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Evaluation of the Proximate and Antinutritional Properties of Juice and Concentrate Produced from Black Plum (*Vitex doniana*) Fruit

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Abstract

Black plum (*Vitex doniana*) juice has received limited attention in terms of comprehensive research on their proximate and anti-nutritional compositions. This study addresses this research gap by exploring the production of dry concentrate, single strength juice and 60% diluted seven juices samples (using different treatments). The investigation of their proximate and anti-nutritional compositions were performed, using standard analytical methods. Also the Juice samples were compared with commercial black currant juice drink.

The results of proximate analysis of the dried concentrate revealed a moisture content of 18.85%, ash content of 4.47%, dietary fibre content of 30.14%, fat content of 2.07%, protein content of 8.69%, and carbohydrate content of 35.78%. The single strength juice had moisture content (59.88%), Ash (1.68%), Dietary fibre (11.08%), Fat (0.70%), Protein (2.36%) and Carbohydrate (24.30%). The juices with 60% dilution had moisture content ranging from 81.26% (SSI) to 86.81% (SSC), lower than the commercial juice CEX (90.68%). An increase in the mass of the pectinase enzyme significantly reduced the moisture content, increased the ash content, but increase in the incubation time had no significant difference in the ash content. Preheating (simmering) the fruit before processing did not affect the ash content too. Neither the mass of pectinase enzyme inoculated nor the length of the incubation significantly affected the total dietary fibre of the juice samples. Both increase in the mass of enzyme inoculated and the length of incubation time did not affect the fat content of the juices. The protein content of the juice decreased significantly ($p \leq 0.05$) as the mass of the pectinase and the length of incubation and aslo the heating temperature and time increased. The carbohydrate content of the diluted juices was between 8.73% (SSC) and 14.37% (SSI). Statistically, SSC, SSD, SSE, SSF, SSG, and SSI have the same carbohydrate (in quality). SSI had a significantly higher carbohydrate (14.37%). The carbohydrate content of commercial juice (CEX) (9.18%) is much less and significantly lower than that of all processed juice samples. The result of the anti-nutrients showed the concentrate (SSA) and single strength juice (SSB) contain the Oxalate (10.64 and 3.75 mg/100g), followed by Saponin (5.31 and 1.96mg/100g), Tanin (4.82 and 1.95mg/100g), Phytate (3.91 and 1.94mg/100g) while Alkaloid (1.27 and 0.39mg/100g) respectively. The increase in pectinase significantly reduced none of the anti-nutrients. Simmering the fruit before obtaining the pulp used for the juices and increasing the preheating temperature had no significant effect on most of the anti-nutrients except for saponin, which was significantly decreased by the simmering. There were no significant differences ($P \geq 0.05$) in the anti-nutrients when the simmering temperature was increased from 43°C to 51°C. Almost no anti-nutrient was in the commercial juice sample (CEX).

Keywords: Black Plum; Juices; Concentrate; Antinutritional; Proximate

Introduction

Background of the Study

Several studies support the notion that consuming fruits and vegetables may aid in the prevention of chronic and degenerative disease [1-4]. In tropical countries, wild and/or non-commercialized fruits offer potential novel sources of macro- and micro-nutrients as well as health promoting phytochemicals for rural populations [5]. Among these wild fruits, Black plum, *Vitex doniana* is found in many parts of sub-Saharan Africa and remains a well-known nutritious and health-promoting food for local populations. Black plum commonly known as *Vitex doniana* Sweet belongs to the Verbenaceae family. It is an indigenous deciduous fruit tree found in the livelihood of the rural population. The plant is commonly found growing in the wild, in the fringes of virgin forest, though it also grows naturally on farms and around dwellings in secondary bushes [6,7].

It can be taken whole, raw, and processed into juices and concentrate. Juices are economically very important fruit products, but Plum juices are rare [22]. However, these fruits are disappearing due to urbanization and industrialization, sweeping through African, leading to the clearing of forests, and this may have dire consequences for the rural populace who eat them fresh. Black plum has over twelve varieties. 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. Black Plum has many local names. It is called "Mbembe" in Anambra and parts of Delta state. Enugu state calls it "Erigheri or Mgbamgba". People from Abia state call it "Uchakiri"or Uchakoro, while Imo states people call it "Achakiri or Urobia". In the North, Hausas call it"Dinya", and Fulani calls it "Galbihi". While in the Western part, the Yorubas call the Black plum"Ori- nIa". The fruit is also referred to as the African Black plum or African Olive [8].

