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Physicochemical and sensory properties of pineapple flavoured roselle powders

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Abstract: This study was carried out to determine the physicochemical and sensory properties of blends of roselle and pineapple powders. The blends were produced by adding powder from natural pineapple to the powder of roselle calyces in the proportion of 15, 20 and 25%. The proximate composition, vitamin C, pH, total soluble solids, bulk density, reconstitution index, particle size, titratable acidity and reducing sugars were determined using standard methods. The proximate compositions of the samples were in the range of 4.94–6.57% (protein), 63.41–67.22% (carbohydrate), 2.31–2.48% (fat), 9.23–10.34% (fibre), 8.04–9.93% (ash) and 7.44–8.09% (moisture). The vitamin C contents ranged between 67.23 and 76.88 mg/100 g. The pH, total soluble solids and reducing sugar increased significantly ($p < 0.05$) while the titratable acidity, bulk density, reconstitution index and mass mean diameter decreased significantly ($p < 0.05$) with increase in addition of pineapple powder to roselle powder. Based on sensory evaluators, the sample with 25% pineapple powder was the most preferred.

Subjects: Beverages; Sensory Science; Processing; Product Development

Keywords: spectrophotometer; vitamin C; minerals; particle size

1. Introduction

Roselle has been used by people for preparing soft drinks and in traditional medicine since time immemorial (Juliani et al., 2009). It is an annual crop used in food, animal feeds, nutraceuticals,

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PUBLIC INTEREST STATEMENT

This study revealed the nutritional and physical properties of pineapple embodied roselle powders. This would help to reduce the post-harvest losses of pineapple. This study established the ease of production of instant roselle drink through the production of roselle powders which can be easily reconstituted in hot water and packaged in tea bags.

cosmeceuticals and pharmaceuticals. The calyces, stems and leaves are acidic in flavour. The juice from the calyces is claimed to be a health-enhancing drink due to its high content of vitamin C, anthocyanins and other antioxidants (Mohamad, Mohd-Nazir, Abdul Rahman, & Herman, 2002). The flower is highly cultivated in the northern part of Nigeria because of the climate (Aliyu, 2000; Osueke & Ehirim, 2004). Many parts of roselle including seeds, leaves, fruits and roots are used in the preparation of various foods. Among them, the fleshy red calyces are the most popular (Yadeng, Chin, Malekian, Berhane, & Gager, 2005). Roselle calyces are used for making juice, wine, herbal tea and as colouring agent for jelly, jam, beverages and foods (Ali-Bradeldin, Al-Wabel, & Gerald, 2005). Roselle calyces are good sources of phenolic compounds and anthocyanins (Al-Hashimi, 2012). The calyces are also known for their antiseptic, diuretic, antioxidant and anti-mutagenic properties (Ali-Bradeldin et al., 2005). The calyces are rich in acid and pectin. Analysis of calyces has shown the presence of crude protein, ascorbic acid and minerals such as iron, phosphorus, calcium, manganese, aluminium, magnesium, sodium and potassium (Gautam, 2004). The dried calyces contain flavonoids gossypetin, hibiscetine and sabdaretine. The major pigment formerly reported as hibiscin, has been identified as daphniphylline. Small amounts of delphinidin 3-monoglucoside (myrtillin), cyaniding-3-monoglucoside (chrysanthemin) and delphinidin are also present (Mohamed, Fernández, Pineda, & Aguilar, 2007).

Roselle drink is a non-alcoholic beverage made from the aqueous extract of dried *Hibiscus sabdariffa* calyces (Ezearigo, Adeniyi, & Ayoade, 2014). Due to intensified religious and health campaigns against alcoholic beverages in Nigeria, roselle drink has great potential as a local alternative to imported red wines in particular and alcoholic beverages in general (Egbere, Anuonye, Chollom, & Okpara, 2007). Moreover, production of this and similar local beverages has become the main source of income in many homes in the rural communities. Recently in the urban areas, these have grown to cottage business proportions due to support from the government through the poverty alleviation schemes, thereby alleviating poverty among the people (Essien, Monago, & Edor, 2011). The production of roselle drink at household level from roselle calyces is laborious and time consuming. The fact that roselle drink begins to deteriorate after 24 h without refrigeration (Omemu, Edema, Atayese, & Obadina, 2006) has made the production of roselle powder with acceptable nutritional and organoleptic properties inevitable. This study therefore aims to investigate the physicochemical and sensory properties of pineapple flavoured roselle powder for the production of roselle drink.

