PROXIMATE AND PHYSICOCHEMICAL PROPERTIES OF JELLY PRODUCED FROM BLENDS OF BEETROOT AND PINEAPPLE JUICE

Abstract

Jelly was produced from beetroot and pineapple and evaluated as a value addeed product for addressing beetroot and pineapple glut during their peak season. The fruits were cleaned, juiced and juices made into different formulations in the following ratio beetroot: pineapple, 50:50, 60:40, 70:30, 80:20 and 90:10. The formulations were identified with the letters; I, R, O, H, and A, respectively, with a commercial jelly sample, K made from beetroot as control. Proximate composition showed that the blends had better nutritional profile than the commercial sample except for energy value (262.72 KJ) and carbohydrate content (63.74 %) of the commercial jelly which was significantly ($p < 0.05$) different. Protein levels within the blends were expectedly low, ranging from 1.52 % in sample I (50 % beetroot and 50 % pineapple juice) to 1.76 % in sample A. The same trend was observed in fat, ash, and moisture content except for the carbohydrate content where the sample with the least amount of beetroot, sample I (50 % beetroot and 50 % pineapple juice) had the highest value of 62.69 % within the blends thus provided the highest amount of energy, 261.30 KJ. Physicochemical properties showed that blends had less sugar contents. Both commercial sample and blends have comparable acidity which is an indication that the formulated product will be shelf stable. Total soluble solids, total sugars, reducing and non-reducing sugars increased as the proportion of pineapple increased. Titratable acidity and pH showed that an inverse relationship existed between them. The beetroot and pineapple jelly blends produced compared favourably with proximate composition and physicochemical properties of commercial jelly.

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Introduction

Fruits and vegetables have similar composition, having high water content (70-85%), relatively high carbohydrate but low in fat and protein and usually contain useful vitamins (Nzelu, 2010). The carbohydrate portion can be further broken down into digestible and indigestible parts which are sugars and starches versus pectin and cellulose material (Potter and Hotchkiss, 2017). Vegetables differ from fruits in chemical composition. Most vegetables contain more starch than sugar as contrasted with fruits which are higher in sugar than starch especially when ripe. Vegetables are edible parts of the plant which are usually cooked and salted before consumption with other foods. These may include leaves, stems, roots, flowers, seeds, fruits, bulbs, tubers, and fungi. (Nzelu, 2010).

Beetroot (*Beta vulgaris L.*) is one of the important root vegetable that belong to the *Chenopodiaceae* family and is originally from temperate climate regions of Europe and North Africa. It is a dark red vegetable whose taste is described as sweet, earthy and tender to eat (Nottingham, 2004). Beetroot is delicious if eaten raw but is more typically cooked or pickled (Partha et al., 2014). It is grown in the ground and is related to turnips, swedes and sugar beet. Beetroots are notable for their sweetness; they have the highest sugar content of vegetables but

they are low in calories. However, fresh beetroots are exposed to post-harvest spoilage due to their high nitrate content. Pineapple (*Ananas comosus)* is a tropical fruit, a member of the *Bromiliaceae* family (TFNET, 2016). Pineapples are rich in vitamins, enzymes and antioxidants. They help boost the immune system, build strong bones and aid digestion. Despite their sweetness, pineapples are low in calories. They are members of the bromeliad family and the only member that produces edible fruit (Arshad et al., 2014).

Different food products like jam, jelly, fruit bar and marmalade are prepared from raw edible fruits. Fruit jams, jellies and marmalades are made by cooking fruits (pieces, pulps and or juice) with sugars, gelling agents (usually pectin) and edible acids, and concentrating the mixture until a characteristic and suitable consistency is obtained. The minimum amount of fruits in the final product may vary from about 35–45% (Fugel et al., 2015). Jellies are defined by Codex Alimentarius Commission, (CAC) section 2-2 as a product brought to semi solid gelled consistency and made from the juice and or aqueous extracts of one or more fruits or vegetables, mixed with foodstuffs with sweetening properties with or without the addition of water (CODEX STAN 2009).

