Global Science Research Journals

ISSN: 2408-5472 Vol. 5 (1), pp. 210-217, January, 2017.

http://www.globalscienceresearchjournals.org/

Global Journal of Food Science and Technology

Full Length Research Paper

Use of baobab powder as a source of pectin in the synthesis of high quality jams

Shizo Kitano and Matsuo Zenko

Laboratory of Food Biosystems and Environment United Graduate School of Agriculture, Kagoshima University, 1-21-24 Korimoto, Kagoshima 890-0065, Japan.

Accepted 18 December, 2016

Baobab (*Adansonia digitata* L.) powder has high gelling capacity, but its potential has not been exploited. In the present study, baobab powder was assessed as a potential alternative for commercial pectin in jam making. Its gelling ability and potential use was compared to that of commercial pectin in the production of jam from different indigenous fruits available in Tanzania. Jams were produced from indigenous fruits obtained from various areas of Tanzania including, Smelly-berry (*Vitex mombassae*), Wild loquat (*Uapaca kirkiana*) and Marula plum (*Sclerocarya birrea*) using lemon extract, commercial pectin and baobab (*Adansonia digitata* L.) powder as sources of pectin. Total soluble solids (TSS) and total titratable acidity (TTA) for fruit pulps and jams were measured to obtain the required acid to sugar ratio for quality jam. Pectin content of the fruit pulps, baobab and lemon extract were also determined. Shelf life of jams stored at room temperature was monitored for six months by determining moisture content, TSS, TTA, and microbiological changes. Sensory evaluation of the jams was performed to assess consumers' preference among the produced jams. Findings of this study reveal that, TSS ranged from 11.6% in *Adansonia digitata* L. to 16.9% in *Uapaca kirkiana.* TTA was highest in *Adansonia digitata* L. (2.27%) and lowest in *Uapaca kirkiana* (0.05%). Pectin content in fruits was highest in *Adansonia digitata* L. (2.56 %) and lowest in *Vitex mombassae* (0.12%). Jams formulated without addition of pectin were inferior in quality. Commercial pectin and baobab powder produced jams which did not differ significantly ($p<0.05$) in moisture content, TSS and TTA. Jams formulated with commercial pectin and baobab powder were of acceptable quality up to six months. Sensory evaluation revealed that jam produced from *Sclerocarya birrea* was significantly ($p<0.05$) superior in all sensory attributes compared to other fruits. The use of baobab powder as a source of pectin gave high quality jams, which compared favorably with that of commercial pectin.

Key words: Indigenous fruits, jam, baobab powder, pectin.

INTRODUCTION

Baobab (*Adansonia digitata* L.) is a large tree in the Western Coast of Africa and Egypt, sometimes attaining large dimensions of about 25 feet in diameter. *A. digitata* L. has been reported to have high gummy substance called pectin, which is found naturally and has high gelling ability (Sidibe and Williams, 2002). Pectin is found in most fruits, some in large varying amounts
. Some fruits provide enough pectin for jam making, whilst others need to have pectin added from another source. A fruit, which has high pectin content, can be added and blended with a fruit that have low pectin content to give an adequate

*Corresponding author: E-mail: shizo.kitano@yahoo.com

amount required for jam making. The gelling potential of baobab powder is unfamiliar to both small and large-scale food processors due to limited information on its characteristics. There is lack of specification on process parameters of its application to enable replication or production of consistent products, a requirement for successful commercialization. It is therefore, necessary to establish the shelf life that is normally marked on the product label as required by the local and international Food Standards. Utilization of baobab powder that is an essentially and organically produced ingredient in jam gelling technology could attract a niche market locally, regionally and internationally. The baobab fruits are either stored in whole until food is prepared or the pulp powder is extracted and stored in dry state. The use of baobab powders in food preparation is almost exhaustively limited to cool and hot drinks and gruels. Baobab powder, in addition to desirable gelling qualities, provides vitamin C ranging from 209 mg to 360 mg/100g and is also rich in carbohydrates, calcium and potassium (Arnold, 1985; Ndabikunze et al., 2002). Domestication and commercial-lization of some indigenous fruits initiatives in Eastern and Southern Africa (Akinnifesi et al., 2004, 2006), are expected to increase utilization of indigenous fruits in the future. Postharvest losses in indigenous fruits from the Miombo ecozone have been reported to be as high as 59% (Mumba et al., 2002). Lack of technology on the processing of these fruits and inadequate information on the chemical properties increases the magnitude of losses. Many studies have focused on the provision of fresh produce of indigenous fruits out of the harvest. Studies on the nutritional and chemical composition of some indigenous fruits have been reported by several authors (Saka and Msonthi, 1994; Tiisekwa et al., 1996 Ndabikunze et al., 2000; Lockett et al., 2000), but their reports provide only a description of nutritional para-meters in different fruits. However, the consumer demand is likely to include better preservation methods as well as improved quality through processing techniques for both local and market consumption. This study therefore aimed at assessing the use of baobab powder as pectin source and its potential as an alternative to commercial pectin in preparation of jams from indigenous fruits (*U. kirkiana, V. mombassae,* and *S. birrea*) available in Iringa, Morogoro and Tabora Miombo woodlands, Tanzania. Organoleptic quality and shelf life of the produced indigenous fruit jams were also assessed.