Black plum is an important nutritious fruit. It contains moisture of about 77.03%, Ash Content 1.65%; Fat 2.9%; Fibre 2.75%; Protein 8.10% and Carbohydrate 7.57%.The Black plum pulp could be promoted as a carbohydrate and lipid supplement for cereal-based diets in rural communities, another cheaper source for juice production [9]. It can be fortified into a feed of ruminants, while its moderate calcium value could be used to manage Osteomalacia [10]. It can make jam, while the leaves can be used as herbs to treat eye problems. The pounded leaves can also be added to warm filtered grain beer to make it stronger, and the bark yields a dye that can be used as a colourant [11]. Black plum can be processed into juice and jam. Just like other fruits, it has high pectin when unripe. In Nigeria, especially the Eastern region, the Black plum has not been accorded the importance they deserve due to their ignorance of the nutritive composition and may lack knowledge of its preservation methods or the conversion to value-added products. The usefulness of the Black plum has not been harnessed [9]. The mature fruits and ripened ones are scattered at the base of the tree for wild animals, and no new or fresh plants are grown because the fruits seem useless, except a few that are kept as shelter in the farm land.

There is scanty or no adequate information on the nutritional content of black plum and its use in producing juice, jam and concentrate. In Nigerian, especially the Eastern region, the Black plum fruit has been under-utilized. The lack of information about its usefulness and potential application in the diet and food industry contributed to the underutilization of this fruit. The lack of utilization has contributed to its lack of domestication, hence its gradual extinct.

The main objective of this research work is to produce and qualitatively evaluate the proximate and anti-nutritional composition of the Concentrate, Juice produced from the Black Plum (*Vitex doniana*) fruit using different treatments.

The creation of awareness of the proximate and anti-nutritional composition of Black plum concentrate, juice and Jam will facilitate the acceptability of Black plum, encourage its utilization in the diet and, more so, the value-added products will curtail its wastefulness and its domestication will be promoted as an economic tree. This will also prevent it from going into extinction.

This work covered raw material collection, the extraction of different concentrations of the juices with different treatments and jam production with different compositions of the Black plum fruit pulp, up to the analyses of the products obtained.

Materials and Methods

Materials Procurement

Procurement of Materials: Black Plum (*Vitex doniana*) fruits were harvested from the farmers who grew them. The chemicals, reagents, of analytical grades and the equipment used were gotten from the Departments of Food Science and Technology, of the Federal University of Technology Owerri.

Methods

Sample Preparation

Production of Black plum Juice Samples: The methods of Olawuni, et al. [22], and Nwokenkwo, et al [23] were adopted for this process. Fresh black ripe plum fruits collected were sorted and washed, and divided into two parts. The first part peeled immediately and had their seed discarded, leaving just the pulps. Some of the pulps were dried at 50˚C in a dehydrator for 8h until a constant weight is attained. The dried pulp was milled with warring laboratory mill blender (HGBTWTS3, Torrington, CT, USA), sieved through, with a 250mm mesh to obtain the dry concentrate powder, SSA (Figure 1). The second part of the pulp obtained from the raw fruit were, blended, and pressed with a sterilized muslin cloth to extract the juice. The juice obtained was bottled, and pasteurized at 85oC for 16 seconds, SSB (Figure 2).

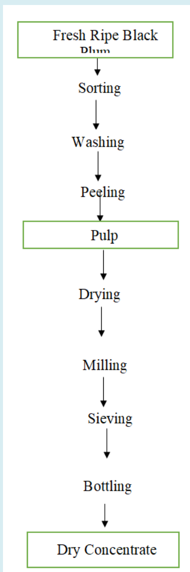

Figure 1: Production of Dry concentrate from black plum fruit.

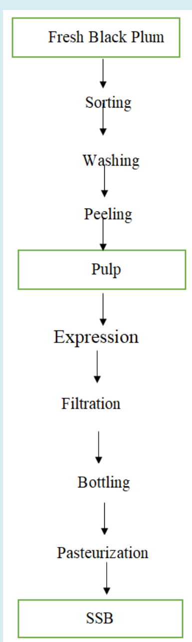

Figure 2: Production of Single strength juice from black plum fruit.

