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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

source of essential amino acids and fatty acids which are vital in animal feed formulations. Leaves are used as vegetables in some countries since they contain 4.0-5.8% protein which alleviates malnutrition in impoverished communities. Leaves can also be used as fodder for domestic animals (Kaitho *et al*., 1988). With such glowing attributes, development and promotion of tamarind based products in Uganda would go a long way in mitigating nutritional as well medical conditions if adequately exploited.

Economically, Uganda can benefit from tamarind through well designed interventions that can enhance production, processing, marketing and utilization of tamarind-based products. In countries like India, Thailand Mexico, Indonesia, Philippines and Costa Rica where tamarind is exploited for commercial uses, their economies have grown tremendously in the last two decades (Gunasena and Hughes, 2000). On the contrary, in Uganda where its usefulness is restricted to food flavour enhancement at domestic level, the economic benefits are dismal. The underutilization of tamarind was attributed to lack of processing technologies/ options and market information. The purpose of the study was to develop commercially value-added products, generate relevant information and package it for key players 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^{o}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

District	Flavour enhancer	Unpasteurized juice	Other
Apac (n= 45)	65	25	10
Soroti (n=56)	95	3	2
Katakwi (n=60)	76	20	4

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 a spread on purposively 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

District	1-5 trees	>5 trees	Quantity harvested (Kgs)
Apac (n= 45)	90.3	9.7	50
Soroti (n=56)	100	0	200
Katakwi (n=60)	60	40	20

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

District	Propylene bags		Jerry-cans		Others (*open air*)	
	Shelled	Unshelled	Shelled	Unshelled	Shelled	Unshelled
Apac (n= 45)	29.0	9.7	10.34	25.5	16.1	9.36
Soroti (n=56)	0	22.7	0	77.3	0	0
Katakwi (n=60)	60	40	-	-	-	-

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

Urban Centre	No. Traders	Percentage of traders (%)	Period of time in trade
Katakwi	3	51.7	> 10 years
Soroti	20	60	> 10 years
		40	> 5 years
Lira	5	100	< 3 years
Apac	None		
Jinja	4	50	>10 years
Kampala: -			
• St.	3	66.7	> 10 years
Balikuddembe	9	33.3	> 5 years
• Nakawa			

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. In Apac, 51.6% of respondents sometimes sold tamarind especially to people who make liquor. Only 9.7% of those who sold the fruit sold up to half 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

Table 5. Level of tamarind preference among consumers

	Percentage preference of provenances		
District	**Sweet**	**Sour**	**Both**
Apac	39.1	43.5	17.4
Soroti	5	95	-
Katakwi	17.9	82.1	-

Table 6. Production estimates at Hometech Food Processing *(*HFP

Product	Unit quantity (g)	No. of units per day	Estimated Annual (271 days) No. Units	Unit production cost (UGX)
Jam	250	1,600	433,600	1,131
Marmalade	250	1,600	433,600	1,401
Sauce	400	600	162,600	2,583
Tam-chilli	250	1,200	325,200	1,292

Table 7. Statistical analysis of culinary attributes of tamarind products

Product	Provenance	Taste	Colour	Astringency	Consistency	Applicability
Marmalade	Sweet	$^{ba}6.29^{\pm 2.29}$	$^{a}6.79^{\pm 1.28}$	$^{ba}6.5^{\pm 1.38}$	$^{ba}6.67^{\pm 0.96}$	$^{ba}7.12^{\pm 1.75}$
	Sour	$^{bdac}5.62^{\pm 2.00}$	$^{b}5.79^{\pm 1.82}$	$^{bc}5.92^{\pm 1.35}$	$^{bc}5.96^{\pm 1.20}$	$^{bac}6.67^{\pm 1.49}$
Jam	Sweet	$^{a}6.88^{\pm 2.15}$	$^{a}7.17^{\pm 1.34}$	$^{a}7.17^{\pm 1.34}$	$^{a}7.21^{\pm 1.50}$	$^{a}7.58^{\pm 1.41}$
	Sour	$^{bdac}5.75^{\pm 2.21}$	$^{cb}5.62^{\pm 1.76}$	$^{bc}5.92^{\pm 1.53}$	$^{ba}6.62^{\pm 1.53}$	$^{ba}6.92^{\pm 1.93}$
Sauce	Sweet	$^{bac}5.92^{\pm 2.45}$	$^{cb}5.46^{\pm 1.69}$	$^{b}6.12^{\pm 1.45}$	$^{ba}6.5^{\pm 1.10}$	$^{ba}6.92^{\pm 1.25}$
	Sour	$^{dc}4.54^{\pm 2.08}$	$^{cb}5.21^{\pm 1.38}$	$^{d}4.71^{\pm 1.73}$	$^{bc}5.83^{\pm 1.97}$	$^{dc}5.79^{\pm 2.08}$
Tam-Chilli	Sweet	$^{bdc}4.92^{\pm 2.92}$	$^{cb}5.50^{\pm 1.98}$	$^{dc}5.04^{\pm 2.48}$	$^{bc}6.08^{\pm 1.82}$	$^{bdc}6.17^{\pm 1.97}$
	Sour	$^{d}4.38^{\pm 2.34}$	$^{c}4.71^{\pm 1.99}$	$^{d}4.37^{\pm 2.02}$	$^{c}5.54^{\pm 1.41}$	$^{d}5.58^{\pm 1.84}$

Different letter denotes significant difference between means ($p<0.05$) while same letters within a column denotes insignificant difference at $p>0.05$.