MATERIALS AND METHODS

Fruit collection

Wild loquat (*U. kirkiana*) fruits were collected from Iringa forest areas in the Southern highlands and Smelly berry (*V. mombassae*) from cleared open areas in Tabora, Western Tanzania. Marura plum (*S. birrea*) fruits were collected from the forest, while Baobab (*A. digitata* L.) fruits were purchased from markets in Morogoro, Tanzania.

Fruit preparation

With exception of baobab, other fruits were thoroughly washed under running tap water to reduce soil, plant and debris load. Undamaged fruits with no symptoms of visible discoloration were selected and soaked in warm water (80°C) for 2 min to reduce surface microbial load.

Extraction of fruit pulp

Vitex mombassae fruits

The washed fruits were boiled for 5 min in equal amount of water (by weight) to soften the tough outer skin. The fruits were pulped in a mortar and pestle; and the crude mixture pulp and seeds were sieved through an 800-micron sieve.

Sclerocarya birrea

S. birrea fruits have a tough outer skin and the pulp is strongly attached to the fruit stone. The pulp was separated from the stone by using an egg-beater (Kenwood Mini Mixer Model A386 THORNEMI Domestic Electrical appliances Limited, New Lane, Hampshire, P09 2NH. England).

Uapaca kirkiana

U. kirkiana fruit has a soft friable skin which was cut and opened using a stainless kitchen knife to obtain a crude mixture, and the pulp was obtained using a similar procedure as described for *V. mombassae* fruits.

Adansonia digitata L. powder

The hard woody shells of the fruits were opened by hand using machete to obtain seeds, embedded in a whitish powdery soft pulp. The seeds were then ground using mortar and pestle to separate the pulp from the seeds. The mixture was sieved through a 0.09 micron sieve to obtain a fine powder. The powder was immediately packed in polyethylene bags sealed and stored in a dark cool place.

Chemical analysis

Moisture content of each fruit jam sample was determined according to AOAC standard method (AOAC, 2000) by accurately weighing 5 g of the sample and drying in an oven at 105C to constant weight. The total soluble solids of the fruits pulps and jam were determined using a hand refractometer (0 to 32% Brix, Model DIGT 0-32ATC for the pulp and 0 to 80% Brix Model DIGT 0-80ATC (The Optical Instruments Co. Ltd, Japan) for jam. The pH was measured using pH meter (Wagtech, Model 3305, Jenway Ltd, UK). Acidity (expressed as total titratable acidity; TTA) was determined according to AOAC standard method by titrating 10 ml of the pulps and juices against 0.1 M NaOH standard solution using phenolphthalein indicator (AOAC, 2000).

Pectin in fruit pulp and in baobab powder was determined using the Kirk and Sawyer (1991) methods with slight modification by first extracting with cold water followed by boiling water, and then filtering the extract. A total of 300 ml aliquot was collected for each fruit, while 100 ml of 0.1 M sodium hydroxide was added to the aliquot and allowed to stand overnight. Then, 50 ml of M acetic acid was added, followed by 50 ml of M $CaCl_2$ solution after 5 min. The mixture was then allowed to stand for 1 h and boiled for 5 min, after

Table 1. Chemical composition of indigenous fruits pulp (based on edible part) (n=4).

Element	Fruits				
	V. mombassae	***U. kirkiana***	***S. birrea***	***A. digitata***	**Lemon extract**
% TSS	12.33±0.16[c]	16.90±0.14[a]	13.30±0.19[b]	11.63±0.16[d]	ND
% TTA	0.14±0.03[c]	0.05±0.02[d]	0.44±0.03[b]	2.27±0.03[a]	ND
pH	3.56±0.04[b]	4.67±0.04 [a]	3.59±0.05[b]	3.4±0.04[b]	ND
% Pectin	0.12±0.05[d]	0.28±0.05[c]	0.17±0.08[d]	2.56±0.03 [a]	0.56±0.01[b]

Mean values within the row with different letters are statistically different at p > 0.05; ND: Not determined.

which it was then filtered. The residues were washed with boiled water until they were free from chloride. The washed residues were then dried and weighed as calcium pectate ($Ca_{17}CH_{22}O_{16}Ca$) and the amount of pectin was calculated as percentage of the dry sample.