2. Materials and methods

2.1. Materials
Dried roselle calyces and ripe pineapples were purchased from New market in Ile-Ife, Osun State, Nigeria. All chemicals used for analyses were of analytical grade. These chemicals were procured from Fisher Scientific (Oakville, ON, Canada) and Sigma Chemicals (St. Louis, MO).

2.2. Methods

2.2.1. Production of pineapple powder
Pineapple powder was produced following a modification of the method of Karim (2010). Fresh, mature and ripe pineapple fruits were washed with water, peeled manually with kitchen knife and sliced with table knife. The slices were dried in a laboratory hot air oven (Gallenkamp hot air oven, OVB 305, UK) at 60°C for 12 h. After drying, they were milled using an electric blender (SAISHO Magic Blender S-742, China) at maximum speed for 1 min.

2.2.2. Production of pineapple flavoured roselle powder
Dried roselle calyces were freed from dirts and extraneous materials by manual sorting and winnowing. The calyces were slightly washed with water to remove adhering dirt and dried in a laboratory oven at 60°C for 3 h. After drying, they were milled using a blender (SAISHO Magic Blender S-742, China) at maximum speed for 1 min. Pineapple powder was added to roselle powder at different proportions (0, 15, 20 and 25% [w/w]), mixed thoroughly and then packaged.

2.2.3. Proximate analysis
The proximate compositions were determined using AOAC (2010) methods 920.53, 920.39, 923.03, 925.10, and 962.09 for protein, fat, ash, moisture and crude fibre contents, respectively. The carbohydrate content was determined by difference (Mbaeyi-Nwaoha & Obetta, 2016).

2.2.4. Determination of vitamin C
The quantity of the vitamin C contained in each sample was determined by titrimetric method (using 2, 6-dichlorophenol indophenol dye) described by Hassan and Hassan (2008).

2.2.5. Mineral analysis
The analysis for essential mineral element was investigated using the method by Fashakin, Ilori, and Olarewaju (1991). Nitric and HCl acid (10 ml each) were individually added to a sample of 0.5 g in a digestion flask. The mixture was digested for 10 min. The digested mixture was filtered. The filtrate was made up to 50 ml with distilled water. Calcium, sodium, iron, potassium and magnesium were measured by Flame Atomic Absorption Spectrophotometer (Perkin Elmer AAnalyst 400, USA).

2.3. Physicochemical properties

2.3.1. pH
The pH was measured by making a 10% w/v suspension of the sample in distilled water. The suspension was mixed thoroughly and the pH (after standardizing the pH meter with buffer solutions of pH 4 and pH 7) was measured with a pH meter (Hanna checker Model HI1270, USA).

2.3.2. Titratable acidity
This was assessed according to AOAC (2000) method. One gram of sample was weighed and placed in a 100 ml glass beaker. Distilled water (40 ml) was added, heated to reach 70°C, and allowed to stand for 1 h. The supernatant was filtered. The roselle residues were rinsed with two portions of 20 ml of hot distilled water. The filtrate was transferred to a 100 ml flask, cooled down to room temperature, brought to volume and thoroughly mixed. An aliquot of 25 ml of the extract was titrated with 0.1 N NaOH until reaching pH 8.3. Results were reported as % malic acid as expressed by Dauda and Adegoke (2014).

$$\text{Titratable acidity } (\% \text{ malic acid}) = \left(\frac{\text{Volume of titration} \times 0.1 \text{ N NaOH} \times 0.067 \times 100}{\text{Volume of Juice}}\right) \quad (1)$$

