Asian Journal of Biotechnology and Bioresource Technology

1(3): 1-8, 2017; Article no.AJB2T.35639

Physicochemical, Sensory and Microbiological Properties of Syrup and Jam Prepared from Locust Bean Fruit Pulp in Storage

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Author's contribution

The sole author deigned, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJB2T/2017/35639
Editor(s):
(1) M. M. Youssef, Food Science and Technology, Faculty of Agriculture, Alexandria University, Egypt.
Reviewers:
(1) Takeshi Nagai, Graduate School of Yamagata University, Japan.
(2) S. Sreedevi, St. Pious X Degree & PG College for Women, India.
(3) Daniela Hanganu, Iuliu Hatieganu University of Medecine and Pharmacy Cluj-Napoca, Romania.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/20765

Original Research Article

Received 23rd July 2017
Accepted 20th August 2017
Published 1st September 2017

ABSTRACT

Aim: To evaluate the storage properties of jam and syrup prepared from African locust bean pulp in storage at ambient conditions.
Study Design: The study was carried out in three replications in completely randomized design. Significantly different means were separated by DMART. Significance was accepted at $p<0.05$.
Place and Duration of Study: The study was carried out in 2016 at The Federal Polytechnic Idah, Nigeria.
Methodology: Jam and syrup were prepared from African locust bean pulp and stored in sterile bottles at ambient conditions (30 ± 2°C, 72-82% RH) for 6 months. Changes in the physicochemical, microbiological and sensory properties of the stored products were analyzed monthly.
Results: The pH of the stored products was not significantly ($p>0.05$) affected by storage. However, the total titratable acidity, total sugars, vitamin C and beta carotene decreased significantly ($p<0.05$) on storage. On the other hand, the soluble solids and reducing sugar contents increased significantly ($p>0.05$) on storage. The sensory properties of the jam and syrup

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did not change significantly ($p>0.05$) on storage. The total plate counts of the jam and syrup decreased significantly ($p<0.05$) on storage.
Conclusion: The locust bean pulp has the potential for making stable jam and syrup.

Keywords: Jam; syrup; locust bean pulp; storage; physicochemical; sensory.

1. INTRODUCTION

*Parkia biglobosa (*Jack) Benth is a perennial crop in the family *Leguminoceae (Fabaceae*). It is popularly known as African locust bean tree and called *igba* or *irugba* by the Yoruba, *dorowa* by the Hausa and *origili* by the Igbo people of Nigeria. The tree grows wide in many parts of the Sahel, particularly, the drier parts of West Africa [1]. In Nigeria, the tree grows wide throughout the Savanna from Guinea Savanna through Sahel to Sudan [2]. The tree produces about 25-52 kg of fruit pods [3]. The mature fruit pods of the locust bean occur in large bunches, of which a pod varies from 12 to 30 cm long and 12 to 15 mm wide [3]. The pod is tough and fibrous, enclosing soft powdery yellowish pulp in which small seeds are embedded [4]. The seeds are used for making condiment called *dawadawa* or *iru* which serves as source of protein intake among the low income groups and rural populations of West Africa. The pulp which is rich in carbohydrate, minerals, vitamins and phytochemicals [5] are licked for its sweet taste but only to a small extent. The pulp is usually washed away when the seeds are processed.

Parkia species have found use traditionally as food and medicinal agents of high commercial value. Various parts of the *Parkia biglobosa* tree are used to make tonics and ointments which are used to treat many ailments. The tree is known to provide ingredient that is used in treating leprosy and hypertension [6]. In Gambia, the leaves and roots are used in preparing lotion for sore eyes and decoction of the bark is used for fever, hot mouth wash and toothache relief [5]. The stem bark is employed in wound healing while the wood is used for canoes and planking. The pulp has been identified as untapped forest resource that deserves attention. The pulp is used in the local environments as substitute for sugar because of its high sugar content [5]. Due to its high sugar content, the pulp potentially serves as raw material for the manufacture of syrup, jam, wine and non alcoholic beverages. However, there are no reported data on the utilization of the pulp as jam and syrup. The pulp could be processed into jam and syrup for the purpose of improving the functional characteristics of the pulp. Functional foods are foods that not only provide nutritional value but health benefits when consumed in a regular diet. The presence of bioactive compounds with antioxidant properties such as flavonoids, carotenoids and vitamin C in the locust bean pulp may exert health promoting effects in addition to those of the dietary fiber [5,7].