Jam preparation

Pulps from the three fruits were processed into fruit jams according to the FAO guideline (FAO, 1997). Pectin from different sources was tasted for gelling capacity needed to produce acceptable jam. The sources of pectin were: the natural pectin in the fruit itself, commercial citrus powdered pectin, lemon-peel extract and baobab powder. For each fruit, jams were prepared by incorporating varying pectin source as follows:

(i) With commercial citrus pectin, a known amount of the commercial pectin equivalent to 0.5 % of the pulp was added to the pulp (CP).
(ii) With lemon extract as a source of pectin, the green peel of the lemon was first removed. The remaining white peel was removed and extracted by boiling one part with two parts of water for 30 min. Then, 100 ml of the pectin extract was added to each litre of the fruit pulp (LEP).
(iii) With *A. digitata* L. as a source of pectin, based on the results of initial trials, 50 g of baobab powder was added per one litre of the fruit pulp instead of commercial pectin (AP).

Total soluble solids (TSS), total titratable acidity (TTA) and pH were determined in the pulp before jam preparation in order to establish any additional requirement to meet the recommended acid to sugar ratio. The amount of sugar required (as total soluble solids) to meet the requirements of jam was calculated using the following formula:

$$\text{Sugar to be added} = \left[\frac{\text{TSS (final) - TSS (pulp)}}{100} \right] \cdot W$$

Where: TSS (final) = required sugar level of the jam (69%); TSS (pulp) = sugar level of the pulp as total dissolved solids; and W = Weight in gram of the pulp to be used.

The mixture was cooked to the desired TSS of 69% and checked by using a hand refractometer (Atago hand refractometer 0 to 80% Brix). Thereafter, the hot jam was filled into sterilized glass bottles, which were air tight closed and stored at room temperature (27 to 32°C). Storage stability of the prepared jams was assessed by following their changes in total soluble solids, titratable and volatile acidity, moisture content, total plate count, total coliforms, feacal coliforms, fungi and other physical changes.

Microbiological analysis

Microbiological analysis was performed according to the FAO Manual (FAO, 1995). The analysis was based on total plate count, total coliform and moulds growth in jam and was monitored every 28 days of storage time.

Acceptability tests

Sensory evaluation was carried out to assess consumers' preference using a 7-point hedonic scale ranging from dislike very much (1) to like very much (7) (Watts et al., 1989). Twenty panelists were used to evaluate the color, taste and general acceptance of the jam. Panelists were aged between 25 and 40 years. For each sample, 10 g of jam was served in white disposable plate with a slice of white bread. The plates were coded with three digit random numbers and randomized between panelists. The panelist assessed spreading behavior of the jam on the bread by applying the jam on a slice of bread and allowing the panelists to write their comments on the assessment form. The evaluation took place at 3.00 pm everyday for a period of 14 days.

Statistical analysis

Data were subjected to statistical analysis using SAS 6.12 (SAS statistical software for Windows, release 6.12, USA). The general linear model (GLM) was used to determine the differences (p<0.05) of means between the jams for each attribute. Means were compared using Duncan's multiple range test at p<0.05.

RESULTS AND DISCUSSION

Chemical composition of four indigenous fruits

The results in Table 1 showed the chemical composition of fruit pulps. The total soluble solids were significantly higher in *U. kirkiana* (p<0.05), while the lowest total soluble solids value was recorded in *A. digitata* L. The TSS values were compared favorably with those of conventional fruits, such as mangoes (14%), normally preferred for jam manufacture as was previously reported by Belitz and Grosch (1999). The acidity (TTA) of the pulps was highest in *A. digitata* L. and lowest in *U. kirkiana* (Table 1). The acidity value for *A. digitata* and *S. birrea* was comparable to those obtained by Belitz and Grosch (1999) for fresh edible portion of conventional

Table 2. Pectin contents in fruit jam of different formulations (n = 3).