2.3.3. Total soluble solids
An extract was obtained by mixing 1 g of roselle powder with 10 ml of distilled water. This blend was allowed to stand for 1 h at room temperature and stirring manually sporadically. Determination of total soluble solids was carried out using a hand refractometer. The refractometer prism surface was cleaned with distilled water and tissue paper, followed by placing a drop of the sample on the prism of the refractometer. The reading was taken by looking through the eyepiece of the refractometer and the soluble sugar was expressed in °Brix (AOAC, 2000).

2.3.4. Reducing sugars
A solution of the sugar containing sample was prepared by weighing 5 g of the sample into a beaker and adding about 100 ml of warm water. It was stirred until all the soluble matter dissolved and then filtered into a 250 ml volumetric flask. The beaker was rinsed into the volumetric flask and the solution was made up to volume. This solution was used for titration. The burette was filled with the sugar solution. Mixed Fehling's solution (10 ml) was pipetted into a conical flask and 4 drops of 1% methylene blue was added. The solution was brought to boil and whilst boiling, sugar solution was added from the burette until the blue colour disappeared. Reducing sugar was calculated using Equation (2) (James, 1996):

$$\% \text{ Reducing sugars (as glucose)} = \frac{49.5 \times 250}{T \times W \times 10} \quad (2)$$

where T = titre of non-hydrolysed sugar solution, W = weight of sample used.

2.3.5. Bulk density
A 10 ml graduated cylinder was gently filled with the samples. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level after filling to the 10 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/ml) as shown in Equation (3) (Siddique, Meyerb, Najni, & Akram, 2010):

$$\text{Bulk density (g/ml)} = \frac{\text{weight of sample (g)}}{\text{volume of sample after tapping (ml)}} \tag{3}$$

2.3.6. Reconstitution index
Reconstitution index was determined as described by Oluwatooyin, Osundahunsi, and Aworh (2002). Ten grams of the sample was mixed with 100 ml of boiling water for 90 s. The volume of the sediment was measured after pouring into a 250 ml graduated glass cylinder. The volume of the sediment recorded after 10 min was taken as the reconstitution index.

2.3.7. Particle size analysis
The particle size distribution of each sample was determined by placing 50 g of the samples on a tier of Endecotts test sieves arranged on an Endecotts test sieve shaker with sieves of decreasing aperture diameter as follows: 1,180, 630, 425, 315, 212, 150 and 63 μm pore diameter sieve. The sieve shaker was operated for duration of 10 min in each test. Percentage particle retention on each sieve was determined. The percentage retention on each sieve and pore diameter of the sieves were used to determine the mass mean diameter of each sample using Equation (4) (Fellows, 2000):

$$\text{Mass mean diameter } (\mu\text{m}) = \frac{\sum (\%\ \text{Mass retained on each sieve} \times \text{sieve aperture})}{100} \tag{4}$$

2.4. Sensory evaluation
Roselle drinks were prepared from the samples by adding boiled water (1 g to 30 ml) to the powdered samples after which sieving was carried out. Sucrose (4%) was added to each sample. The samples were presented to ten semi-trained sensory panelists who are used to roselle drink. The panelists evaluated the samples on colour, flavour, taste and overall acceptability on a 9-point hedonic scale where 9 represents like extremely and 1 denotes dislike extremely.

2.5. Statistical analysis
All data were subjected to one-way Analysis of Variance and means were separated using Duncan's multiple range tests using SPSS for Windows version 16.