Consumers find the flavour of beetroot repulsive and so avoid it, which calls for the need to make the vegetable available in more palatable forms. On the other hand, beetroots are rich in nitrates. This high concentration of nitrates makes it prone to microbial attacks responsible for the early deterioration of fresh raw beetroots (Nottingham, 2004). In essence, processing beetroots into jelly will solve the problem of high rate of spoilage of fresh beets, improve the usage of these nutritious root on the table of households and also enrich health with the numerous nutritional and health benefits it brings. More so, blending beetroot juice with pineapple juice will improve the flavour and provide the important nutrient, vitamin C which beetroot lacks in a nutritionally significant level, making it more acceptable and more nutritious. The objective is to produce and evaluate jelly from beetroot and pineapple juice as a value added product to curb peak season post –harvest losses of the two produce.

Materials and Methods

Fresh beetroot (*Beta vugaris L*) were purchased from Jos, Plateau state, Nigeria. Pineapples (*Ananas comosus*), golden penny granulated sugar and pfizer citric acid were purchased from Ogige main market in Nsukka, Enugu state Nigeria. Sure jell rapid set Pectin was ordered through Alibaba.com (online market) and was supplied through DHL courier service.

Preparation of beetroot and pineapple juice

Fresh beetroots and pineapples were washed separately under running tap water to remove dirt and dusts. They were further peeled, sliced, blended and juiced separately before formulating into the different required blends.

Making beetroot and pineapple blend jelly

Beetroot juice 2,500 ml and 2,000 ml of pineapple juice were extracted. The different formulations were mixed in the following ratio beetroot: pineapple, 50:50, 60:40, 70:30, 80:20 and 90:10 and 400 ml of each blend was weighed out identified with the letters; I, R, O, H, and A, respectively. Sugar 500 g was used for every 400 ml of juice. The sugar was measured and divided into three equal parts (166.67 g) each. First part was added into the juice and boiled at

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130 ^{o}C. The second part was mixed with pectin (6 g), the heat was reduced to 100 ^{o}C and the pectin and sugar mixture was heated until a gel is formed. The gel was added to the juice and was stirred continuously till it was totally dissolved, before the third part was added. Upon reaching 60 degree Brix, citric acid was added to get a pH of 3.4 for gel enhancement. Heating was discontinued at 65 degree brix and the jelly was allowed to cool to 80 ^{O}C before they were filled into already pre-sterilized glass jars leaving about ¼ inch head space for vacuum formation.

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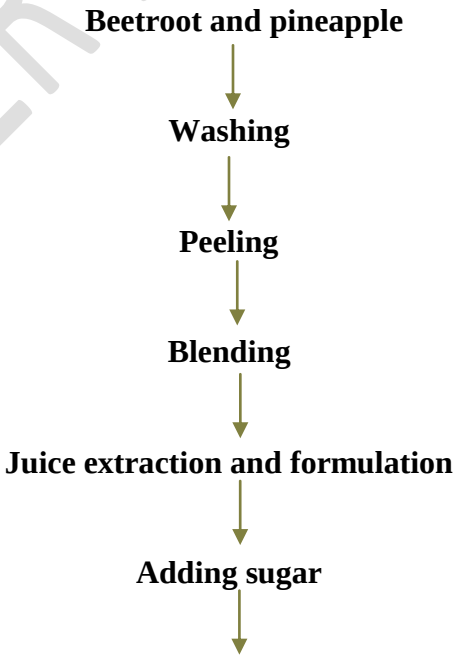