Syrups find wide applications in the food industry and in the home as nutritive sweeteners [8]. In some cases, syrups are preferred to granulated sugar because of their unique physical properties [9]. Similarly, the dietary awareness of consumers has brought demand for the reduction of the sugar content of industrially prepared foods such as biscuits and replacement of sucrose by other sweeteners such as syrup [10]. Syrup has been produced from fruits such as apples, pears, peaches, blackcurrant, rasp berries, strawberries, Logan berries, black plum, date palm, *spondias mombin* etc [8,10-15]. No published information is available detailing the utilization of African locust bean pulp solely as jam and syrup. The objective of the present study was to determine the changes in the quality of jam and syrup prepared from locust bean fruit pulp in storage.

2. MATERIALS AND METHODS

Mature and ripe African locust bean (*Parkia biglobosa*) pods were plunked from African locust bean trees in a local farm in Ugwaka-Ollah, Kogi State, Nigeria, during the March-April (2016) fruiting season. Sugar, food grade citric and sodium benzoate were purchased from a store in a local market in Idah Township, Kogi State, Nigeria. The fruit pods were sealed in jute bags and stored in a refrigerator prior to use.

2.1 Preparation of Locust Bean Pulp Powder

The locust bean pods were sorted, cleaned and split open manually. The yellow pulp along with the attached seeds were removed from the hulls, sun dried at 30°C for 2 days and pounded lightly in a mortar with pestle. The pulps were separated from the seeds and then milled in a hammer mill.

2.2 Preparation of Locust Bean Pulp Jam

The locust bean pulp powder (100 g) was mixed with 700 ml distilled water (1:7, pulp: water) to obtain a slurry. Sugar (200 g), pectin (1.5%) and sodium benzoate (0.5%) were added to the slurry. The pH of the mixture was adjusted to 3.2 with 20% food grade citric solution using pH meter. The mixture was concentrated in a stainless steel pot in a vacuum oven to 67^{o}Brix. The jam was hot filled into sterile jam bottle (1 cm headspace), sealed and stored at ambient temperature (30°C) in a refrigerator prior to use.

2.3 Preparation of Syrup

The locust bean pulp powder was blended with distilled water (pulp: water, 1: 4, 1: 5, 1: 6,1: 7, 1: 8, 1: 9 and 1: 10) in Kenwood food blender (model 49074, Uk) operated at full speed for 5 minutes. The pulp to water ratio of 1:10 was found as most appropriate for the extraction of juice from the pulp and was used for further study. A 400 g pulp powder was blended with 1000 ml distilled water pre-heated to 50, 60, 70, 80, 90 and 100°C, respectively in a Kenwood food blender operated at full speed for 10 minutes. The mixtures were allowed to stand for 2 hours with occasional stirring. The mixtures were filtered through double folded cheese cloth (180 µg). The optimum temperature for the extraction of juice from the pulp was 80°C. The extracted juice was then concentrated in a vacuum oven to 72^{0} Brix. The syrup was hot filled into sterile bottles (1 cm head space) sealed, cooled and then stored in a refrigerator (10± 2°C) until used.

2.4 Storage Stability Studies

The hot locust bean pulp jam and syrup were divided in to 200 ml portions and stored in sterile bottles (1 cm head space) at ambient conditions (30±2°C, RH 72-82%) for 6 months. The physical, chemical and sensory changes in the stored jam and syrup were determined.

3. ANALYTICAL METHODS

3.1 Sensory Evaluation

A panel of 20 trained panelists was randomly selected from the students of the Department of Food Science and Technology, Federal Polytechnic –Idah who were consumers of jam and syrup and used for the sensory evaluation. The African locust bean pulp jam and syrup were evaluated for color, taste, flavor, texture, spreadability and overall acceptability on a 5-point Hedonic scale (1=disliked extremely, 3=neither liked nor disliked and 5= liked extremely) as described by Ihekoronye and Giddy [16]. Five grams of each of the samples were presented to the panelists in three-digit coded white plastic plates. The order of presentation of the samples to the panelists was randomized. Clean water was provided for the panelists to rinse their mouths in between evaluations. For the evaluation of spreadability, 2 g of the jam was smeared on thin sliced bread and observed for evenness of the spread. The evaluation was carried out in a sensory evaluation laboratory in the mid morning (10 am) under fluorescent lighting and adequate ventilation.

