure quality
and safety of products to guarantee their marketability.

One of the many consumer demands is the desire for
minimally processed, high-nutrition/low-energy natural
foods with no or minimal chemical preservatives
(García-Parra et al., 2011). Although tamarind pulp is
relatively poor in protein, fat and fibre (Table 9), it is a rich
source of minerals such as calcium, phosphorus, zinc,
iron, magnesium and potassium (Ishola et al., 1990).
However, a recent Uganda demographic health survey
(UDHS) by Uganda’s Ministry of Health (MoH) showed that
23% of the child bearing women (15-49) and 50% of
children less than 5 years of age were classified as
anaemic (MoH, 2011). This severe hidden hunger among
vulnerable communities in Uganda is unacceptable when
tamarind fruit is locally available and laden with
micronutrients.

CONCLUSION

The value-addition among the diverse utilization options
for Tamarind (Tamarindus indica L) offers opportunities
for its exploitation. The positive responses from the
consumers in areas where tamarind products were not
previously available indicated that demand for tamarind-
based products was relatively high. With market
expansion to the western region of Uganda and probably
other parts of the country like cosmopolitan city of
Kampala, farmers from North and Eastern Uganda will
boost their sales of high quality unprocessed pulp. This
activity will inevitably improve their incomes from the
tickle-back effect of accrued profits of processing plants
like HFP.

RECOMMENDATIONS

Further research should be undertaken to refine tamarind
pulp as food enhancer because the current artificial
enhancers are being phased out based on health
grounds. In addition, isolation of tamarind tree
components with medicinal properties should be carried
out to verify assertions made in the study. A
comprehensive cost benefit analysis should be
undertaken to examine the profitability of tamarind-based
enterprises in Uganda.

ACKNOWLEDGEMENTS

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REFERENCES

Bates RP, Morris JR, Crandall PG (2001). Principles and practices of
small-and medium-scale fruit juice processing (No. 146). Food &
Agriculture Organization. Pg 23

Wiley & Sons. pg 13

Broomfield RW (1996). The manufacture of preserves, flavourings and
dried fruits. In Fruit Processing (pp. 165-195). Springer US.

El-Siddig K, Gunnessena HPM, Prasad BA, Pushpakumana DKN, G
(Tamarindus indica L). International Centre for underutilized Crops,
Southampton. Pg 13.

García-Parra J, González-Cebriño F, Delgado J, Lozano M, Hernández
T, Ramírez R (2011). Effect of Thermal and High-Pressure
Processing on the Nutritional Value and Quality Attributes of a
Nectarine Purée with Industrial Origin during the Refrigerated
Storage. Journal of food science, 76(4), C618-C625.

(Tamarindus indica L). International Centre for underutilized Crops,

Ishola MM, Agbaji EB, Agbaji AS (1990). A chemical study of
Tamarindus indica (Tsamiya) fruits grown in Nigeria. J. Sci. Food
Agric., 51: 141–143. doi: 10.1002/jsfa.2740510113

Jadhav DY, Sahoo AK, Ghosh JS, Ranveer RC, Mali AM (2010).
Phytochemical detection and in vitro evaluation of tamarind fruit pulp
for potential antimicrobial activity. International Journal of Tropical
Medicine, 5(3), 69-72.

Khurana AL, Ho CT (1989). HPLC Analysis of Nonvolatile Flavor
Components in Tamarind (Tamarindus indica L). Journal of liquid
chromatography, 12(3), 419-430.

Quality evaluation of flavoured RTS beverage and beverage
concentrate from tamarind pulp. Journal of Food Science and
Technology (India), 42(5), 411-415.

Leakey RR (1999). Potential for novel food products from agroforestry
trees: a review. Food chemistry, 66(1), 1-14.

MoH, 2011. Ministry of Health household demographic health survey among vulnerable communities of Uganda. Study conducted by FANTA