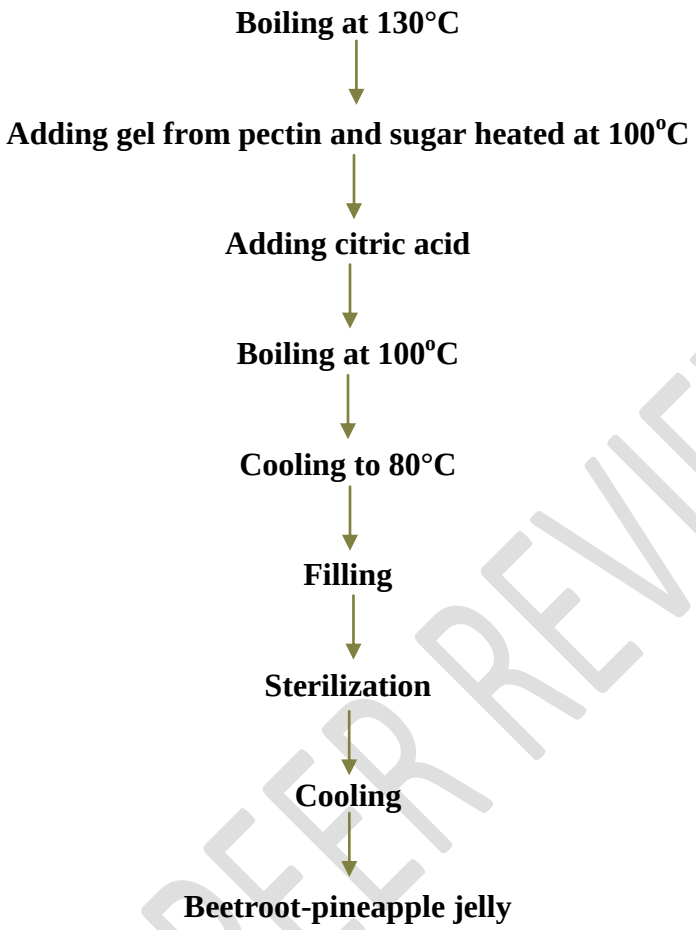

Figure 1: Flow diagram for beetroot and pineapple blend jelly production.
Source: *Gava* et al. (2008).

Table 1: Proportions of beetroot and pineapple juice in the jelly blends

Sample	Beetroot Juice (%)	Pineapple Juice (%)
K	--	--
I	50	50
R	60	40
O	70	30
H	80	20
A	90	10

Keys: Sample K= Commercial fruit jelly.
Sample I=50% beetroot juice and 50% pineapple juice.
Sample R= 60% beetroot juice and 40% pineapple juice.
Sample O=70% beetroot juice and 30% pineapple juice.
Sample H=80% beetroot juice and 20% pineapple juice.

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Sample A=90% beetroot juice and 10% pineapple juice.

Proximate Analyses

The proximate composition of jellies was determined according to the method of Association of Official Analytical Chemist (AOAC) (2010).

Determination of moisture content

Moisture content was determined by the hot air oven method. Stainless steel moisture dishes were cleaned and dried in the oven (Memmert Model UN30), at 100 ^{o} C for one hour to achieve constant weights. The moisture dishes were cooled in a desiccator and then weighed. Two grams of each sample was weighed into respectively labeled moisture dish and dried at 100 ^{o}C, for 1 hour, removed from the oven and placed in a desiccator to cool to room temperature before weighing. The moisture dishes were put back into the oven, dried and weighed intermittently until a constant weight was attained. The loss in weight from the original sample weight was calculated as the moisture content using the expression

$$\% \text{ moisture content} = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) \times \frac{100}{1}$$

Where: W_1 = weight of empty moisture dish, W_2 = weight of moisture dish + sample before drying, W_3 = weight of moisture dish + sample after drying.

Determination of ash content

Two grams of each sample was weighed into crucibles that had been previously washed, dried and weighed. The crucibles were placed in a muffle furnace (Vecstar, Model Lf3, USA) and ignited at 550 ± 2 ^{o}C for four hours, cooled and weighed. The ash content was calculated with the expression

$$\% \text{ Ash content } \left(\frac{W_2 - W_3}{W_2 - W_1}\right) \times \frac{100}{1}$$

Where: W_1 = weight of empty crucible, W_2 = weight of crucible and sample before ashing, W_3 = weight of crucible and sample after ashing.

Determination of fat content

A Soxhlet extractor with a reflux condenser and a previously dried cooled and weighed 250 ml round bottom flask was assembled. Two grams of each sample was weighed into labeled thimble and petroleum ether (150 ml, boiling point 60 – 80 ^{O}C) filled into the round bottom flask. The extraction thimble was plugged with cotton wool. The Soxhlet apparatus after assembling was allowed to reflux for 6 hours. The thimble was removed with care and the petroleum ether was recovered for reuse. The round bottom flask containing the petroleum ether was dried at 70 ^{O}C for 1 hour in an oven (Memmert UN30, Germany), cooled in desiccator and weighed.