3.2 Physicochemical Analysis

The pH of 10% (w/v) diluted jam and was measured with a digital pH meter [17]. Soluble solids were determined using Abbe refractometer following the AOAC [17] methods. For the determination of total titratable acidity, 10% (w/v) jam/syrup solution was filtered and titrated against 0.1N NaOH solution (AOAC, 2010). Total sugars, glucose, fructose, sucrose, reducing sugars and beta carotene contents were determined as described by the AOAC [17] methods. Vitamin C content was determined by the 2, 6- dichloro indophenol titration method [17].

3.3 Microbiological Analysis

Total plate count was determined as described by APHA [18].

3.4 Statistical Analysis

Data were analyzed by analysis of variance using Statistical Package for Social Sciences (SPSS) soft ware version 20 in completely randomized design. Significantly different means were separated by DMART. Significance was accepted at $p<0.05$.

4. RESULTS AND DISCUSSION

4.1 Changes in the Physicochemical Properties of Jam and Syrup

The changes in the physicochemical properties of jam stored at ambient temperature for 6 months are shown in Table 1. There was no significant (p>0.05) change in the pH of the jam during storage. The pH decreased from 3.2 to 2.9 at the end of the storage period. The low pH (2.9-3.2) of the jam was a desirable quality characteristic as it enhanced the storage stability of the jam and the preservation effect of the sodium benzoate added to the jam. The total titratable acidity, on the other hand, increased steadily from 0.44% to 0.95% at the 6th month of storage. While the total sugars decreased, the soluble solids and reducing sugars contents increased steadily with increase in the storage time. This may be attributed to the cleavage of the non reducing sugars in the acidic (pH 2.9-3.2) medium of the jam during storage. Acid hydrolysis of polysaccharides especially gums and pectin may have occurred [7]. The increase in reducing sugars may be due to inversion of non reducing sugars during storage [6,7]. The inversion of the non reducing sugars may be due to the presence of acids such as citric acid, malic acid which along with the high temperature of the storage speeded up the inversion process [9]. Similar findings were reported by Hussain et al. [19] during the storage of Sudanese mango jam. The increase in the total titratable acidity (TTA) was in agreement with the decrease in pH [15]. The increase in TTA may be due to the increase in the concentration of weakly ionized acids and their salts during storage [15]. The increase in acidity may also be due to formation of acids by degradation of polysaccharide and oxidation of reducing sugars or by the breakdown of pectic substances and uronic acids [19].

There was no significant (p>0.05) change in the vitamin C content of the jam during the 3 months storage. Thereafter, the vitamin C content of the jam decreased significantly (p<0.05) to 10 mg/100 g. The initial vitamin C content of the jam was 16.8 mg/100 g. The retention of vitamin C is an index of quality and nutritive value of fruit and fruit products [20,21]. The added sodium benzoate stabilized the vitamin C in the jam for 3 months. The stabilizing effect of sodium benzoate on vitamin C of spondias jam has been reported [22]. The ambient temperature used in the present study might have accelerated the oxidation of vitamin C in the jam. Generally, the extent and rate of vitamin C oxidation are affected by time, temperature, oxygen, pH and the extent of cell damage and the presence of oxidative enzymes [20]. Up on oxidation, vitamin C loses 2 atoms of hydrogen to yield dehydroascorbic acid (DHAA) which has reduced nutritional quality (only 75% of the antiscorbic activity) [7,20]. The container used for packaging was impermeable to oxygen, therefore, the vitamin C destruction was probably caused via oxidation by residual oxygen in the head space and by the destructive of light since the jam was packed in transparent bottles. The beta-carotene content of the jam decreased steadily with storage time.

The effect of storage on the physicochemical properties of locust bean pulp syrup are shown in Table 2. The total sugars decreased from 62% to 51% while the reducing sugars and soluble solids increased from 45 to 68% and 67 to 78 °Brix, respectively, with storage time. The increases were probably due to hydrolysis of non reducing sugars which was probably enhanced by the increased acidity (pH 3.5-3.2) during storage. There was no change in the pH of the syrup until after 5 months when a slight decrease was observed. The titratable acidity on the other hand, increased steadily from 0.33 to .98% at the end of the storage period which was in agreement with the fall in pH. The low pH (3, 5) functioned synergically with the high sugar in the syrup and prevented chemical deterioration.