3. Results and discussion

3.1. Proximate composition
The results of proximate compositions of roselle powder and pineapple flavoured roselle powder samples are presented in Table 1. The crude fat contents of roselle powder and pineapple flavoured roselle powders ranged between 2.31 and 2.48%. The values increased significantly ($p < 0.05$) as the proportion of pineapple powder to roselle powder increased. The crude fat content of unflavoured roselle powder sample (2.31%) was similar to 2.00% reported by Luvonga, Njoroge, Makokha, and Ngunjiri (2010) for roselle powder. However, it was higher than the values reported by Mohamed, Sulaiman, and Dahab (2012) and Ameh, Isa, Ahmed, and Adamu (2009) for dried roselle calyces which were 0.16 and 1.60%, respectively. Differences from the results reported by other researchers might be attributable to the sources and/or varietal differences of the roselle calyces. The low crude fat content of the samples is advantageous because rancidity of the products will be significantly minimal if present.

The protein contents of the roselle powder and pineapple flavoured roselle powder samples ranged between 4.94 and 6.57%. The values of roselle samples with 0 to 20% inclusion of pineapple were not significantly different ($p > 0.05$) but were all significantly different from the protein content of the roselle sample with 25% pineapple content. The protein content of the roselle powder which

Table 1. Proximate compositions (%) of powder and pineapple flavoured roselle powders

Sample	Protein	Carbohydrate	Fat	Fibre	Ash	Moisture
RP0	6.57 ± 0.00^a	63.41 ± 0.02^d	2.31 ± 0.01^d	10.34 ± 0.01^a	9.93 ± 0.05^a	7.44 ± 0.08^d
RP15	6.35 ± 0.62^a	64.97 ± 0.09^c	2.41 ± 0.02^c	9.31 ± 0.01^b	9.36 ± 0.03^b	7.63 ± 0.01^c
RP20	6.02 ± 0.15^a	65.90 ± 0.12^b	2.45 ± 0.01^b	9.27 ± 0.01^c	8.47 ± 0.02^c	7.89 ± 0.02^b
RP25	4.94 ± 0.15^b	67.22 ± 0.08^a	2.48 ± 0.00^a	9.23 ± 0.02^d	8.04 ± 0.03^d	8.09 ± 0.07^a

Key: RP0: 100% roselle powder, RP15: 85% roselle powder and 15% pineapple powder, RP20: 80% roselle powder and 20% pineapple powder, RP25: 75% roselle powder and 25% pineapple powder.

Notes: Values are means ± standard deviation of triplicate determinations. The mean values along the same column with different superscripts are significantly different ($p < 0.05$).

was 6.57% was lower than 7.80% reported by Mohamed et al. (2012) for dried roselle calyces. It was however higher than the values reported by Ameh et al. (2009) for dried roselle caylces and Luvonga et al. (2010) for roselle powder which were 2.64 and 4.70%, respectively. This might be attributable to the source and/or dryness of the roselle calyces.

The carbohydrate contents of the powder samples ranged between 63.41 and 67.22%. The values increased significantly ($p < 0.05$) as the level of incorporation of pineapple powder to roselle powder increased. The carbohydrate content of the unflavoured roselle powder which was 63.41% was similar to the value reported by Mohamed et al. (2012) for dried roselle calyces which was 61.55%, slightly lower than the value reported by Luvonga et al. (2010) for roselle powder which was 68.7% and substantially lower than the value reported by Ameh et al. (2009) for dried roselle calyces which was 86.92%. The high carbohydrate content obtained lends further support to the assertion of Babalola (2000) and Ojokoh, Adetuyi, Akinyosoye, and Oyetayo (2002) that roselle calyces contain high carbohydrate content.

The crude fibre contents of roselle powder and pineapple flavoured roselle powders ranged between 9.23 and 10.34%. The contents decreased significantly ($p < 0.05$) with increasing additions of pineapple powder to roselle powder. This might be due to the differential quantity of the fibre contents of the roselle and pineapple powders. The fibre content of unflavoured roselle sample (10.34%) was lower than the values reported by Mohamed et al. (2012) for dried roselle calyces and Luvonga et al. (2010) for roselle powder which were 13.20 and 14.60%, respectively but higher than 2.46% reported by Ameh et al. (2009) for dried roselle calyces. This might be due to the sources and rate of dryness of the roselle calyces.