Calculation:

$$\%Fat = \frac{Weight\ of\ \ fat}{Weight\ of\ \ sample} \times \frac{100}{1}$$

Determination of fiber content

Two grams of each sample was weighed and defatted using petroleum ether (Boiling point of 40 to 60°C). The defatted sample was boiled for 30 minutes in 200 ml of 1.25% H_2SO_4 and the

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solution filtered through a funnel fitted with muslin cloth. It was washed with boiling water until it was free of acid. The residue was boiled for another 30 minutes with 100 ml of 0.02 M NaOH. It was further washed with boiling water then with 1 % hydrochloric acid and finally with boiling water to ensure that it was free of acid. The final residue was transferred into a crucible and dried in the oven for 1 hour. The crucible with its content was cooled in a desiccator and weighed. The residue was transferred into crucible and dried at 100 ^{o}C to a constant weight. Incineration to ash was done at 600 ^{o}C for 30 minutes, cooled in a desiccator and weighed. The difference in weight between oven dry weight and weight after incineration was taken as the fiber content of the sample. This was expressed as a percentage of the original weight of sample taken for analysis.

$$\text{Crude fiber (\%)} = \frac{\textit{Weight of dried sample} - \textit{weight of sample after incineration}}{\textit{Initial weight of sample}} \times \frac{100}{1}$$

Determination of crude protein content

Protein was determined using the Kjeldahl method. Two grams of each sample was weighed into a Kjeldahl flask and added anhydrous sodium sulphate (5g of Kjedahl catalyst), concentrated H_2SO_4 (25 ml) and few boiling chips. The samples were digested in the fume chamber to clear sample solution. Each sample digest was allowed to cool and then transferred into a 250 ml volumetric flask made up to volume with distilled water. Five milliliters of 2% boric acid solution with few drops of methyl red indicator was introduced into a distillate collector (100 ml conical flask) and placed under the condenser in a distillation unit. Five milliliters of each sample digest was pipetted into the distillation unit, washed down with distilled water followed by addition of five milliliters of 60% sodium hydroxide solution to the digest. The sample was heated until 50 ml of the distillate was collected in the receiving flask. The distillate was titrated against 0.01N HCl to a pink colored end point. For the blank diluted digest from filter paper was also distilled and the distillate titrated against 0.01N HCl Total nitrogen (%) was estimated using the expression:

$$\text{\% Nitrogen} = \frac{\textit{Titre value} - \textit{Blank} \times \textit{Normality of acid}}{\textit{Weight of sample}} \times \frac{100}{1}$$

Crude protein = %N x 6.25

Where T= Titre

B= Blank

N= Normality

W= weight of acid

Determination of carbohydrate content

Carbohydrate content of each sample was calculated by difference. The difference between 100 and the sum of percentages of moisture, protein, fat, fiber and ash of each sample was calculated and the result expressed as

% carbohydrate = 100 – (% moisture + % crude protein + % crude fiber + % ash + % fat)

Determination of energy value

The values obtained for protein, fat, and carbohydrate was used to calculate the energy value of the samples, using the At-water factor described by AOAC (2010).

Calorific value (Kcal/100g) = P×4.0+F×9.0+C×3.75

Where P, F, and C are (%) protein, fat, and carbohydrate in the samples.

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Physicochemical analyses

Determination of Total soluble solid (TSS)

The TSS content of pulp was determined in accordance with AOAC [2010], using Erma hand refractometer at 20 ^{o}C and by reference tables expressed as % sucrose by weight (^{O}Brix) The prism of refractometer was washed with water and wiped to dry after each reading.