Table 1. Changes in the physicochemical properties of locust bean pulp jam during storage

Storage (month)	pH	TTA (%)	Soluble solids (°Brix)	Vitamin C (mg/100 g)	Beta carotene (mg/100 g)	Total sugar (%)	Reducing sugar (%)
0	3.2[a]	0.44[a]	72[g]	16.8[a]	17.5[a]	75.8[a]	35[h]
1	3.2[a]	0.50[a]	73[f]	16.4[a]	17a	73.5[b]	37[f]
2	3.2[a]	0.58[a]	74[e]	16.0[a]	16[b]	71.2[c]	40[e]
3	3.2[a]	0.65[a]	76[d]	14.9[b]	15.3[c]	70.0[d]	42d
4	3.1[a]	0.80[a]	77[c]	13.0[c]	15[c]	68.6[e]	43[c]
5	2.9[a]	0.89[a]	78[b]	10.0[d]	14[d]	64.0[f]	50[b]
6	2.9[a]	0.95[a]	80[a]	10.0[d]	12[e]	62.0[g]	52[a]
$Lsd_{0.05}$	0.8	0.50	0.91	1.0	0.99	1.0	0.98

Values are means of 3 replicates. Means with in a column with the same superscript were not significantly different (p>0.05). The samples were stored at ambient conditions (30°C, RH 72-82%). TTA, total titratable acidity

The vitamin C content decreased from 24 mg/100 g at the beginning of the storage to 15 mg/100 g at the end of the 6 month storage. There was no significant change ($p>0.05$) in the vitamin C content during 3 months storage but decreased significantly ($P<0.05$) thereafter. The beta- carotene content of the syrup decreased steadily with storage. There was high negative correlation between storage time and beta-carotene content during storage (r=-94). The decrease in vitamin C and beta carotene contents may be attributed to storage effect. Similar observation was reported for other fruits and vegetables [23]. The syrup was stored in a container that was impermeable to oxygen. Therefore, the destruction of both vitamin C and beta- carotene was probably by the destructive effect of light especially as the syrup was packed in transparent bottles [23].

4.2 Changes in Sensory Properties of the Jam and Syrup in Storage

The effect of storage on the sensory properties of the jam is shown in Table 3. There were no significant differences ($p>0.05$) in the sensory scores for color, flavor, taste, texture and spreadability of the locust bean pulp jam during storage. The scores for taste, texture and spreadability were slightly higher at the end of the storage period than when the jam was prepared. On the other hand, the scores for color, flavor and overall acceptability fluctuated with the storage period, though not significantly ($p>0.05$). The scores for color decreased slightly due chemical reactions of the organic acids in the jam. The decrease in the score for color of the jam might be attributed to Maillard reactions, ascorbic acid degradation and polymerization of anthocyanins with other phenolics [24]. Organic acid and sugars ratio primarily creates a sense of taste which is perceived by specialized taste buds in the tongue. The increase in the taste score might be due to the increase in reducing sugars and soluble solids content. The overall flavor impression is the result of the taste perceived by the taste buds in the mouth and the aromatic compounds detected by the epithelium of the olfactory organ in the mouth. The scores for flavor decreased with storage probably due to storage effect. Changes in flavor are the most sensitive index for detection of quality deterioration during storage which is followed by color [24]. Texture is comprised of those properties of a product that can be appraised by visually or by touch. The jam and the syrup remained acceptable to the panelists up to the end of the storage period. Akhtar et al. [25] reported that sensory traits are not generally inter-related and contribute independently towards the overall sensory perception.

At the end of the storage, the taste, texture, spreadability and overall acceptability scores did not fall below 4.0 on a 5- Hedonic scale. The initial scores for color and flavor respectively were 3.3 and 3.6. These scores decreased slightly to 3.0 and 3.4 for color and flavor, respectively. The high level of sugar in the jam and the added sodium benzoate in addition to the low pH and storage effect seemed to protect the sensory properties of the locust bean. There was a slight decrease in the score for flavor due to alteration in the volatile compounds of the jam and syrup. Taste is very significant parameter in sensory evaluation after color and flavor. The increase in the scores for taste with storage was probably due to hydrolysis of carbohydrates to simple sugars.