Ash content is an index of inorganic mineral elements in food (Onyeka, 2008). The ash contents of the samples ranged between 8.04 and 9.93%. The ash decreased significantly ($p < 0.05$) as the concentration of pineapple powder to roselle powder increased. The ash content of the unflavoured roselle sample (9.93%) was similar to 9.50% reported by Mohamed et al. (2012) for dried roselle calyces but lower than 12.20% reported by Luvonga et al. (2010) for roselle calyces.

The moisture contents of the roselle powder and pineapple flavoured roselle powders ranged between 7.44 and 8.09%. The values increased significantly ($p < 0.05$) with increase in the inclusion of pineapple powder to roselle powder. The moisture content of unflavoured roselle sample (7.44%) was comparable to 7.60% reported by Luvonga et al. (2010) for oven-dried roselle powder. It was however lower than 11.00% reported by Mohamed et al. (2012) for sun-dried roselle calyces but higher than 5.10% reported by Ameh et al. (2009) for oven-dried roselle calyces. The low moisture contents of the powders indicated that the samples will have good keeping qualities.

3.2. Vitamin C contents
The vitamin C contents of the roselle powder and pineapple flavoured roselle powders are shown in Table 2. The values ranged between 67.23 and 76.88 mg/100 g. The values decreased significantly

Table 2. Vitamin C contents of roselle powder and pineapple flvoured roselle powders

Sample	Ascorbic acid (mg/100 g)
RP0	76.88 ± 0.18[a]
RP15	70.63 ± 0.13[b]
RP20	68.53 ± 0.12[c]
RP25	67.23 ± 0.05[d]

Key: RP0: 100% roselle powder, RP15: 85% roselle powder and 15% pineapple powder, RP20: 80% roselle powder and 20% pineapple powder, RP25: 75% roselle powder and 25% pineapple powder.

Notes: Values are means ± standard deviation of triplicate determinations. The mean values along the same column with different superscripts are significantly different ($p < 0.05$).

($p < 0.05$) as the proportion of pineapple powder to roselle powder increased. This may be attributed to the loss of vitamin C as a result of leaching out of juice during the slicing of the pineapple and the drying of the slices in the oven. The vitamin C content (76.88 mg/100 g) of the unflavoured roselle powder was slightly lower than 80 mg/100 g reported by Mohamed et al. (2012) for dried roselle calyces but significantly higher than 32.36 mg/100 g reported by Ameh et al. (2009) for dried roselle calyces.

This might be attributed to the source and the rate of dryness of the roselle calyces. Vitamin C content of roselle calyces is related to the state of freshness or dryness. Lower value of vitamin C content of roselle reported in this study could be associated with nutritional losses during the unit operations of washing and drying dried calyces used. Williams (1998) reported that vitamin C is water-soluble and that it can be easily lost through boiling, heating and cooking in water.

3.3. Mineral composition

The results of some minerals analysed are presented in Table 3. The decrease in some minerals as the concentration of pineapple powder to roselle powder increased might be due to the leaching out of juice containing water soluble minerals during slicing of the pineapple fruits prior to drying. The calcium contents of the roselle powder and pineapple flavoured roselle powders ranged between 36.09 and 43.13 mg/100 g. The values decreased significantly ($p < 0.05$) as the proportion of pineapple powder to roselle powder increased. The percentage decrease of calcium content in samples with 15, 20 and 25% pineapple inclusion levels were 7.50, 13.50 and 16.30%, respectively.

The calcium content (43.13 mg/100 g) of the unflavoured roselle powder was higher than 14.8 mg/100 g reported by Luvonga et al. (2010) for roselle powder but lower than 60 mg/100 g reported by Mohamed et al. (2012) for dried roselle calyces. The differences might be partly attributed to the source of the roselle calyces. Calcium is vital for healthy teeth, bones, aids muscles growth and prevents muscles cramps. The Recommended Daily Allowance (RDA) ranged between 400 and 1,200 mg per day for infants, children and young adults (Carolyn, 1998). Functions of calcium include bone mineralization, muscle contraction, cell signalling and regulation of cell metabolism (Carolyn, 1998).