Determination of total sugars

Total sugar was determined using the method described by AOAC (2010). Five grams of sample was put in a 500 ml beaker, 100 ml warm water was added and it was neutralized with 10% NaOH. Two milliliters of lead acetate solution was added it was allowed to stand for 10 minutes. The necessary amount of sodium oxalate was added to remove excess lead in the solution. The volume was made up to 250 ml mark with distilled water and filtered. Fifty milliliters of the clarified and deleaded solution was transferred into a 250 ml flask. Ten milliliters of 1N HCL was added into the flask. This solution was boiled for two minutes. After cooling, 3 drops of phenolphthalein was added and the content was neutralized with NaOH. The solution was diltered and the volume, made up to 250 ml with distilled water. Ten milliliters of a mixed fehling's solution was pipetted into a conical flask. A burette was filled with the clarified sample solution and running the whole volume required to reduce the fehling's solution so that, 0.5-1.0 ml was still required to complete the titration. The content of the flak was mixed and heated to boiling for 2 minutes. Three drops of methylene blue indicator were added then the titration continued until color completely disappeared. The percentage total sugar was calculated as follows:

Mg total sugar per 100 ml = $\frac{Factor \times 100}{Titre}$

Percentage total sugar = $\frac{mg\ per\ 100ml \times Dilution}{weight\ of\ the\ sample \times 1000} \times 100$

Determination of reducing sugars

Reducing sugars was determined using the method described by AOAC (2010). Five grams of sample was put in a 500 milliliters beaker, 100 milliliters warm water was added and it was neutralized with 10 % NaOH. Two milliliters of lead acetate solution was added it was allowed to stand for 10 minutes. The necessary amount of sodium oxalate was added to remove excess lead in the solution. The volume was made up to 250 milliliter mark with distilled water and filtered. Ten milliliters of mixed fehling's solution was pipetted into a conical flask. A burette was filled with the clarified sample solution and running the whole volume required to reduce the fehling's solution so that, 0.5-1.0 ml was still required to complete the titration. The content of the flak was mixed and heated to boiling for 2 minutes. Three drops of methylene blue indicator were added then the titration continued until color completely disappeared. The percentage reducing sugar was calculated as follows:

Mg reducing sugar per 100 ml = $\frac{Factor \times 100}{Titre}$

Percentage reducing sugar = $\frac{mg\ per\ 100ml \times Dilution}{weight\ of\ the\ sample \times 1000} \times 100$

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Determination of non-reducing sugar

Non-reducing sugars was determined using the method described by AOAC (2010). Percentage reducing sugar was subtracted from total sugar and the result obtained were values for the non-reducing sugar.

Determination of pH

pH was determined using a standard pH (model 20 pH) conductivity meter (Denver instrument united national inventory database) as described by AOAC (2010). Two grams of sample was homogenized in twenty millilitres of distilled water in a beaker. The pH meter was first standardized using buffer solutions of pH 4 and 9. The electrode was rinsed with distilled water and then dipped into the homogenate, allowing sufficient time for stabilization before taking the reading.

Determination of titratable acidity

Titratable acidity was determined by the methods described by AOAC (2010). Ten grams of the sample was diluted into 250 ml of boiled distilled water and titrated just before the end point using 0.1 N NaOH using 0.3 ml phenolphthalein as an indicator. Two grams of sample was diluted in 20 ml of distilled water. With this, the colour was easily noticed and then it was titrated with NaOH solution until a pink colour was obtained that persisted for 30 seconds. The titration was done in duplicates and the end point was taken. The acidity was calculated using the formula:

Titratable acidity (%) = $\frac{0.1N(NaOH)\times T\times 75}{V\times 1000}\times 100$

Where T = titre value

V = volume of sample

Experimental design

The experiment was laid on a Completely Randomized Design (CRD). The mean and standard deviation were calculated by one-way analysis of variance using statistical package foe service solution (SPSS) software version 22. Means were separated by Duncan's new multiple range test. Significant difference were at $p < 0.05$ according to Steel and Torrie, (1980).

Proximate composition of beetroot and pineapple blend jelly

Protein content of the samples ranged from 0.88 in sample K to 1.77 in sample H. No significant ($p>0.05$) difference was observed between samples A, H and O. Sample K varied significantly ($p<0.05$) from the rest of the samples and no significant ($p>0.05$) difference was observed between samples I and R. Sample K had the least protein content followed by I and R. Sample A had the highest. The protein content is generally about 1% of fresh fruits and 2% in most vegetables (Nzelu, 2010). It was observed that the protein content of the jellies increased with increase in beetroot. This is because beetroots have more protein than pineapples. The same trend was observed by Ajenifujah and Aina (2011), in the study of physicochemical properties and sensory evaluation of jam made from black-plum fruit and beetroot where the protein content was increasing with increase in beetroot.