The sensory properties of locust bean pulp syrup during storage are presented in Table 4. There were no significant differences ($p>0.05$) in the sensory scores for color, taste, texture and overall acceptability of the syrup in storage. Indeed, the scores for color, taste and overall acceptability increased steadily up to the 5th month of storage and thereafter, were reduced, though not significantly($p>0.05$).

4.3 Microbial Stability of Jam and Syrup in Storage

The total plate count of the jam and syrup are presented in Table 5. The initial counts of the locust bean pulp syrup (LBPS) and locust bean pulp jam (LBPJ) were 20 and 12 cfu/g, respectively. These counts were in conformity with the microbiological profile of jams, syrups, preserves, jellies and marmalades reported by Frazier and Westhoff [26]. The counts for these products reduced on storage. At the end of the 6 months storage, no growth was observed in the jam whereas only 5 counts were recorded for the syrup. The lower initial counts for the jam which was further reduced during storage indicated the inhibitory effect of the sodium benzoate. The reduction in pH from 3.5 to 2.9 in jam (Table 1) provided a suitable environment for sodium benzoate to act and prevented mould and bacteria growth. Similarly, the reduction of pH from 3.5 to 3.2 in syrup and its high level of sugar inhibited microbial growth. This explains why there was also decline in the microbial load of the syrup during storage. Similar observations were documented for millet *fura* dough during storage [27]. Preservatives such as sodium benzoate and sodium nitrite have often been used to reduce water activity in foods [28]. The sugar in the jam and syrup may have bound the water in these products. The spoilage of foods depends also on the moisture and sugar contents. High sugar and low moisture contents do not favor microbial growth [29]. Sugar in solution exerted an osmotic pressure which helped in keeping osmophilic loads in the jam and syrup. The sugar added to the jam prevented microbial spoilage [29]. Results presented here were in agreement with the earlier investigation of Anonymous [29] who reported no yeast and mold growth and insignificant total viable count in Sudanese mango jam during storage.

Table 2. Changes in the physicochemical properties of locust bean pulp syrup during storage

Storage time (month)	pH	TTA (%)	SS (^{o}Brix)	Vitamin C (mg/100 g)	Beta carotene (mg/100 g)	Total sugar (%)	Reducing sugar (%)
0	3.5^{a}	0.33^{a}	67^{g}	24.3^{a}	20.0^{a}	62.3^{a}	45^{g}
1	3.5^{a}	0.45^{a}	71^{f}	23.8^{a}	19.0^{b}	61.0^{b}	56^{f}
2	3.5^{a}	0.60^{a}	72^{e}	23.0^{a}	18.0^{c}	60.0^{c}	48^{e}
3	3.5^{a}	0.68^{a}	73^{d}	21.4^{b}	16.3^{d}	58.5^{d}	55^{d}
4	3.5^{a}	0.80^{a}	74^{c}	21.4^{b}	16.3^{d}	58.5^{d}	59^{c}
5	3.2^{a}	0.85^{a}	76^{b}	18.0^{d}	12.8^{f}	55.0^{e}	62^{b}
6	3.2^{a}	0.98^{a}	78^{a}	15.0^{e}	10.0^{g}	51.0^{g}	68^{a}
$Lsd_{0.05}$	0.82	0.64	1.0	0.98	0.93	1.0	0.99

Values are means of 3 replicates. Means with in a column with the same superscript are not significantly different (p>0.05). The samples were stored at ambient conditions (30°C, RH 72-82%). TTA, Total titratable acidity; SS, Soluble solids

