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PHYSICO-CHEMICAL PROPERTIES AND SENSORY EVALUATION OF JAM MADE FROM BLACK-PLUM FRUIT (*Vitex doniana*)

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ABSTRACT

The potential of some wild-growing indigenous fruits such as black-plum (*Vitex doniana)* has remained largely untapped. Most tropical fruits can be processed and preserved in small-scale operations using simple techniques. Various uses have been reported for black-plum ranging from medicinal to dietary utilization. This study was carried out to investigate the possibility of producing jam from black-plum and to evaluate the physico-chemical properties, nutritional properties and consumer acceptability of the product. Black-plum jam was produced using traditional open-kettle method. The physico-chemical analyses of black-plum fruit and jam were determined. Physico-chemical analyses of black-plum fruit showed that it had soluble solids of 18.83 $\pm$ 0.11 ^{o}Brix, pH 3.85 $\pm$ 0.07 and ascorbic acid was 33.35 $\pm$ 0.21 mg/100g. Na, K and Ca contents were (0.1 mg/100g); (1.33 mg/100g); and (0.765 mg/100g), respectively. Physico-chemical analyses of the jam showed that it had soluble solids of 68.0 $\pm$ 0.71^{o}Brix, 24.22 $\pm$ 0.08% reducing sugar, pH of 3.42 $\pm$ 0.03 and total acidity of 0.34 $\pm$ 0.01%. Proximate analysis of the jam showed nutrient values of crude protein 4.23 $\pm$ 0.03%, crude fibre 1.0 $\pm$ 0.03%, ash 4.30 $\pm$ 0.02%, crude lipid 2.43 $\pm$ 0.03%, carbohydrate 68.1 $\pm$ 0.28%, sodium (Na) 0.28 $\pm$ 0.01 mg/100g, potassium (K) 1.42 $\pm$ 0.01 mg/100g, calcium (Ca) 0.97 $\pm$ 0.01 mg/100g, moisture 21.65 $\pm$ 0.33%, dry matter 78.36$\pm$ 0.33%. Physico-chemical and proximate analyses of the fruit on wet and dry basis were also carried out. Sensory evaluation by untrained panelists indicated consumer acceptability. Statistical evaluation using simple-paired comparison between black-plum jam and commercial black currant jam on a nine-point hedonic scale showed a preference for the commercial jam, particularly in terms of colour. The differences in flavour and spreadability were not significant ($P > 0.05$) 5% level; while the differences in colour, taste and overall acceptability were significant ($P < 0.05$) 5% level. Some assessors, however, scored black-plum jam high for flavour and spreadability.

Key words: indigenous, *Vitex doniana*, black-plum jam, evaluation

INTRODUCTION

The awareness of the significant contributions that wild-growing indigenous fruits make to the diets of a good percentage of the African population, especially in the sub-Sahara is increasing [1, 2, 3, 4]. They serve to supplement the nutrients provided by cereals, legumes and root crops. They are important sources of carbohydrate, calcium, magnesium, potassium and vitamin C and are pleasant to taste. They also provide substantial income to the economy of the rural populace in its place as an article of informal trade. In Africa, particularly in the Sahel regions where drought and other weather-related calamities reduce traditional staple crop yields, wild fruits are gaining increasing importance.

However, these wild fruits are fast disappearing and this may have dire consequences on the rural populace who eat them fresh [5]. This is due to the changes sweeping through African societies such as urbanization and industrialization, leading to the clearing of forests [6]. There is little documentation on the cultivation of indigenous trees [7], and this situation is responsible for the little progress in the improvement and utilization of indigenous plant species for food and other uses. It is, therefore, important to improve existing methods, and/ or adopt new methods for the greater utilization of perishable food resources. Without this, nutrient depletion, quality loss, and damage of physiological structures before consumption or conversion into secondary products occur [8, 9]. Broadening the utilization of indigenous food species, which would otherwise be lost, will contribute to the national effort of greater self-reliance in food production.