The potassium contents ranged between 107.42 and 113.94 mg/100 g. The potassium content increased significantly ($p < 0.05$) as the addition of pineapple powder to roselle powder increased but there was no significant difference ($p > 0.05$) between roselle samples flavoured with 20 and 25% pineapple powder. The potassium content of the unflavoured roselle powder was slightly higher than 101.5 mg/100 g reported by Luvonga et al. (2010) for roselle powder. Potassium participates in several essential physiological processes, such as the transmission of nerve impulses, contraction of cardiac, smooth and skeletal muscles. It stabilizes blood pressure and helps in electrochemical transmissions. It has been shown to prevent strokes and works with sodium to maintain a proper water balance in the body (Shahnaz, Atiq-Ur-Rahman, Qadiraddin, & Shanim, 2003).

Table 3. Mineral compositions (mg/100 g) of roselle and pineapple flavoured roselle powders

Sample	Ca	K	Na	Fe	Mg
RP0	43.13 ± 0.35^{a}	107.42 ± 0.81^{c}	37.12 ± 0.44^{a}	7.14 ± 0.09^{a}	98.14 ± 0.58^{a}
RP15	39.88 ± 0.19^{b}	112.21 ± 0.32^{b}	32.47 ± 0.46^{b}	5.45 ± 0.23^{b}	93.98 ± 1.63^{b}
RP20	37.31 ± 0.27^{c}	113.44 ± 0.55^{a}	29.40 ± 0.35^{c}	6.35 ± 0.09^{bc}	91.22 ± 0.39^{c}
RP25	36.09 ± 0.12^{d}	113.94 ± 0.62^{a}	27.63 ± 0.91^{d}	6.13 ± 0.06^{c}	87.96 ± 0.89^{d}

Key: RP0: 100% roselle powder, RP15: 85% roselle powder and 15% pineapple powder, RP20: 80% roselle powder and 20% pineapple powder, RP25: 75% roselle powder and 25% pineapple powder.

Notes: Values are means ± standard deviation of triplicate determinations. The mean values along the same column with different superscripts are significantly different ($p < 0.05$).

The sodium contents of the roselle powder and pineapple flavoured roselle powders ranged between 27.63 and 37.12 mg/100 g. The values decreased significantly ($p < 0.05$) as the concentration of pineapple powder to roselle powder increased. This could be attributed to the differential quantity of sodium in both the natural pineapple and roselle powders. The unflavoured roselle powder sample had the highest level (37.12 mg/100 g) of sodium while the 25% pineapple flavoured sample recorded the lowest (27.63 mg/100 g). The sodium content of the unflavoured roselle powder was lower than 72.1 mg/100 g reported by Luvonga et al. (2010) for roselle powder. Sodium is considered the backbone of body fluid, because the quantity of water in the extracellular fluid is regulated by the quantum of sodium in circulation, acid-base balance, nerve and muscle function.

For iron, the values ranged between 6.13 and 7.14 mg/100 g. The values decreased significantly ($p < 0.05$) as the level of incorporation of pineapple powder to roselle powder increased. There was no significant difference ($p > 0.05$) between samples with 15 and 20% flavouring levels. Samples with 20 and 25% pineapple inclusion also had no difference among each other. Recorded iron content of unflavoured roselle powder compared favourably with 7.46 mg/100 g reported by Luvonga et al. (2010) for roselle powder. It was however lower than 20 mg/100 g reported by Mohamed et al. (2012) for dried roselle calyces. Iron content in any of the samples is enough to meet the recommended daily allowance of iron for infants and adults if sufficient amount is consumed. This is because the RDA for infants, children and adults ranges between 6 and 15 mg per day (Carolyn, 1998). Iron is vital for the production of haemoglobin, formation of red blood cells and the oxygenation of red blood cells. It also improves circulation, digestion, elimination and respiration (Bamishaiye, Olayemi, & Bamishaiye, 2011).