The remaining raw pulp were then diluted with 60% by volume of distilled water and divided into five portions. To the first portion, 0.4% of pectinase enzyme by weight of the raw pulp was inoculated and allowed to stay for 2hours, after which the mixture was filtered, bottled, and pasteurized at 85˚C for 16 seconds, then labelled as SSC (Figure 3). The second portion of the diluted mixture was inoculated with 0.4% of pectinase, but was incubated for 5h. The juice was expressed, filtered, bottled and pasteurized at 85˚C for 16 sec to get sample SSD (Figure 3). The third and fourth portion of the diluted pulp were inoculated with 0.6% pectinase, incubated for 2h and 5h respectively expressed, filtered, bottled and pasteurized to get samples SSE and SSF respectively (Figure 3). The last part of the diluted raw pulp was expressed, filtered, bottled, and pasteurized labelled as SSI. Then to the second part of the washed black plum fruit, one parts was simmered at 43˚C for 2 min while the other was simmered at 51˚C for 2min. Both were peeled, blended, diluted with 60% water, pressed to get the juice, filtered, bottled and pasteurized at at 85˚C for 16 seconds. then labelled as SSG and SSH respectively (Figure 4).

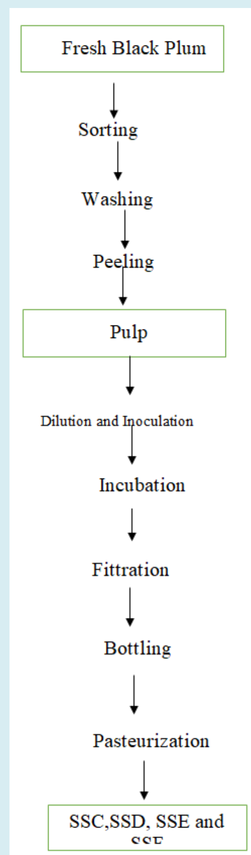

Figure 3: Production of 60% diluted juice with 0.4%and 0.6% pectinase respectively and incubated for 2h and 5h respectively from the Black plum fruit (Samples SSC, SSD, SSE and SSF).

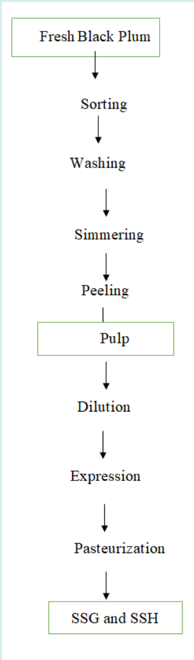

Figure 4: Production of 60% diluted juice by preheating the fruit to 43˚C and 51˚C respectively.

SSA produced above can be reconstituted to produce a single strength using the brix, codex standard 247-2005. The uncorrected concentration of the powdered black plum (*Vitex doniana*) pulp was 61oBrix. The correction factor was 9.38, and the corrected oBrix was 70.38 oBrix. Since Codex minimum single strength (SS) Brix for black plum is 11.02, the concentration factor was obtained as 70.38/11.02=6.39.

And 100g of the juice concentrate ×6.39 = 639g of SS juice. Therefore, 100g of the juice concentrate + 539g of water was used to produce single-strength juice.

Analysis of the samples

Proximate Analysis: The method of AOAC [12] was used for the determination of proximate compositions of the black plum samples. Moisture, Ash, Dietary fibre, Crude protein, fat contents were determined.

The total carbohydrate content of the samples was determined by difference as described by Wolever, et al. [13]. It was obtained by summing up the values of Moisture, Ash, Crude fat, Protein and Dietary fibre contents obtained from the analysis, and subtracting the sum from 100%.

Determination of Anti-Nutritional Factors: The method used to determine the anti-nutritional factors was obtained from the AOAC [12] and Alagbaoso, et al. [27]. The anti-nutritional factors in the Black plum samples determined were Oxalate, Phytate, Tannin, Alkaloid and Saponin.

Statistical Analysis

The experimental data were expressed as mean ± standard deviation (SD) in triplicate. They were analysed using one-way Analysis of variance (ANOVA) comprising (1×9×3) factorial experiment. The results obtained were subjected to statistical analysis using Statistical Packaging For Service Solution (SPSS) version 20.0. and the means separated using Fisher's Least Significant Difference at 95% confidence level ($P \leq 0.05$). The data were presented in tabular and graphical forms