Black-plum (*Vitex doniana* Sweet*)* of the family *Verbanaceae* is a tree crop that grows in open woodland and savannah regions of tropical Africa; it is the commonest of the *Vitex* species in West Africa [10,11]. It produces fruits which are plum-like, sweet and edible [12]. The fruit is green when mature and changes to dark brown when fully ripe, with the pulp surrounding a hard stone containing 1 – 4 seeds. It is a savanna species and can therefore be found in northern, eastern and western Nigeria. It is known by the local names: Hausa – *dinyar*; Fulani – *galbihi;* Yoruba - *ori nla;* Ibo – *ucha koro.* The fruits are also referred to as black-plum or African olive [13]. Locally, it is used for making candies (*alewa* in northern Nigeria); and the leaves of the fruits are mixed with groundnuts, salt and pepper (*dinkin dinya)* [11]. It has been reported that syrup similar to honey was produced from the fruit and that physico-chemical and sensory results showed that it can substitute for other syrups as a nutritive sweetener [14]. There are also reports of its use by various communities in Nigeria for many purposes and its potential for use in the production of wine and jam [15]. Other reported uses of the tree include its stem bark extract for the control of hypertension and its anti-hepatotoxic effect and treatment of stomach ache, pains, disorders and indigestion [16,17]. In Ghana it is used for treatment of colds and cough in children and its bark in treatment of sterility [18]. In Sierra Leone, the fruits are regarded as a remedy for A and B avitaminosis. In Eastern Sudan, the roasted fruits are said to be a substitute for tea. Post-harvest studies carried out on *V. doniana* in Nigeria, showed that fungi were mostly responsible for post-harvest rot of the fruit [19]. The commercial value of *Vitex doniana* has not been exploited at all despite the reported uses. The tree may be facing the risk of becoming extinct as farmlands and urbanization is gradually decreasing the availability. Older members of the society recall the trees growing at their backyards but now they have to look further into the bushes and forests to obtain (harvest) the fruits.

This study sought to produce jam from the fruits of *Vitex doniana.* Jam is a fruit preserve with a stable shelf-life that depends on high sugar content (68-72%) combined with the fruit acidity that prevents microbial invasion and growth. A good jam is, in fact, a complex product that requires precise balance between sugar level, acidity and pectin content of fruit boiled together to produce a gel on cooling [20]. Jams are very sweet items made from whole fruit or fruit pulp and are consumed as accompaniments to other foods [21]. Almost all tropical fruits can be processed and preserved in small-scale operations using simple techniques. Since fruit trees tend to crop in flushes and the fruits are usually difficult to store fresh, it leads to gluts in the local markets with people literally giving them away because they do not want to carry them back home. Also, the extortionate prices being charged for processed fruit products such as canned fruits, juices and jam makes one encouraged to tap into available market.

MATERIALS AND METHODS

Fully ripened black-plum (*V. doniana)* fruits were harvested from Ile-Ife, Osun State, Nigeria and kept in the freezer for three months. Other raw materials which included sugar, lime and bottles for packaging were purchased at Bodija market in Ibadan. Whole frozen black-plum fruits were allowed to thaw and washed under running water, weighed and blended in a warring blender. The seeds and skins were separated from the pulp with the addition of water to facilitate the separation using a coarse sieve. The weight of the seeds and skins was taken to determine the weight of the pulp obtained.

Preparation of the black-plum jam

Black-plum jam was prepared using the open kettle method as described by DeGregorio and Cante [22]. The extracted pulp was poured into a pot and brought to boil to concentrate at atmospheric pressure and temperature 105^{o}C. The pre-determined weight of sugar was added to the boiling pulp while stirring vigorously until it became concentrated to desired consistency. Abbey refractometer (Bausch and Lomb Model) was used to determine the ^{o}Brix. A refractometer reading indicating the attainment of 68.0 ^{o}Brix was the point at which the concentration was stopped. Lime was added to adjust the pH to 3.2 and further heated to remove excess water from the lime. The jam was filled while hot into sterilized jars, which had been washed properly with soap and water and sterilized by boiling (jars and lids separated) in water to 100^{o}C for 10 min, leaving 1/4inch headspace and turned over. Samples of the jam were stored at ambient and refrigeration temperatures.