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Fat content of the samples ranged from 0.46 in sample K to 0.60 in sample A. No significant ($p>0.05$) differences existed between samples K, I, R, and O but there was a significant ($p<0.05$) difference between them and samples H and A. The amount of lipids found in fruits and vegetables are usually small, comprising less than 1% of the bulk with avocado as an exception (Nzelu, 2010) (They are usually associated with the cell membranes). The fat content in the samples showed that beetroots contains, even though they are in trace levels, higher amount of fat than pineapples as seen.

Table 2: Proximate composition of beetroot and pineapple blend jelly

Samples	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Fiber (%)	Carbohydrate (%)	Energy value (kj)
K	$0.88^{a}\pm0.02$	$0.46^{a}\pm0.04$	$34.80^{a}\pm0.00$	$0.12^{a}\pm0.02$	ND	$63.74^{f}\pm0.04$	$262.72^{e}\pm0.09$
I	$1.52^{b}\pm0.02$	$0.50^{a}\pm0.00$	$35.11^{b}\pm0.00$	$0.19^{b}\pm0.01$	ND	$62.69^{e}\pm0.01$	$261.30^{d}\pm0.06$
R	$1.54^{b}\pm0.01$	$0.53^{ab}\pm0.04$	$35.14^{b}\pm0.01$	$0.21^{b}\pm0.01$	ND	$62.59^{d}\pm0.03$	$261.25^{d}\pm0.15$
O	$1.75^{c}\pm0.00$	$0.53^{ab}\pm0.04$	$35.40^{c}\pm0.01$	$0.20^{b}\pm0.00$	ND	$62.13^{c}\pm0.02$	$260.23^{c}\pm0.23$
H	$1.77^{c}\pm0.02$	$0.58^{bc}\pm.0.04$	$35.75^{d}\pm0.03$	$0.25^{c}\pm0.01$	ND	$61.66^{b}\pm0.03$	$258.88^{b}\pm0.12$
A	$1.76^{c}\pm0.01$	$0.60^{c}\pm0.00$	$36.17^{e}\pm0.02$	$0.26^{c}\pm0.01$	ND	$61.22^{a}\pm0.00$	$257.26^{a}\pm0.03$

Values are means ± standard deviation of 2 replications. Values with the same superscripts in a column are not significantly different ($p>0.05$).
Key: Sample K=commercial mixed fruit jelly, I=50:50% beetroot and pineapple blend jelly, R=60:40% beetroot and pineapple blend jelly, O=70:30% beetroot and pineapple blend jelly, H=80:20% beetroot and pineapple blend jelly, A=90:10% beetroot and pineapple blend jelly.

Moisture content of the samples ranged from 34.80 in sample K to 36.17% in sample A. This is similar to but does not exactly conform to the 32 to 35% moisture levels for jellies (USDA 2015). No significant ($p>0.05$) difference was found in sample I and R but the rest of the samples varied significantly ($p<0.05$) from each other. Sample K had the least amount of moisture and sample A, the highest. Usually, fruits and vegetables have very high levels of moisture and as a result, they have low energy value and short shelf life (Nzelu, 2010). However, the heat treatment that was given to the fruit and vegetable raw materials resulted to about 60 % reduction in the moisture content, to give higher energy value and shelf stable products. The moisture content was observed to be increasing as the beetroot increased probably because beetroots, having 87.5% moisture (Gajanan et al, 2014) has about 1.5% more moisture than pineapples, with 86% (Black, 2012). Olugbenga et al. (2018) observed a similar trend in the moisture content of banana, watermelon and pineapple blend jam where the sample with the highest amount of pineapple had the least moisture level.

Ash content of the samples varied from 0.12 % in sample K to 0.26 % in sample A. Sample K, was significantly ($p<0.05$) different from the rest of the samples, no significant ($p>0.05$) difference was observed between samples I, R and O but they were different, significantly ($p<0.05$) from sample H and A. Sample K had the least amount of ash. Within the blends, sample I had the least amount of ash and sample A the highest. The ash content was seen to be increasing with incorporation of beetroot. This confirms the report of Bakkali et al. (2009) that the ash content of most vegetables are generally higher than that of fruits. Since ash content of a food material is a measure of the inorganic compounds present, it is not wrong to assume that the samples with higher ash content are rich in inorganic compounds.