Results and Discussion

Samples	Moisture (%)	Ash (%)	Dietary Fibre (%)	Fat (%)	Protein (%)	Carbohydrates (%)
SSA	18.85e±0.71	4.47a ±0.13	30.14a±1.15	2.07a±0.38	8.69a±0.23	35.78a±0.49
SSB	59.88d±1.68	1.68b ±0.06	11.08b±0.13	0.70b±0.07	2.36b±0.38	24.30b±1.65
SSC	86.81ab±2.14	0.11cd±0.08	3.22c±0.16	0.25c±0.03	0.88c±0.17	8.73d±1.73
SSD	86.39b±3.45	0.13cd±0.09	3.28c±0.88	0.26c±0.01	0.58e±0.07	9.36d±4.13
SSE	86.15b±3.05	0.15c±0.06	3.44c±0.12	0.22c±0.02	0.82d±0.24	9.22d±2.93
SSF	85.96b±2.45	0.15c±0.07	3.89c±0.23	0.22c±0.01	0.56ef±0.11	9.22d±2.52
SSG	85.95b±3.52	0.14c±0.01	3.69c±0.26	0.24c±0.04	0.49g±0.04	9.49d±3.54
SSH	86.48b±2.51	0.06cd±0.04	3.39c±0.35	0.26c±0.01	0.48g±0.04	9.33 d ±2.71
SSI	81.26c±2.48	0.04cd±0.03	3.54c±0.53	0.24c±0.01	0.54f±0.03	14.37c±2.83
CEX	90.68a±0.63	0.02d±0.02	0.01d±0.00	0.01d±0.01	0.09h±0.02	9.18d±0.64
LSD(0.05)	4.18	0.12	0.88	0.21	0.03	4.38

Table 1: The Mean scores of the Proximate compositions of the Concentrate and Juice Samples (%).
Note: The means with the same subscripts are not significantly different, whereas those with different subscripts are significantly different ($P \leq 0.05$).

SSA = Dried Concentrate; SSB=Single strength Juice.
SSC = 60%dilution, 0.4% pectinase and 2h incubation; SSD= 60% dilution, 0.4% pectinase and 5h incubation; SSE=60% dilution, 0.6% pectinase and 2h incubation
SSF= 60% dilution, 0.6% pectinase and 5h inoculation; SSI = 60% dilution and pasteurized only. SSG= 60% dilution, preheating to 43˚C for 2min
SSH= 60% dilution, preheating to 51oC for 2min; CEX = commercial juice

Moisture Content

The dry concentrate (SSA), has a moisture content of 18.85%. This is in line with the work of Vunchi, et al. [10] and Odimegwu, et al. [26]. SSB, the single-strength juice, has a moisture content of 59.55%. The diluted juice samples had moisture content that ranged from 81.26% to 86.81%. The result aligns very close with what was obtained by Okigbo [9] but is slightly lower than what was obtained by Vunchi, et al. [10]. The difference was likely due to the amount of water added to the single-strength juice in the different works. Expectedly, the single-strength juice (SSB) had significantly lower moisture content than the dry concentrate. All the juice from the black plum (SSC-SSI) had significantly lower moisture content than the commercially produced juice CEX (90.68%). The results suggest that they may be more viscous, contain more nutrients on dry matter, and have a higher shelf life. It was also observed that SSC had the highest moisture content, which suggests that at a lower time of incubation with less amount of pectinase, the moisture content of the juice may be higher than when more pectinase is used for a longer time. This is in line with the work of Kashyap, et al. [14], who asserted that pectinase which breakdown pectin tends to increase juice extract. Also, with low pectinase percentage added in juice production without heating the fruit prior to processing, the fruit will be highly pertinacious and yield little or no juice, meaning that the juice will contain more water than dry matter.

Ash Content

The dry concentrate (SSA) had an Ash content of 4.47%, while the single-strength juice had 1.68%. The ash content of the diluted juices ranged from 0.04% (SSI) to 0.15% (SSE and SSF). The commercial juice (CEX) had the least ash content (0.02%), while the single-strength juice (SSB) had the highest ash content. The ash content of the juices was quite low but compared favourably with what was obtained by Amah and Okogeri [15] and Begum, et al. [16]. An increase in the mass of the pectinase enzyme significantly increased the ash content, but the length of time the pectinase enzyme was incubated did not affect the ash content. Preheating (simmering) the fruit before processing did not affect the ash content. High ash content depicts high mineral content.