The quantity of sugar to be added to the jam in order to attain the desired ^{o}Brix of 68 was calculated as:

$$\text{wt of sugar} = \frac{^{o}\text{Brix of product} - {^{o}\text{Brix of fruit}}}{100} \times \text{wt of pulp}$$

Physico-chemical analysis of black-plum fruit and jam

The physico-chemical properties of black-plum fruit and jam such as the ^{o}Brix, refractive index (RI), pH, total acidity, vitamin C, pectin, reducing sugar and viscosity were determined according to standard methods. The pH meter was calibrated by adjusting with buffers 4 and 7 solutions. The soluble solids of the fruit and jam calculated in ^{o}Brix were determined using Abbey refractometer (Bausch and Lomb). Samples were placed on the sample holder of the refractometer that had been standardized to the zero mark with distilled water. The refractive index and ^{o}Brix were read from the refractometer. pH was determined using pH meter (model BA 350 EDT instruments). Total acidity of the pulp and jam samples were determined using methods as described by Ruck [23]. 25g of blended portion of fruit and jam samples were taken. The samples were transferred to 400 ml beakers containing hot water, which was made up to the 200 ml mark, boiled gently for 15 min and filtered. 50 ml of the filtrates were pipetted into 250 ml beakers; 100 ml of water was added to each of them. They were titrated to pH 8.1 using a pH meter. Total acidity was calculated as:

$$\% \text{ Total acid} = \frac{0.1 \times \text{equivalent wt of acid} \times \text{N of NaOH} \times \text{titre}}{\text{wt of sample}}$$

Ascorbic acid was determined by the 2,6-dichlorophenol indophenol titration procedure [24]. Ascorbic acid was extracted using an acetic acid and metaphosphoric acid solution. The extracts were transferred with distilled water into a 50 ml volumetric flask and made up to the mark with more water and filtered rapidly. The filtrate was run from a burette into a test tube containing one drop of dilute acetic acid and 1ml of the redox dye, 2,6 dichlorophenol indophenol solution. The volume of extract required to decolorize the dye was noted. The titration was repeated using standard ascorbic acid solution (1 mg pure vitamin per 100 ml) in place of the jam and fruit extracts.

Ascorbic acid per 100g of jam or pulp is calculated as:

$$\% \text{ ascorbic acid} = \frac{w \times 100}{100}$$

w= volume of dye

Pectin content was determined by methods as described by Ruck [23]. 50g of sample was boiled in 400 ml of water for 1 hr; replacing water lost by evaporation. The volume of the sample was made up to 500 ml and filtered. 100 ml of aliquot was taken and 10 ml NaOH and water added up to 800 ml while stirring constantly and left to stand for 5 min. 25 ml of 1.0 N $CaCl_2$ solution was added while stirring and allowed to stand for 1 hr. It was heated to boiling and allowed to boil for 1 min and then filtered through filter paper that had been washed with hot water, oven-dried for 2 hr at 100°C, cooled in a dessicator and weighed. The precipitate was washed with almost boiling water until chloride free. It was tested for white precipitate with $AgNO_3$. The filter paper was dried overnight at 100°C, cooled in a desiccator and weighed. Total pectin was calculated as:

$$\% \text{ Ca pectate} = \frac{\text{wt of Ca pectate} \quad \text{X} \quad 100}{\text{wt of sample}}$$

The reducing sugar and viscosity of the jam were determined using methods as described by AOAC [24]. Reducing sugar was determined by dissolving 2 g of sample in 250 ml of distilled water. 1 ml of solution was diluted with 100ml of distilled water in a beaker. 1 ml of the diluted solution was pipetted into a test-tube and 1 ml of 5% phenol was added drop by drop. The test-tube was allowed to stand for 10 min before the content was transferred into clean, grease-free cuvette and read with spectrophotometer at a wavelength of 490 nm. A blank was prepared as above to set the equipment to calibrate the equipment. The viscosity of the jam was measured by dissolving 2g of finely blended sample in 20ml of distilled water, stirring intermittently to completely dissolve. Filtrate of the sample was filled into 1 ml Volac viscosity pipette (1N 20°C). The rate of dropping was noted in seconds with a stop-watch in ml/s.