Pectin source	Percentage pectin as Ca-pectate (w/w)				
	***V. mombassae* jam**	***U. kirkiana* jam**	***S. birrea* jam**	***A. digitata* jam**	**SE**
(CPT)	0.56^{b}	0.55^{b}	0.53^{b}	0.82^{a}	0.13
(LEP)	0.31^{b}	0.36 ^{b}	0.31^{b}	0.79^{a}	0.04
(APP)	0.51 ^{a}	0.48^{a}	0.50 ^{a}	-	0.03

Means values with different superscript letter within the same row are significantly deferent (p< 0.05).
CPT: with commercial pectin; LEP: with lemon extract as source of pectin; APP: *Adansonia digitata* powder as source of pectin; SE: Standard error of mean.

fruits. The level of acidity in fruit pulp has an influence on the gel formation, an important aspect in jam processing. On the other hand, *U. kirkiana* fruit pulp had significantly higher pH (p<0.05) when compared with other fruits. One of the critical control points in jam manufacturing is the pH of the fruit pulp in balancing the sugar and pectin in order to facilitate gel formation (Belitz and Grosch, 1999; Dauthy, 1995).

Pectin content was significantly high (p<0.05) in *A. digitata* L. powder (ca. 2.6%) as compared to other indigenous fruits which ranged between 0.12 and 0.28% (Table 1). The pectin content of *A. digitata* L. powder used in the current study was two times higher than that used in conventional fruits reported by Belitz and Grosch (1999) and Singh (1986). Lemon peel extract, which was used as a pectin source in the current study, contained only 0.5% pectin. These results indicate that *A. digitata* L. powder and lemon could be used as good sources of pectin in jam and jellies processing. The low level of acidity, TSS and pectin content in *V. mombassae* and *U. kirkiana* was probably due to ripeness of the fruits before processing, which was also observed by Fweja (2002) and Kansci et al. (2003) for mango fruits at different ripening stages.

Pectin in fruit jams formulations

The amount of pectin in fresh prepared fruit jams of different formulations is shown in Table 2. There was no significant difference in pectin content (p > 0.05) for all fruit jams with the same treatment with the exception of *A. digitata* L. jam that showed significantly higher pectin content (0.82%). The higher pectin content in jam treated with *A. digitata* L. powder (APP) and commercial pectin (CPT) as a pectin source was due to high content of pectin in *A. digitata* L powder and commercial pectin, respectively. This observation is supported by the results presented for *A. digitata* L. jam where the addition of other pectin sources resulted in higher pectin level beyond the recommended level (0.5%) of pectin as suggested by Belitz and Grosch (1999) for jam. The observation of the current study is consistent with the hard texture exhibited by *A. digitata* L. jam reported by Tiisekwa et al. (2002). These results show that *A. digitata* L. powder could be used as a good source of pectin in jam formulations.

The effect of storage time on pH of fruit jams

The result in Table 3 shows the effect of storage time on pH of jams. There was no effect of time on pH of all fruit jam formulations. For good quality jam, the right amount of acid and pectin ration is critical for gel formation and stability. The pH of jams formulated with (CPT), (LEP) and (APP) throughout the storage time was within the required range of 3.0 to 3.5 (FAO, 1997).

The effect of storage time on total soluble solids (TSS) of fruit jams

Time of storage did not have significant influence (p > 0.05) on the TSS in all fruit jams formulations (Table 4). In general, fruit jams treated with commercial pectin (CPT), lemon extract (LEP) and *A. digitata* L. powder (APP) maintained the recommended level of TSS above 65% (TBS, 1985; FAO, 1997) throughout the storage time. The ratio of acid, sugar and pectin might have contributed to the stability of the jam during storage time. According to Kirk and Sawyer (1991) and Beltiz and Grosch (1999), for jam to be kept longer, it must have a TSS value of at least 65%, pH (3.0 to 3.5) and pectin (0.5%), which was the case with all formulated jams.

The effect of storage time on the moisture contents of jams

Moisture content of the formulated jams is shown in Table 5. Storage time did not affect the moisture content recommended for jam by TBS (1985), Kirk and Sawyer (1991) and FAO (1997). The moisture content is maintained in the recommended range for a stable jam formulation.

Effect of storage time on total microbiological growth in jam

The microbial quality of jams at different time of storage

Table 3. The effect of storage time on pH of fruit jams (n=3).