Dietary Fibre

The dry concentrate (SSA) had dietary fibre content of 30.14%, while the single-strength juice had 11.08%. The dietary fibre in the black plum diluted juices was between 3.22(SSC) and 3.89% (SSF). These values were higher than what Dadjo [7] and Olawuni, et al [25]. The differences might have been because of the type of fruit used (pawpaw in their case), the amount of enzyme used, and the preheating temperature (64˚C) in their case. The higher dietary fibre obtained in this work may imply that black plum contains higher dietary fibre than pawpaw, which may be an advantage since some fruit juice are sometimes taken to aid digestion after the main meal. Neither the amount nor mass of pectinase enzyme inoculated nor the length of the incubation significantly affected the total dietary fibre of the juice samples. This suggests that either the amount of pectin in black plum is insignificant when compared to the total dietary fibre or that pectinase, was not effective in the degradation of pectin during processing.

Fat

The result of the fat content of the juice samples showed that they contain very low fat. The fat ranged from 0.01% (for commercially produced juice) to 0.70% (Single strength juice) and down to 2.07% for the dry concentrate. Abdusalam, et al. [17] reported that high-fat content is not expected in juice because it might encourage oxidative rancidity. Both increases in the mass of enzyme inoculated and the length of incubation time did not affect the fat content of the juices. Vunchi, et al. [10] also reported that fruits are generally low in fat and that when processed, the fat content of juice reduces even further due to a reduction in total dry matter, which arises from skin removal and water loss. Protein content: The dry concentrate had a protein content of 8.69%, and the single-strength juice had 2.36%. This is in line with Vunchi, et al. [10]. Ofoedu, et al. [24] also reported that food preparation rich in nutrients are very essential for healthy growth. Thus, the protein content of the black plum juices, as seen in Table 1, ranges from 0.48% (SSH) to 0.88% (SSC). The protein content of the commercially produced juice is 0.09. That implies that all the other juices had less than 1% protein content apart from the single-strength juice. Protein is only higher than the fat and ash content of the juices. As seen between SSC and SSI, protein content is affected by the length of time in which the enzyme was incubated. The protein content of the juice decreased significantly ($p \le 0.05$) as the length of incubation increased from 2 hours to 5 hours. Also, the mass of the pectinase inoculated in the juice significantly affected it. There are significant differences ($p \le 0.05$) in the value of the proteins as the mass of the enzyme and the length of incubation are increased. There are also significant ($P \le 0.05$) decrease in protein as the heating temperature and time increases. Heating the fruit before processing significantly reduced the protein content more than the enzyme. The degradation may be due to the enzymes used, while protein coagulation may be responsible for protein loss in the samples processed at higher temperatures, as some of the coagulated protein may have filtered off.

Carbohydrate

The result of the proximate obtained in this work, as seen in Table 1, showed the carbohydrate content of the concentrate to be 35.78% while the single-strength juice had 24.30%. The result is higher than the result obtained by Vunchi, et al. [10] (28%) and lower than that by Nnamani, et al. [18]. Though Nnamani reported on the *Vitex doniana* leaves, the difference in the work of Vunchi, et al. [10] may be due to environmental differences. The carbohydrate content of the diluted juices was between 8.73% (SSC) and 14.37% (SSI). Statistically, SSC, SSD, SSE, SSF, SSG, and SSI have the same carbohydrate (in quality). SSI had a significantly higher carbohydrate (14.37%). The fact that the carbohydrate content of commercially produced juice (9.18%) is much less and significantly lower than that of all processed juice suggests that they may contain non-nutritive sweeteners. The result showed that carbohydrate has the highest dry matter in the juice.

Samples	Saponin	Oxalate	Tanin	Phytate	Alkaloids
SSA	5.31a±0.26	10.64a±0.37	4.82a±0.43	3.91a±0.31	1.27a±0.05
SSB	1.96b±0.15	3.75 a ±0.27	1.95b±0.19	1.94b±0.15	0.39b±0.03
SSC	0.43c±0.05	0.12 c ±0.05	0.09c±0.02	0.15c±0.02	0.06c±0.03
SSD	0.37c±0.05	0.11 c ±0.02	0.05c±0.01	0.15c±0.01	0.04c±0.03
SSE	0.41c±0.04	0.13 c ±0.02	0.09c±0.03	0.14c±0.02	0.07c±0.03
SSF	0.29c±0.03	0.09 c ±0.01	0.05c±0.02	0.12c±0.01	0.04c±0.00
SSG	0.22d±0.02	0.09 c ±0.04	0.02c±0.02	0.09c±0.01	0.04c±0.01
SSH	0.15d±0.03	0.06 c ±0.02	0.01c±0.01	0.06c±0.02	0.02c±0.01
SSI	0.35c±0.03	0.13 c ±0.02	0.13c±0.02	0.14c±0.02	0.07c±0.01
CEX	0.00e±0.00	0.02 c ±0.01	0.00c±0.00	0.00c±0.00	0.00d±0.00
LSD(0.05)	0.17	0.25	0.25	0.19	0.05

Table 2: The mean scores of the Anti-nutritional composition of the Concentrate and Juice samples (mg/100g).
Mean values with same superscript have no significant difference while those with different superscript are significant difference ($P \leq 0.05$).