Proximate and nutritional analyses of black-plum fruit and jam
The proximate and nutritional parameters of the fruit and jam evaluated were crude protein, crude fibre, ash, crude lipid, carbohydrate, sodium, potassium, calcium, moisture, and dry matter. The analyses were carried out using methods as described by AOAC [24]. Crude protein was carried out using the Kjeldhal (micro-kjeldhal method) procedure with nitrogen to protein factor of 6.25. Moisture content was determined using the oven method.

Sensory evaluation of black-plum jam
Simple paired comparison between black-plum jam and commercially available blackcurrant jam using a nine-point hedonic scale was carried out by untrained panelists. The scale ranged from like extremely (9) to dislike extremely (1). The parameters evaluated were colour, taste, flavour, spreadability and overall acceptability.

RESULTS

Physico-chemical analyses of black-plum fruit and jam
Black-plum fruit had soluble solids of 18.83 $\pm$ 0.11 and the brix of concentrated jam was 68.0 $\pm$ 0. 71 °Brix. pH was recorded as 3.85 $\pm$ 0.07 and 3.42 $\pm$ 0.03, respectively for black-plum fruit and jam. Ascorbic acid (mg/100g) was 33.35 $\pm$ 0.21 and 27.06 $\pm$ 0.19 in the fruit and jam, respectively. Total acidity value of 0.60 $\pm$ 0.02 % and pH range of 3.4-3.8 shows that the fruit is fairly acidic. The pH of the jam, however, increased to 3.4 from 3.85 value of the fruit. Results of physico-chemical analyses of black-plum fruit and jam are presented in Table 1.

Proximate and nutritional analyses of black-plum fruit and jam

Crude protein content of the fruit ranged between 2.2 and 3.08(%) on wet and dry basis, respectively while the value of 4.23 $\pm$ 0.03 % was recorded for the jam. Crude fibre, ash, crude lipid and carbohydrate contents on dry weight basis were 1.25 $\pm$ 0.07; 5.46 $\pm$ 0.02; 3.81 $\pm$ 0.03 and 66.40 $\pm$ 0.71 percent, respectively. Moisture content was 70.62 $\pm$ 0.37 % (wet basis) and 20.02 $\pm$ 0.67% (dry basis) in the fruit while moisture content in jam was 21.65 $\pm$ 0.33 %. Na, K and Ca content were (0.1 mg/100g); (1.33 mg/100g); and (0.765 mg/100g), respectively. Results are presented in Table 2.

Sensory Evaluation of black-plum jam

Mean scores of sensory evaluation are presented in Table 3. Black currant jam had the highest mean scores for all attributes being compared. The differences in flavour and spreadability were not statistically significant at the ($P > 0.05$) 5% level. The differences in colour, taste and overall acceptability were, however significant at ($P < 0.05$) 5% level.

DISCUSSION

Physico-chemical analyses of black-plum fruit and jam

The pH value of 3.85 $\pm$ 0.07 recorded for black-plum fruit varies from that reported from the value of 4.38 reported by Egbekun *et al*. [14] and 5.20 reported by James [25]**.** Ascorbic acid content of 33.35 $\pm$ 0.21 mg/100g was recorded, which varies with 18.1 mg/100ml reported by Egbekun *et al.* [14] and fairly close to that reported by James [25]. Reducing sugar was 2.20 $\pm$ 0.08 % compared to 7.3% reported by James [25]. The ^{o}Brix value of 68.0 $\pm$ 0.71 and pH 3.44 recorded in the jam conforms to values recommended for jam to hinder microbial growth and maintain keeping quality [5,26,27]. The ^{o}Brix value of the jam is also close to 67 ^{o}Brix recorded for syrup produced from black-plum fruit [14]. The pH of 3.44 of the current study (Table 1) is close to the reported pH 3.2 for optimum gel formation [28]. Reducing sugar content of 24.16% (Table1) was within the values (20-40%) acceptable in commercial jams [20].