Fruit jam formulation	pH				
	0 month	2 month	4 month	6 month	SE
V(CPT)	3.43^A	3.30^A	3.20^A	3.30^A	0.09
V(LEP)	3.34^A	3.30^A	3.16^A	3.20^A	0.08
V(APP)	3.44^A	3.48^A	3.37^A	3.37^A	0.08
U(CPT)	3.56^A	3.49^A	3.42^A	3.39^A	0.09
U(LEP)	3.32^A	3.33^A	3.42^A	3.18^A	0.09
U(APP)	3.47^A	3.44^A	3.18^A	3.18^A	0.09
S(CPT)	3.57^A	3.36^A	3.37^A	3.37^A	0.07
S(LEP)	3.50^A	3.43^A	3.36^A	3.36^A	0.07
S(APP)	3.36^A	3.38^A	3.36^A	3.10^A	0.07

Means within with different superscript letter in the same row are significantly deferent ($p < 0.05$). V: *Vitex mombassae* fruit; U: *Uapaca kirkiana* fruit; S: *Sclerocarya birrea* fruit;

A: *Adansonia digitata* fruit; CPT: produced with commercial pectin; LEP: produced with lemon extract as pectin and APP: *Adansonia digitata* powder as pectin; SE: Standard error of mean.

Table 4. The effect of storage time on total dissolved solids (TSS) of fruit jams (n=3).

Fruit jam formulation	Total Soluble Solids				
	0 month	2 month	4 month	6 month	SE
V(CPT)	67.77^A	67.57^A	67.63^A	67.76^A	0.3
V(LEP)	68.47^A	67.57^A	68.80^A	68.20^A	0.3
V(APP)	68.63^A	67.90^A	67.80^A	67.77^A	0.3
U(CPT)	68.53^A	67.97^A	67.97^A	68.73^A	1.0
U(LEP)	68.67^A	68.33^A	68.37^A	67.40^A	1.00
U(APP)	68.80^A	68.40^A	67.87^A	67.77^A	1.00
S(CPT)	67.53^A	68.56^A	68.60^A	68.67^A	0.68
S(LEP)	67.93^A	67.87^A	67.77^A	67.63^A	0.68
S(APP)	67.73^A	67.60^A	67.98^A	68.03^A	0.68

Means within with different superscript letter in the same row are significantly different ($p < 0.05$). V: *Vitex mombassae* fruit; U: *Uapaca kirkiana* fruit; S: *Sclerocarya birrea* fruit;

A: *Adansonia digitata* fruit; CPT: produced with commercial pectin; LEP: produced with lemon extract as pectin; APP: *Adansonia digitata* powder as pectin, SE: Standard error of mean.

Table 5. Effect of storage time on moisture content on fruit jams (n=3).

Fruit jam formulation	Percentage moisture W/W				
	0 month	2 month	4 month	6 month	SE
V(CPT)	31.74^A	33.08^A	30.03^A	31.04^A	0.40
V(LEP)	33.06^A	31.46^A	30.77^A	30.14^A	0.40
V(APP)	34.06^A	34.12^A	33.45^B	32.45^B	0.40
U(CPT)	32.35^A	31.07^A	31.90^A	32.10^A	1.68
U(LEP)	31.96^A	32.12^A	32.51^A	30.43^A	1.68
U(APP)	32.77^A	28.97^A	33.58^A	32.19^A	1.68
S(CPT)	32.92^A	34.26^A	31.10^A	31.21^A	5.44
S(LEP)	30.96^A	33.57^A	34.90^A	34.53^A	5.44
S(APP)	32.33^A	31.59^A	31.59^A	31.21^A	5.44

Means within with different superscript letter in the same row are significantly deferent ($p < 0.05$). V: *Vitex mombassae* fruit; U: *Uapaca kirkiana* fruit; S: *Sclerocarya birrea* fruit;

A: *Adansonia digitata* fruit; CPT: produced with commercial pectin; LEP: produced with lemon extract as pectin; APP: *Adansonia digitata* powder as pectin; SE: Standard error of mean.

Table 6. Effect of storage time on microbiological growth (TPC cfu/g) in jam (n=3).