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 %)

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

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

Product	Provenance	Yeast and Mould Count (CFU/g)	*Aflatoxin Level (µg/Kg)
Marmalade	Sweet	<10	0.03
	Sour	<10	0.04
Jam	Sweet	<10	0.05
	Sour	<10	0.04
Sauce	Sweet	<10	0.03
	Sour	<10	0.03
Tam-chilli	Sweet	<10	0.07
	Sour	<10	0.07

*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.

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

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

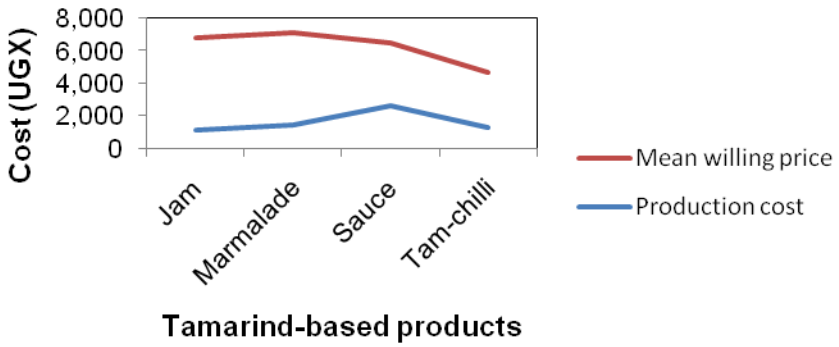

Figure 1. The mean willing price in comparison with unit production of each tamarind product

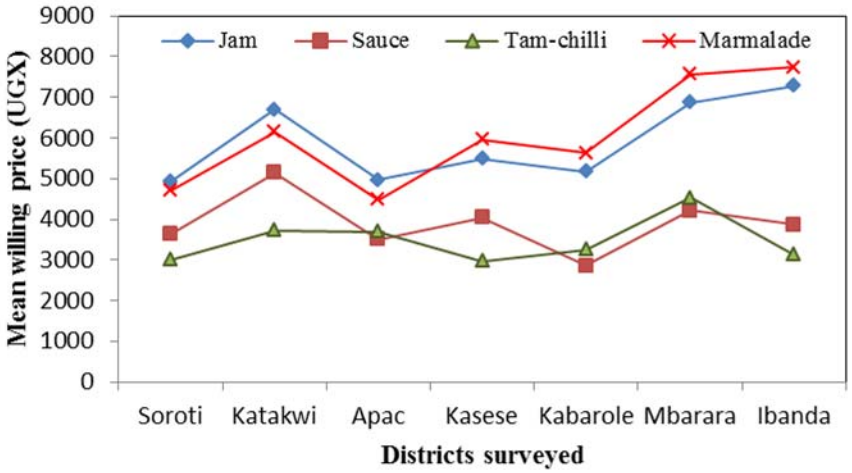

Figure 2. Mean willing-price (UGX) for tamarind-based products in respective districts.

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

Product	Gender	N	Willing Prices by Potential Consumers (UGX)			
			Mean	Std-deviation	Maximum	Minimum
Jam	Male	318	5,915.41	4,872.117	50,000	3,500
	Female	114	5,104.39	3,078.368	15,000	1,500
Sauce	Male	313	3,868.05	3,499.359	40,000	2,500
	Female	114	4,020.18	3,233.157	20,000	3,000
Tam-chilli	Male	293	3,561.77	4,681.358	60,000	5,000
	Female	105	2,990.48	2,028.381	10,000	1,500
Marmalade	Male	313	5,984.66	4,869.847	50.000	10,000
	Female	111	5,134.23	3,355.552	20.000	3,500

Exchange rate; 1US$ = 2,650 UGX

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

Product	Region	N	Willing prices by potential consumers (UGX)			
			Mean	sd	Minimum	Maximum
Jam	Northern & Eastern	216	5337.96	3853.243	1500	30,000
	Western	216	6064.81	5012.335	2000	50,000
Sauce	Northern & Eastern	216	3926.85	3063.168	500	20,000
	Western	211	3890.05	3770.985	700	40,000
Tam-chilli	Northern & Eastern	212	3427.83	3732.479	1000	35,000
	Western	186	3391.94	4598.871	400	60,000
Marmalade	Northern & Eastern	213	4948.83	3553.746	1000	25,000
	Western	211	6582.94	5226.589	200	50,000

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-timber 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 trickle-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.

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