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Crude fibre was tested for but was not detected in any of the samples because the raw materials were juiced and the fibrous materials were removed before further processing.

Carbohydrate content of the jellies ranged from 61.22% in sample A to 63.74% in sample K. All the samples varied significantly ($p<0.05$) from each other. Sample A had the least amount of carbohydrate and sample I, the highest within the blends. Sample I with the least amount beetroot and the highest amount of pineapple recorded the highest amount of carbohydrate. Similar trend was observed by Anuradha et al. (2017) in pineapple and papaya blend jam where the samples with more pineapple had more carbohydrate and also Olugbenga et al. (2018) observed same trend in banana, watermelon and pineapple blend where the sample with the most pineapple had the highest carbohydrate content. Increase in pineapple resulted in increase in the carbohydrate content. In general, fleshy fruits possess high sugar content than vegetables, glucose, fructose, sucrose and starch constitute the available carbohydrate of fruits and vegetables. Starches in fruits usually disappears on ripening (Nzelu , 2010) therefore sugars are the predominant carbohydrate in the product and are very necessary for proper functioning of the brain.

The energy value of the products ranged from 257.26 Kj in sample A to 262.72 Kj in sample K. No significant ($p>0.05$) difference was observed between sample I and R but the rest of the samples differed significantly from each other. Within the blends, sample I had the highest energy level of 261.30 Kj. The energy value of a food indicates its value to the body as fuel (Schmidt, 2015). Energy requirement can be thought of as the amount needed to maintain the basic processes of life at rest, that is, basal metabolism, plus the amount needed for physical activity under a variety of circumstances. Body weight is an important factor in determining how much energy we need, since more energy will be needed to sustain and move a greater body mass (Schmidt, 2015). USDA (2015) recommends that the daily energy intake of the average man should be about 10,500kj and 40 to 65% of this should come from dietary carbohydrate which is about 6300kj from carbohydrates. The carbohydrate in the product provides about 244.88kj which is roughly 4.0% of the daily requirements for carbohydrates

Physicochemical properties

The total soluble solids (TSS) content of the jellies in the present study were in the range of 63.84 % in sample A to 65.20 % in sample K, with the commercial sample K, having the highest percentage. The final Total Soluble Solids (TSS) content of a jam (jelly) (also known as "Degrees Brix") shall in all cases be between 60 to 65 % (CODEX STAN, 2009). The TSS is a measure of the amount of material that is soluble in water. It is expressed as a percentage. A product with 100 % soluble solids, has no water and one with 0 % soluble solids is all water. The correct sugar content is critical for proper gel formation and for preservation of jelly. If the final TSS is lower than 60-65 % the shelf life will be reduced. The product will have a runny consistency and bacteria and moulds will be able to grow in the product. If the TSS is higher than 65%, the jelly will be very stiff and the sugar might start forming crystals in the product (CODEX STAN 2009). However, according to CODEX STAN (2009), all the products fell within this range therefore the products can be said to be of adequate quality.

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Table 3: Total soluble solids, total sugar, reducing and non-reducing sugar composition

Samples	Total soluble solids (°Brix)	Total sugar (%)	Reducing sugars (%)	Non-reducing sugars (%)
K	$65.20^{e} \pm 0.00$	$44.15^{e} \pm 0.02$	$28.90^{e} \pm 0.00$	$15.25^{c} \pm 0.02$
I	$64.89^{d} \pm 0.00$	$43.94^{d} \pm 0.00$	$28.77^{d} \pm 0.04$	$15.18^{bc} \pm 0.04$
R	$64.86^{d} \pm 0.01$	$43.92^{d} \pm 0.03$	$28.76^{d} \pm 0.00$	$15.16^{bc} \pm 0.03$
O	$64.60^{c} \pm 0.01$	$43.75^{c} \pm 0.05$	$28.60^{c} \pm 0.01$	$15.15^{b} \pm 0.06$
H	$64.25^{b} \pm 0.03$	$43.51^{b} \pm 0.00$	$28.49^{b} \pm 0.00$	$15.02^{a} \pm 0.00$
A	$63.84^{a} \pm 0.02$	$43.23^{a} \pm 0.02$	$28.30^{a} \pm 0.02$	$14.94^{a} \pm 0.04$

Values are means ± standard deviation of 2 replications. Values with the same superscripts in a column are not significantly ($p>0.05$) different.
Key: Sample K=commercial mixed fruit jelly, I=50:50% beetroot and pineapple blend jelly, R=60:40% beetroot and pineapple blend jelly, O =70:30% beetroot and pineapple blend jelly, H=80:20% beetroot and pineapple blend jelly, A=90:10% beetroot and pineapple blend jelly.