Fruit jam formulation	Total Plate count TPC (cfu/g)				
	0 month	2 month	4 month	6 month	SE
V(WP)	<1x10$^{-2\ C}$	1x10$^{-2\ C}$	4x10$^{-2\ B}$	18x10$^{-2\ A}$	0.03
V(CPT)	<1x10$^{-2\ B}$	<1x10$^{-2\ B}$	<1x10$^{-2\ B}$	3x10$^{-2\ A}$	0.03
V(LEP)	<1x10$^{-2\ C}$	<1x10$^{-2\ C}$	2x10$^{-2\ B}$	6x10$^{-2\ A}$	0.03
V(APP)	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	0.03
U(WP)	<1x10^{-2B}	<1x10$^{-2\ B}$	8x10^{-2A}	8x10$^{-2\ A}$	0.02
U(CPT)	<1x10$^{-2\ A}$	<1x10^{-2A}	2x10^{-2A}	1x10$^{-2\ A}$	0.02
U(LEP)	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	2x10$^{-2\ A}$	2x10^{-2A}	0.02
U(APP)	<1x10$^{-2/B}$	<1x10$^{-2/B}$	1x10$^{-2\ B}$	3x10$^{-2\ A}$	0.02
S(WP)	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	2x10$^{-2\ A}$	1x10^{-2A}	0.03
S(CPT)	<1x10$^{-2\ B}$	<1x10$^{-2\ B}$	4x10$^{-2\ A}$	1x10$^{-2\ B}$	0.03
S(LEP)	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	0.03
S(APP)	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	1x10$^{-2\ A}$	1x10$^{-2\ A}$	0.03
A(WP)	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	<1x10$^{-2\ A}$	0.03

Means within with different superscript letter in the same row are significantly deferent (p < 0.05) V: *Vitex mombassae* fruit; U: *Uapaca kirkiana* fruit; S: *Sclerocarya birrea* fruit;

A: *Adansonia digitata* fruit; CPT: produced with commercial pectin; LEP: produced with lemon extract as pectin; APP: *Adansonia digitata* powder as pectin, WP: Without addition of pectin; SE: Standard error of mean.

is shown in Table 6. Jam formulated without addition of pectin (WP) had a significant higher number of microorganism than all other jams formulated using pectin (p < 0.05). The fruit jams that were formulated without addition of pectin had low pectin content that lead to their poor gel formation and its consequent separation that increased the water activity of the product, which could have influenced the growth of microorganism on the 4th and 6th month of storage. However, there was no significant microbial growth in other formulations and no coliform growth in all jams throughout the storage time. This clearly shows that when indigenous fruits are used to prepare jam, it is important to balance the pectin, sugar and acid. The results show that jams formulated with additional pectin could be stored for six months at room temperature without spoilage.

Sensory evaluation of jams

The sensory evaluation of the formulated jams is presented in Table 7. In general, addition of pectin had no significant (p > 0.05) effect on the colour of the jams produced. Spreadability of the jam on the bread was significantly different (p < 0.05) between V*. mombassae* and *U. kirkiana* jams formulated without pectin (WP). However, spreadability of *V. mombassae* jam with lemon extract (LEP*)* was significantly (p < 0.05) poor compared to other formulations with added pectin. This was probably due to the spongy and brittle characteristics observed by panelists that could have occurred probably during heating (over heating) and resulted into jam with low moisture content compared to other jams (Table 5). Jam prepared from *A. digitata* L. alone had also poor spreadability due to the high content of pectin found in the powder, that is, the observation that was previously reported by other researchers (Tiisekwa et al., 2002; Saka et al., 2007). This shows that *A. digitata* L. powder cannot be used alone to produce jam of required spreadability, but can be mixed with fruits that are deficient in pectin for better results. The taste of jam from *S. birrea* (WP) was ranked significantly high among all other jams formulated with and without an addition of pectin (Table 6). There were no significant differences in taste among jams formulated with commercial pectin and *A. digitata* L. powder (p > 0.05). Tiisekwa et al. (2002) also observed the same trend. In their study, jams prepared at banana/baobab ratio of 3:1 were ranked higher in terms of taste. However, jams formulated with lemom (LEP) were slightly disliked in terms of taste. This could have been due to its low water content in comparison with other jams and the bitter taste, which was reported by the panelists. General acceptability results show that S*. birrea* jams with all formulations, except with lemon extract, were more accepted than other fruits. Also, fruit jams formulated with commercial pectin were equally accepted as those formulated with *A. digitata* L. powder. However, *V. mombassae* jams were least accepted. This might be due to the fact that the fruit had a characteristic strong flavour and colour, which was not familiar to some of the panelists. These results show that *A. digatata* L. powder could be used as a substitute of the expensive commercial pectin in the preparation of indigenous fruit jams.

Table 7. Sensory assessments of indigenous fruit jams (n=20).