The magnesium content of the roselle powder and pineapple flavoured roselle powders ranged between 87.96 and 98.14 mg/100 g. The values decreased significantly ($p < 0.05$) as the addition of pineapple powder to roselle powder increased. The unflavored roselle sample had the highest value (98.14 mg/100 g) while 25% pineapple flavoured roselle sample had the lowest (87.96 mg/100 g). The percentage decreases in the magnesium content observed in the samples with 15, 20 and 25% pineapple inclusion were 4.20, 7.10 and 10.40%, respectively. Magnesium is a co-factor in a number of enzyme system which is involved in neuro-chemical transmission and muscular excitability along with calcium and vitamin C (Bamishaiye et al., 2011). The RDA for infants, children and adults ranges between 40 and 350 mg per day (Carolyn, 1998). More than 300 metabolic reactions require magnesium as a cofactor (Carolyn, 1998).

3.4. Physicochemical properties

The physicochemical properties of the roselle powder and pineapple flavoured roselle powders are presented in Table 4. The pH values ranged between 1.40 and 1.50. The pH values increased significantly ($p < 0.05$) as the level of inclusion of pineapple powder to roselle powder increased. This implies that the acidity of the samples decreased with increase in addition the flavouring agent. The pH values of the samples indicate that the samples belong to a class of foods referred to as high acid foods (Frazier & Westhoff, 1988).

Table 4. Physicochemical properties of roselle powder and pineapple flavoured roselle powders

Sample	TTA (% malic acid)	pH	TSS (°Brix)	Reducing sugar (% glucose)	Bulk density (g/ml)	Reconstitution index (%)	Mass mean diameter (μm)
RP0	4.23 ± 0.01^{a}	1.40 ± 0.00^{d}	3.00 ± 0.00^{d}	2.26 ± 0.01^{d}	0.72 ± 0.01^{a}	44.50 ± 0.50^{a}	399.21 ± 0.24^{a}
RP15	3.73 ± 0.01^{b}	1.46 ± 0.01^{c}	4.50 ± 0.00^{c}	5.28 ± 0.01^{c}	0.65 ± 0.02^{b}	42.33 ± 0.58^{b}	342.13 ± 0.39^{b}
RP20	3.45 ± 0.01^{c}	1.49 ± 0.01^{b}	4.80 ± 0.00^{b}	6.61 ± 0.02^{b}	0.61 ± 0.01^{c}	40.67 ± 0.58^{c}	327.60 ± 0.44^{c}
RP25	3.19 ± 0.01^{d}	1.50 ± 0.01^{a}	5.00 ± 0.00^{a}	7.90 ± 0.01^{a}	0.58 ± 0.00^{d}	38.00 ± 0.19^{d}	311.49 ± 0.54^{d}

Key: RP0: 100% roselle powder, RP15: 85% roselle powder and 15% pineapple powder, RP20: 80% roselle powder and 20% pineapple powder, RP25: 75% roselle powder and 25% pineapple powder.

Notes: Values are means ± standard deviation of triplicate determinations. The mean values along the same column with different superscripts are significantly different ($p < 0.05$).

The titratable acidity of the samples ranged between 3.19 and 4.23% malic acid. The values decreased significantly ($p < 0.05$) as the concentration of pineapple powder to roselle powder increased and this might be because pineapple power has a lower titratable acidity compared to roselle drink concentrate. This suggests that pH and %TTA are inversely related for these samples (Egbere et al., 2007).

The total soluble solids (TSS) ranged between 3.00 and 5.00°Brix. The values increased significantly ($p < 0.05$) as the flavouring levels increased. This could be attributed to higher soluble solids in pineapple powder than roselle powder. The total soluble solids of the unflavoured roselle sample obtained was similar to 3.20°Brix reported by Fasoyiro, Babalola, and Owosibo (2005) for roselle extract without sugar.