Table 3. Sensory properties of locust bean pulp jam during storage

Storage (month)	Color	Flavor	Taste	Texture	Spread ability	Overall acceptability
0	3.3^{a}	3.6^{a}	3.9^{a}	3.9^{a}	4.0^{a}	4.7^{a}
1	3.3^{a}	3.7^{a}	4.0^{a}	3.9^{a}	4.0^{a}	4.7^{a}
2	3.4^{a}	3.8^{a}	4.1^{a}	4.0^{a}	4.1^{a}	4.8^{a}
3	3.5^{a}	3.6^{a}	4.2^{a}	4.1^{a}	4.2^{a}	4.7^{a}
4	3.2_{a}	3.5^{a}	4.2^{a}	4.0^{a}	4.3^{a}	4.7^{a}
5	3.2^{a}	3.4^{a}	4.3^{a}	4.0^{a}	4.4^{a}	4.6^{a}
6	3.0^{a}	3.4^{a}	4.4^{a}	4.0^{a}	4.4^{a}	4.6^{a}
$Lsd_{0.05}$	0.93	0.79	0.94	0.58	0.81	0.67

Means within a column with the same superscript are not significantly different (p>0.05). Samples were evaluated on 5 –point Hedonic scale (1=disliked extremely and 5=liked extremely).The ambient storage conditions were 30^{o}C and 72-82% RH

Table 4. Sensory properties of locust bean pulp syrup during storage

Storage period (Month)	Color	Flavor	Taste	Texture	Overall acceptability
0	3.0^{a}	4.2^{a}	4.0^{a}	3.8^{a}	4.1^{a}
1	3.0^{a}	4.2^{a}	4.0^{a}	3.8^{a}	4.0^{a}
2	3.1^{a}	4.1^{a}	4.1^{a}	3.9^{a}	4.1^{a}
3	3.1^{a}	4.2^{a}	4.3^{a}	3.8^{a}	4.1^{a}
4	3.0^{a}	4.3^{a}	4.3^{a}	3.8^{a}	4.2^{a}
5	3.0^{a}	4.3^{a}	4.4^{a}	5.8^{a}	4.2^{a}
6	2.9^{a}	4.2^{a}	4.5^{a}	3.8^{a}	4.0^{a}
Lsdo.o5	0.65	0.57	0.7	0.50	0.80

Means within a column with the same superscript are not significantly different (p>0.05). Samples were evaluated on 5 –point Hedonic scale (1=disliked extremely and 5=liked extremely).The ambient storage conditions were 30^{o}C and 72-82% RH

Table 5. Changes in total plate count (Cfu/G) of locust bean pulp syrup and locust bean pulp jam

Storage period (month)	Locust bean pulp syrup	Locust bean pulp jam
0	20^a	12^a
1	17^b	7^b
2	15^c	5^c
3	15^d	4^d
4	10^e	3^e
5	7^f	3^f
6	5^g	1^g

Values are means of 3 replicates. The samples were stored at ambient conditions (30°C, RH 72-82%). Means within a row with the same superscript are not significantly different (p.0>05)

5. CONCLUSION

Based on the results of this study, it may be concluded that storage of African Locust bean pulp jam and syrup in bottles for 6 months did not adversely affect the microbiological and sensory properties of the stored jam and syrup. However, the vitamin C and beta carotene contents of the jam and syrup decreased significantly in storage.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Ajaiyeoba EO. Phytochemical and antibacterial properties of *Parkia bigloba* and *Parkia bicolor* leaf extracts. African Journal of Biomedical Research for Washington. 2002;3:125-127.
2. Aiyelaagbe OO, Ajaiyeoba EO, Ekundayo O. Studies on the seed oil of *Parkia biglobosa* and *Parkia bicolor*. Plant Foods Human Nutrition. 1996;493:229-233.
3. Dosumu OO, Oluwaniyi OO, Awlola GO, Oyedji OO. Nutritional composition and antinutritional properties of three Nigerian condiments. Nigerian Food J. 2002;30(1): 43-50.
4. Akubor PI, Adedeji EO. Effect of pH and sodium chloride concentration on the functional properties of locust bean pulp flour. FUW Trends in Science and Technology Journal. 2016;1(2):344-347.
5. Akubor PI. Chemical composition and functional properties of locust bean pulp flour and wheat flours. FUW Trends in Science and Technology Journal. 2016;1(1):248-253.
6. Olajide JD, Ade-omowaye BIO. Some physical properties of locust bean seed. Journal of Agricultural Engineering Research. 1999;74:213-215.
7. Onimawo IA, Akubor PI. Food chemistry (Integrated approach with biochemical background). 2nd Edn. Joytal Printing Press, Agbowo, Ibadan, Nigeria; 2012.
8. Egbekun MK, Akowe JI, Ede RJ. Physicochemical and sensory properties of formulated syrup from black plum (*Vitex doniana*) fruit. Plant Foods for Human Nutrition. 1996;49:301-306.
9. Hyvonen L, Torma R. Examination of sugars, sugar alcohols and artificial sweeteners as substitute for sucrose in strawberry jam. Keeping quality. Journal of Food Science. 1983;48:186-93.
10. Abu JD. Development of a sweetener from black plum (*Vitex doniana*) fruits. International Journal of Food Properties. 2002;51:153-59.
11. Marie S, Pigot JR. Hand book of sweeteners. Glasgow, Blackie, London; 1991.
12. Akubor PI, Yusuf D. Effect of incorporation of date palm syrup on the sensory and physical properties of wheat flour biscuit. Journal of Applied Science and Environment. 2007;1(1):25-28.
13. Oyewole EO, Adepoju OT. Nutrient composition and acceptability of honey – substituted jam from *Spondias mombin* (Hog plum) fruit pulp. Nigerian Journal of Nutritional Science. 2005;26(2):38-44.
14. Adepoju OT, Oyewole EO. Nutrient composition and acceptability study of fortified jams from *Spondias mombin* (Hog, *Iyeye*) fruit pulp. Nigerian Journal of Nutritional Science. 2008;29(2):180-189.
15. Okudu HO, Umoh EJ, Ojinaka MC, Chiankwalam OF. Nutritional, functional and sensory attributes of jam from velvet