Proximate and nutritional analyses of black-plum fruit and jam

The values of proximate and nutritional composition of the fruits obtained are comparable to values reported on the dry matter basis [17]. Crude protein content of 3.08 $\pm$ 0.02 % recorded in this study was close to the value of 3.75% reported by Ladeji and Okoye [29]. These values for crude protein in black-plum fruit are higher than for most fleshy fruits and compares with prunes, figs, dates and sultanas [30]. Crude lipid was 3.81 $\pm$ 0.03 % compared to 0.56 % reported by Egbekun *et al*. [14]. Black-plum fruit is a fairly good source of Na (0.1 mg/100g); K (1.33 mg/100g); Ca (0.765 mg/100g). It is a fairly good source of crude protein and lipid and high in carbohydrate (66.40 $\pm$ 0.71 %). The variations observed in some of the physico-chemical and proximate analyses from other authors could be due to the different sources of the fruits, and the effects of storage and processing methods.

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Sensory Evaluation of black-plum jam

Sensory evaluation indicated that black-plum jam was acceptable to consumers. The black currant jam, however, had the highest mean scores for all attributes being compared. The differences in flavour and spreadability were not statistically significant at the ($P>0.05$) 5% level. The differences in colour, taste and overall acceptability were, however, significant at ($P < 0.05$) 5% level. Some assessors scored black-plum higher for flavor. The colour of black-plum had the lowest scores than other parameters.

CONCLUSIONS

V. doniana can be used in making jam. The low gel strength of the jam can be improved by the addition of pectin during processing to attain the commercially acceptable gel strength or a combination of fruits rich in pectin can be used to make up for the deficiency. Optimum gel formation is reported at pH 3.2 and satisfactory gel formation in tropical fruits is achieved at lower pH range [28,31,32]. The combination with other fruits could serve to improve the flavour and the colour. African indigenous fruits are under-utilized; efforts should go toward finding more commercial uses for them. Most are still being collected from the wild; and there are no deliberate attempts to domesticate and cultivate them. Expanding the utilization of these crops will be an incentive for farmers to cultivate them.

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Table 1: Physico-chemical properties of black-plum fruit and jam

Parameter	Black-plum fruit *Mean+ SD	Black-plum jam *Mean+ SD
Soluble solids °Brix	18.83 + 0.11	68.0 + 0.71
pH	3.85 + 0.07	3.42 + 0.03
Total acidity (%)	0.60 + 0.02	0.34 + 0.01
Reducing sugars (%)	2.20 + 0.08	24.22 + 0.08
Ascorbic acid (mg/100g)	33.35 + 0.21	27.06 + 0.19
Pectin	0.35 + 0.014	ND
Refractive index	ND	1.42 + 0.00
Viscosity	ND	3.75 + 0.07

***Values are means of triplicate determinations**

Table 2: Proximate and nutritional analyses of *Vitex doniana* fruit and jam

Nutrient	Fruit (%) wet basis *Mean+ SD	Dry basis *Mean+ SD	Jam % *Mean+ SD
Crude protein	2.2 + 0.014	3.08 + 0.02	4.23 + 0.03
Crude fibre	0.95 + 0.0	1.25 + 0.07	1.0 + 0.03
Ash	1.61 + 0.03	5.46 + 0.02	4.30 + 0.02
Crude lipid	2.74 + 0.01	3.81 + 0.03	2.43 + 0.03
Carbohydrate	21.89 + 0.36	66.40 + 0.71	68.1 + 0.28
Moisture	70.62 + 0.37	20.02 + 0.67	21.65 + 0.33
Dry matter	29.38 + 0.37	79.99 + 0.67	78.36+ 0.33
mg/100g			
Sodium (Na)	0.065 + 0.01	0.1 + 0.01	0.28 + 0.01
Potassium (K)	0.55 + 0.01	1.33 + 0.03	1.42 + 0.01
Calcium (Ca)	0.385 + 0.01	0.76 + 0.01	0.97 + 0.01

***Values are means of triplicate determinations**

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Table 3: Mean scores for sensory evaluation

Sample	Colour	Taste	Flavour	Spreadability	Overall acceptability
Blackcurrant	7.6[a]	7.6[a]	7.3[a]	7.0[a]	7.7[a]
Black-plum	4.7[b]	6.7[b]	6.6[a]	6.6[a]	6.0[b]
Av.Diff. (d)	2.9	0.9	0.7	0.4	1.7

Values with same index are not significantly different at P < 5% level

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