Sensory attribute	Pectin source	Fruit jam type			
		V. mombassae	***U. kirkiana***	***S. birrea***	***A. digitat***
Colour	WP	2.67±0.26^{cB}	5.7±0.26 ^{aA}	5.6±0.26 ^{aA}	4. 9±0.26 ^{b}
	APP	5.0±0.26 ^{aA}	5.36±0.26 ^{aA}	3.7±0.26 ^{bB}	
	LEP	3.3±0.26 ^{cB}	5.6±0.26 ^{aA}	4.5±0.26 ^{bB}	
	CPT	5.1±0.26 ^{bA}	6.1±0.26 ^{aA}	4.3±0.26 ^{cB}	
Spreading on the bread	WP	5.6±0.27 ^{aA}	4.3±0.27 ^{bB}	5.3±0.27 ^{aA}	4.4±0.27 ^{b}
	APP	5.2±0.27 $^{a/A}$	5.1±0.27 ^{aA}	4.9±0.27 ^{aA}	
	LEP	3.8±0.27 ^{bB}	4. 8±0.27 ^{aA}	4.9±0.27 ^{aA}	
	CPT	5.7±0.27 ^{bA}	5.5±0.27 ^{aA}	5.1±0.27 ^{aA}	
Taste	WP	3.6±0.26 ^{bB}	4.4±0.26 ^{abA}	6.1±0.26 ^{aA}	5.5±0.26 ^{a}
	APP	4.7±0.26 ^{bA}	4.9±0.26 ^{bA}	5.8±0.26 ^{aA}	
	LEP	3.3±0.29 ^{bB}	4.5±0.26 ^{aA}	4.3±0.26 ^{aB}	
	CPT	5.2±0.26 ^{aA}	5.3±0.26 ^{aA}	5.9±0.26 ^{aA}	
Overall acceptability	WP	3.6±0.28 ^{bB}	3.9±0.28 ^{bB}	5.9±0.28 ^{aA}	5.2±0.28 ^{a}
	APP	4.6±0.28 ^{aA}	5.3±0.28 ^{aA}	4.9±0.28 ^{aB}	
	LEP	3.4±0.28 ^{bB}	4.8±0.28 ^{aA}	3.4±0.28 ^{bC}	
	CPT	5.0±0.28 ^{aA}	5.8±0.28 ^{aA}	5.7±0.28 ^{aA}	

V: *Vitex mombassae* fruit; U: *Uapaca kirkiana* fruit; S: *Sclerocarya birrea* fruit;

A: *Adansonia digitata* fruit; CPT: produced with commercial pectin; LEP: produced with lemon extract as pectin; APP: *Adansonia digitata* powder as pectin; WP: Without addition of pectin; SE: Standard error of mean.

Mean values with different lower case superscript letters within the row are significantly different ($p < 0.05$), and mean values with different upper case superscript letter within a column are significantly different ($p< 0.05$).

Conclusions

The study has demonstrated that *V. mombassae, U. kirkiana, S. birrea* and *A. digitata* L. do vary in functional characteristics required for jam manufacturing. The studied fruits contain low level of pectin content except *A. digitata* L., which had high pectin and acidity. The pectin found in baobab (*A. digitata* L.) powder was successfully utilized in the production of other fruit jams and proved to be a potential substitute for expensive commercial pectin. Commercial pectin apart from being expensive is not easily available in rural areas, where these fruits are found in large quantities. For example in Tanzania, 1 kg of commercial pectin was available at US$ 50.00 (May, 2009). When compared with cultivated fruits, the indigenous fruits are much far less expensive. If the farmers, in areas where these fruits are found, are trained to have sufficient skills, they can easily utilize them to produce fruit products for commercial purpose to earn income and for their own consumption. In this way, indigenous fruit can contribute to the improvement of food and nutrition security. It is therefore recommended that, the use of baobab powder as a substitute for commercial pectin should be promoted. However, an in-depth examination of chemical changes of the fruits from maturity to ripening need to be intensively studied in order to optimize the processing technique and minimize loses encountered during ripening and storage. More research to characterize pectin found in baobab powder is needed; this will help to find fraudulent baobab powder mixtures currently sold in markets.

ACKNOWLEDGEMENT

The authors wish to acknowledge the financial support from the Tanzania Government through the Ministry of Health and the International Centre for Research in Agro forestry (ICRAF).

REFERENCES

Akinnifesi FK, Kwesiga F, Mhango J, Mkonda A, Chilanga T, Swai (2004). Domesticating priority miombo indigenous fruit trees as a promising livelihood option for smallholder farmers in southern Africa. Acta Horticulturae., 632: 15-30.

Akinnifesi FK, Kwesiga F, Mhango J, Chilanga T, Mkonda A, Kadu CAC, Kadzere I, Mithofer D, Saka JDK, Sileshi G, Ramdhani T, Dhliwayo P (2006). Towards the development of miombo fruit trees as commercial tree crops in southern Africa. Forests, Trees and Livelihoods, 16: 103-121.