tamrind pulp. African Journal of Food Science. 2017;11(2):43-49.
16. Ihekoronye AI, Nggody PO. Integrated food science and technology. Macmillan Education Ltd, London; 1985.
17. AOAC. Official methods of analysis. 14th Edn. Association of Official Analytical Chemists, Washington D.C.; 2010.
18. APHA. American Public Health Association Compendium of methods for the microbiological examination of foods. In: Downes FP, Ito K, (Eds). 4th Edn; 2001.
19. Hussain I, Muhammed RK, Khan TM, Sabeen ND, Iftkhar S. Varietal suitability and storage stability of mango squash. International Journal of Agriculture and Biology. 2005;7:1038-1039.
20. Ryan CB, Biren DO. Ascorbic acid retention in shredded iceberg lettuce as affected by minimal processing. Journal of Food Science. 1999;64:498-500.
21. Karem M, Samak P, Hashemiravan M, Mokhtari F. Evaluation of sensory and physicochemical properties of synbiotic squash jam. International Journal of Advanced Biotechnology and Research. 2016;7(3):537-1544.
22. Adepoju OT, Karim SA. Nutrient composition, antinutritional factors and jams production from *Spodias mombin* (Hog, Iyeye) fruit pulp. Nigeria Journal Nutritional Science. 2004;25(1):20-25.
23. Kirk I, Dennison D, Kokozka P, Herdman OC. Degradation of ascorbic acid in hydrated food system. Journal of Food Science. 1977;5:1274-80.
24. Akhtar S, Mahmood S, Naz M, Nasir T, Suitan MT. Sensory evaluation of mangoes (*Magnifera indica* L) grown in different regions of Pakistan. Pakistan Journal of Botany. 2009;41:2821-2829.
25. Garcia VC, Zafrill F, Romero F, Abellan P, Ates F, Barberan FAT. Color stability of strawberry jam as affected bu cultivar and storage temperature. Journal of Food Science. 1999;64:243-247.
26. Frazier WC, Wethoff AC. Food microbiology 4th edn. Tata McGraw Hill Publishing Co Ltd, New Delhi; 1997.
27. Mordi JI, Elemo GN, Ozumba AU, Olawole OB, Maiyaki OM, Onyibe J, Onuh LI. Production and evaluation of jam from roselle calyx extract. Nigerian Food Journal. 2011;29(1):90-93.
28. Aina VO, Ibrahim MB, Peter M, Adewumi AAJ, Adulsalami MS. Nutrient and anti-nutrient composition of jam prepared from pineapple (*Ananas cosmosus)*. Journal of Nutrition Research. 2015;5(2):23-29.
29. Anonymous. Jams, jellies and marmalades- Specifications and test methods, the National Standard of Iran No. 214. Institute of Standards and Industrial Research of Iran [In Persian]; 2015.

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