The reducing sugar of the roselle powder samples ranged between 2.26 and 7.90%. The values increased with increase in the inclusion of pineapple powder to roselle powder. The unflavoured roselle powder had the lowest (2.26%) reducing sugar while the sample with 25% pineapple incorporation level recorded the highest (7.90%).

The bulk density of the samples ranged between 0.58 and 0.73 g/ml. There was significant difference ($p < 0.05$) between all the samples and the bulk density decreased as the level of incorporation of pineapple powder to roselle powder increased. The decrease in bulk density of the powder samples as the inclusion of pineapple powder to roselle powder increased could be attributed to the fact that pineapple powder is less dense than roselle powder. Bulk density is generally affected by particle size. This means that more quantity of sample with 25% pineapple can be packed more than other samples for the same specific volume.

The reconstitution index of the roselle powder and pineapple flavoured roselle powder samples ranged between 38.0 and 44.5%. Unflavoured roselle powder had the highest (44.5%) reconstitution index while the flavoured sample with 25% pineapple had the lowest (38.0%). There was significant difference ($p < 0.05$) among all the samples and the reconstitution index decreased as the addition of pineapple powder to roselle powder increased. The amount of undissolved roselle particles in the samples decreased as the addition of pineapple powder to roselle powder increased.

The mass mean diameter (Particle size) is essential in packaging requirement and material handling. This is closely associated with the behaviour of the material and/or its physicochemical properties (Guerrero-Beltran, Jimenez-Munguia, Welti-Chanes, & Barbosa-Canovas, 2009). The mass mean diameters of the samples ranged between 311.49 and 399.21 μm. The unflavoured roselle powder had the highest average particle size value (399.21 μm) while the flavoured sample with 25% pineapple recorded the lowest (311.49 μm) when subjected to the same blending conditions. It

Table 5. Sensory evaluation of roselle drinks produced from roselle powders

Sample	Colour	Flavour	Taste	Overall acceptability
RP0	7.50 ± 0.06^{a}	5.80 ± 0.04^{d}	6.20 ± 0.02^{c}	6.30 ± 0.03^{d}
RP15	7.70 ± 0.11^{a}	6.50 ± 0.03^{c}	6.90 ± 0.02^{b}	7.00 ± 0.02^{c}
RP20	7.80 ± 0.04^{a}	7.70 ± 0.06^{b}	7.60 ± 0.03^{a}	7.90 ± 0.04^{b}
RP25	7.80 ± 0.09^{a}	8.40 ± 0.02^{a}	7.90 ± 0.04^{a}	8.50 ± 0.03^{a}

Key: RP0: 100% roselle powder, RP15: 85% roselle powder and 15% pineapple powder, RP20: 80% roselle powder and 20% pineapple powder, RP25: 75% roselle powder and 25% pineapple powder.

Note: The mean values along the same column with different superscripts are significantly different ($p < 0.05$).

became evident that the average particle size of the samples decreased with increase in the addition of pineapple. The dried pineapple slices were finer than the roselle powder upon milling.

3.5. Sensory evaluation

The result of sensory evaluation of the drinks produced from the samples is shown in Table 5. In terms of colour, there was no significant difference ($p > 0.05$) in the samples. This showed that the addition of pineapple powder to the roselle powder at 15, 20 and 25% did not affect the colour of the drinks. In terms of flavour, taste and overall acceptability, roselle sample containing 25% pineapple had the highest sensory hedonic score and the preferences increased significantly ($p < 0.05$) with increase in the level of incorporation of pineapple powder to roselle powder.

4. Conclusions

The incorporation of pineapple powder to roselle powder decreased some nutritional values (protein, ash, fibre, vitamin C, calcium, sodium, iron, magnesium and antioxidant activity) but increased fat, moisture, carbohydrate and potassium contents as the level of incorporation of pineapple powder to roselle powder increased. The addition of pineapple powder to roselle powder also impacted flavour. This study established that roselle drink can be prepared more conveniently from the pineapple flavoured roselle powder.

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