The values for the total sugars in the samples ranged from 43.23 in sample A to 44.15% in sample K. All the samples varied significantly ($p<0.05$) from each other except for sample I and R that had no significant ($p>0.05$) difference. As seen on the table, the total sugar level was decreasing as beetroot increased showing that beetroot contained less sugar than pineapples.

Reducing sugars ranged from 28.30 in sample A to 28.90 % in sample K. No significant ($p>0.05$) difference was seen between sample I and sample R, every other sample differed significantly ($p<0.05$) from each other. The result obtained was in accordance with that obtained by Lokonuzzaman et al. (2015) in quantitative estimation of the amount of sugar in fruit jams available in Bangladesh where the reducing sugars for pineapple jam was 28.00 %.

The values for the non-reducing sugars followed the same trend as that of reducing sugar where sample I and R had no significant ($p>0.05$) difference between them. Sample A had the least value of 14.94 % while sample K had the highest value of 15.25 %. According to Lokonuzzama et al (2015), the values for non-reducing sugar was 10.00 % which corresponds to the values from the samples.

The pH of the products ranged from 3.41 in sample K to 3.46 in sample H. No significant ($P>0.05$) difference existed between sample R, H, and A, but they differed ($p<0.05$) significantly from sample K, I and O. Therefore it can be said that pineapple contributed significantly to the acid concentration of the product. The result was also in line with that from Olugbenga et al. (2018). The pH of jams and jellies are very essential as low pH is maintained in the product to prevent microbial growth and enhance the colour and flavour of the product. On the other hand, low pH is necessary for the setting of jams or jellies.

The acidity in the products ranged from 0.28 % in sample H to 0.32 % in sample K. Sample K varied significantly ($p<0.05$) from sample H and no significant ($p>0.05$) difference was seen

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between the rest of the samples. Acidity reduced with increase in beetroot. The level of acidity in jams and jellies are inversely related to the pH as seen from Table 4. High acidity is required for preservative actions, colour and flavour improvement and setting of the jelly. A moderate level of acid is critical as too much acid will cause the jelly to weep and too little acid, may deter the product from setting (Tomas *et al*. 2007).

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Table 4: Physicochemical composition of beetroot and pineapple blend jelly

Sample	pH	Titratable acidity(%)
K	3.41^{a}±0.01	0.32^{b}±0.03
I	3.42^{a}±0.00	0.31^{ab}±0.01
R	3.45^{b}±0.00	0.30^{ab}±0.00
O	3.42^{a}±0.02	0.30^{ab}±0.01
H	3.46^{b}±0.01	0.28^{a}±0.01
A	3.45^{b}±0.01	0.29^{ab}±0.01

Values are means ± standard deviation of 2 replications. Values with the same superscripts in a column are not significantly ($p>0.05$) different.
Keys: Sample K=commercial mixed fruit jelly, I=50:50% beetroot and pineapple blend jelly, R=60:40% beetroot and pineapple blend jelly, O=70:30% beetroot and pineapple blend jelly, H=80:20% beetroot and pineapple blend jelly, A=90:10% beetroot and pineapple blend jelly.

Conclusion

This study has shown that beetroot utilization in Nigeria can be improved and postharvest losses reduced by processing them into value added products such as jellies. Proximate composition showed that the blends had better nutritional profile than the commercial sample except for the energy value and carbohydrate content where the commercial jelly was significantly ($p<0.05$) higher. Physicochemical properties showed that blends had less sugar contents and thus will be preferred by most adults. Both commercial sample and blends have comparable acidity which is an indication that the formulated product will be shelf stable.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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