Arnold TH, Well MJ, Wehmeyer AS (1985). Koisan food plants: taxa with potential for economic exploitation. In Wickens GE, Goodin JR, Field DV (Eds.), Plants for Arid Lands. Allen and Unwin, London. pp. 69-86

Association of Official analytical Chemistry (2000). Official method of analysis (AOAC) International. 17^{th} edition. AOAC International. Maryland. U.S.A.

Belitz D, Grosch W (1999*).* Food chemistry, second edition. Springer-Verag. Berlin German, p. 987.

Dauthy ME (1995). Fruit and vegetable processing. FAO Agricultural services bulletin No119. FAO of United Nations. Rome p. 203.

FAO (1995). Manual of food quality control, 14/4 microbiological analysis, FAO, Rome, p. 337.

FAO (1997). Guidelines for small-scale fruit and vegetable processors, FAO agricultural services bulletin 127, Peter Midway technology Ltd. St Oswalds Barn, Cifford Hay on Wye, Hereford. United Kingdom.

Fweja LW (2002). Composition, Sensory characteristics and aroma profile of off vine ripened mango (*Mangifera indica* L.). MSc Thesis, Sokoine Unversity of Agriculture, Morogoro, Tanzania, p78.

Kansci G, Koubala BB, Israel Mbome Lape IM (2003). Effect of ripening on the composition and the suitability for jam processing of different varieties of mango (*Mangifera indica)*. Afr. J. Biotechnol., 9: 301-306.

Kirk RS, Sawyer R (1991). Pearson's composition and analysis of foods 9^{th} Edition John Wily and sons Inc. New York. p. 570.

Lockett TC, Calvert CC, Grivetti EL (2000). Energy micronutrient composition of dietary and medical wild plants consumed during drought. A study done on rural Fulani, Northeast Nigeria. Int. J. Food Sci., 51: 195-208.

Mumba MS, Simon SM, Swai SM, Ramadhani T (2002). Utilization of indigenous fruits of Miombo woodlands: A Case of Tabora District, Tanzania. Agroforestry Impacts on Livelihoods in Southern Africa: Putting Research into Practice. Regional Agroforestry onference. 20 – 24 May. Warmbaths, South Africa.

Ndabikunze BK, Mugasha AG, Tiisekwa BPM, Chamshama SAO (2000). Nutrition and utilization of indigenous tree food resources in Tanzania. In: Proceedings of SADC Tree seed Centre Network meeting on domestication and commercialization of indigenous fruit trees in SADC region held in Windhoek, Namibia, pp. 56-60.

Ndabikunze BK, Mugasha AG, Chamshama SAO, Tiisekwa BPM (2002). Nutritive value of selected forest/woodland edible fruits, seed and nuts in Tanzania. Agroforestry Impacts on Livelihoods in Southern Africa: Putting Research into Practice. Regional Agroforestry Conference. 20 – 24 May, Warmbaths, South Africa.

Saka JDK, Msonthi JD (1994). Nutritional value of edible fruits of indigenous wild trees in Malawi. For. Ecol. Manag., 64: 245-248.

Saka J, Isabel R, Akinnifesi F, Victoria NV, Mhango J (2007). Physicochemical and organoleptic characteristics of Uapaca kirkiana, *Strychnos cocculoides, Adansonia digitata* and *Mangiferia indica* fruit products. Int. J. Food Sci. Technol., 42: 836 -841.

Sidibe M, Williams JT (2002). Baobab (*Adansonia digitata* L). Fruits for the Future. International Centre for underutilized Crops, Southampton, UK.

Singh A (1986). Fruit physiology and production. Second revised edition. Kalyani Publishers. New Delhi India, p. 148*.*

Tiisekwa BPM, Ndlangamandla SB (1996). Suitability and limitation of some indigenous fruits of Swaziland for manufacturing jams and jellies. UNISWA J. Agric., 5: 106-115.

Tiisekwa BPM, Ndabikunze BK, Samson G, Juma M (2002). Suitability of some indigenous Tree Fruits for Manufacturing juice and jam in Tanzania. In: Proceedings of the Region Agroforestry Conference. (Edited by ICRAF) 20-24 may, Warmbaths, South Africa, p. 68.

TBS (1985). Tanzania standard. Jam, jellies and marmalade specification. Tanzania Bureau of Standard. Dar – es –Salaam, Tanzania, p 6.

Watts BM, Ylimak, GL, Jeffery LE, Elias LG (1989). Basic sensory methods for food evaluation. International Development Research center. Ottawa, Canada, p.160.