SSA = Dried Concentrate; SSB= single strength juice.
SSC = 60% dilution, 0.4% pectinase and 2h incubation; SSD= 60% dilution, 0.4% pectinase and 5h incubation
SSE=60% dilution,0.6% pectinase and 2h incubation;SSF= 60% dilution, 0.6% pectinase and 5h incubation.
SSI = 60% dilution and pasteurized only; SSG= 60% dilution, preheating to 43˚C for 2min
SSH= 60% dilution, preheating to 51˚C for 2min; CEX= Commercial juice

The results from the analysis of anti-nutritional properties of the black plum juice samples are as seen in Table 2. The main anti-nutrients (quantitatively) is the oxalate(10.64mg/100g), followed by saponin (5.31mg/100g), while alkaloid (1.27mg/100g) was the least of anti-nutrients present in the samples among the list of anti-nutrients determined in this research work. The result showed that the single-strength juice (SSB) dilution significantly reduced all the anti-nutrients in the samples. The increase in pectinase significantly reduced none of the anti-nutrients. The quantity of anti-nutrients in black plum fruit juices in this study was similar to what was obtained for the single-strength sample but much lower in the diluted samples than that obtained by Imoisi, et al. [19]. Also, simmering the fruit before obtaining the pulp used for the juices and increasing the preheating temperature had no significant effect on most of the anti-nutrients except for saponin, which was significantly decreased by the simmering. There were no significant differences ($P \geq 0.05$) in the anti-nutrients when the simmering temperature was increased from 43˚C. Almost no anti-nutrient was in the commercially produced juice sample (CEX). This suggests that the sample may not contain fruit concentrate even though the label tells otherwise. Unaegbu, et al. [20] had earlier asserted that one of the main differences between a fruit juice and a fruit drink is that while the former is most likely to have some anti-nutrients if processed from freshly harvested fruits, the latter, is not likely to have anti-nutrients unless it contains some concentrate from natural fruit and not from 100% synthetic material. This may imply that some fruit juices ar fruit drinks but with misleading labels [21].

Conclusion and Recommendations

In conclusion, the results of this research study highlight the potential of the black plum (*Vitex doniana*) as a valuable fruit for various food applications.

The nutrient-dense nature of the black plum, as evidenced by its proximate and antinutrional compositions, underscores its potential as a valuable dietary source. Saponin is not always in large quantity in plants, so the high saponin content (5.31%) in black plum offers potential health benefits, including reducing blood lipids, liver cancer risks, and blood glucose response. Furthermore, saponins can be beneficial in treating dental caries, hypercalciuria, and acute lead poisoning.

Considering the nutritional composition and potential for value-added products, the availability of black plum can be extended beyond its natural season. This, in turn, presents economic opportunities and job creation in the food industry. Furthermore, promoting the consumption of black plum and domesticating the tree can contribute to its conservation and prevent its extinction.

In summary, the findings of this study emphasize the nutritional value and versatility of the black plum, positioning it as a promising fruit for various food applications. Further exploration and utilization of black plum can lead to the development of innovative food products and contribute to economic growth and environmental conservation.

The blackish colour of the jam may be lightened by mixing the black plum fruit with mango or pawpaw fruit. A more efficient means should be devised for easy pulping and juice extraction in further studies.

Contributions to Knowledge

The following key contributions can be drawn from this research:
The study demonstrates that high-quality juice and concentrate can be produced from the black plum, a nearly extinct fruit. The production of a dry juice concentrate, offers a practical solution for enjoying black plum flavours even when the fruit is out of season.

The significant saponin content found in black plum (5.31 mg/100g) positions the fruit and its products as potential nutraceuticals and supplements.

Competing Interest

The authors have affirmed that they have no conflicts of interest.

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Contributions from Writers

All authors worked together to complete this project. In addition to writing the protocols and the first draft of the article, Author N. J.N planned and designed the study. Data interpretation and statistical analysis were carried out by authors O.M., O.N and O.A.F. Author A.E.J. conceived, conducted literature research, participated in data gathering and oversaw study analysis. The final draft was read by all writers and got their approval.

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