



Effect of Processing Methods on the Antioxidant, Physicochemical, and Microbiological Properties of Non-Alcoholic Beverages Made from Roselle Calyces

Olatidoye, O.P.^{1*}, Onipede, G.O.², Sobowale, S.S.³, Alabi, A.O.⁴ and Adeoti, O.A.⁴


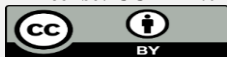
¹Department of Food Technology, Yaba College of Technology, P.M.B.2011, Yaba, Nigeria

²Department of Microbiology, Federal University of Health Sciences, Ila-Orangun, Osun State

³Department of Food Science and Technology, College of Basic and Applied Sciences, Mountain Top University, Ibafo, Ogun State, Nigeria.

⁴Department of Food Science and Technology, The Oke-Ogun Polytechnic, Saki, Oyo State, Nigeria.

*Corresponding author: waleolatidoye@gmail.com; +2348037284556
olawale.olatidoye@yabatech.edu.ng

Abstract	Article History
<p>Fruits and vegetables belong to an essential class of foods that supply the human diet with vitamins and minerals that are essential for normal body health and function. Hence, this study aims to provide an overview of the effect of processing on the antioxidant, physicochemical, and microbiological properties of non-alcoholic beverages made from roselle calyces using standard procedures. Roselle drink and squash were produced from roselle extract and pineapple juice at a ratio of 4:1 respectively using hot and cold-water extraction methods after pasteurization at 80°C for 5 min and aseptically packaged. The result showed that the pH of the samples CSS, HSS, CSS, and HPSS ranged between (3.89 to 4.44), total soluble solid (5.5-6.7 °Brix), viscosity (5.5-28.5 m. Pa.s), titratable acidity (0.62 to 1.40%), specific gravity(0.7856-1.019), vitamin C(43-47mg/100g). color dimension showed that L*(14.3-21.9), a*(14.3-19.25) and b* (3.89-8.0). The antioxidant activity showed that phenol ranged between (58.51-79.59mg/100g), flavonoid (22.62-50.14mg/100g), and total antioxidant capacity (70.67-75.03mg/100g). DPPH, reducing power, total phenols, total flavonoids, and total antioxidant content increased significantly ($p < 0.05$). The blending of pineapple fruit juice with roselle extract has improved antioxidant properties and good source of vitamin C. Therefore, the consumption of roselle-fruit juices with higher flavonoid and antioxidant activity will protect the human body from several diseases attributed to the reactions of free radicals.</p> <p>Keywords: <i>Squash, drinks, organoleptic attributes, fruits, roselle</i></p>	<p>Received: 24 Feb 2025 Accepted: 04 Mar 2025 Published: 15 Mar 2025</p>  <p>Scan QR code to view*</p> <p>License: CC BY 4.0*</p>  <p>Open Access article.</p>
<p>How to cite this paper: Olatidoye, O. P., Onipede, G. O., Sobowale, S. S., Alabi, A. O., & Adeoti, O. A. (2025). Effect of processing methods on the antioxidant, physicochemical, and microbiological properties of non-alcoholic beverages made from Roselle calyces. <i>IPS Journal of Nutrition and Food Science</i>, 4(1), 342–351. https://doi.org/10.54117/ijnfs.v4i1.79.</p>	

1. Introduction

In Nigeria, fruits and vegetables are produced in abundance which are perishable and are destroyed easily due to various factors. The formulation of new products involves several technical aspects that support product improvements, quality improvements, customer requests (upgrade/ acceptance), and cost-saving initiatives (Vijayan and Prabhat, 2015). Products such as jam, jelly, squashes, and beverages can be made using fruits. Fresh squashes are becoming popular compared with synthetic beverages because of the refreshing quality, taste, flavour, nutritive value, and storage stability of fresh squashes

(Jothi et al., 2014). Squash is a popular and non-alcoholic concentrated syrup that is usually made from fruit juice, water, and sugar or sugar substitutes (Joseph and Shukla, 2015, Babasaheb, 2000). It must be mixed with a certain amount of water or carbonated water before drinking. Nowadays herbal extracts are added to squash to enhance its sensory and therapeutic properties (Jain et al., 2016). Fruit squashes have a low quantity of twenty-five percent via the capacity of fruit juice and are proposed to be drunk after dilution. The acidities are generally in the mixture of 1.5 to 2.5 per w/v citric acid. The squash is packed into washed and pure bottles, exited with

the plan to one-inch top space with a blocked peak, and placed in a safe for one to 1.5 years with no large amount of change in colour or taste (Gupta, 1993).

Roselle (*Hibiscus sabdariffa* L.) is a unique species cultivated in many tropical regions for its leaves, seeds, stem, and calyces in which the dried calyces are used to prepare tea, syrup, jams, and jellies as beverages. It belongs to the family of Malvaceae which originated in West Africa and is available in tropical African countries such as Sudan, Egypt, Ethiopia, Mali, Nigeria, and Chad (Abu-Tarboush *et al.*, 1997). It is also, widely cultivated in India, Indonesia, Philippines, Malaysia, Brazil, Australia, Mexico, Hawaii, and the USA but known by different names in different countries and popularly recognized as 'mesta' or 'chukur' in the Indian subcontinent (Halimatul *et al.*, 2007; Rao, 2008, Ismail *et al.*, 2008). Roselle is a miracle plant with various utilizations with different colour groups: pink, green, red, dark red, purple, or yellow are available in the tropics (Halimatul *et al.*, 2007). The calyces of red and dark red types are used to extract juice for fresh drinks after sweetened and the leaves of green types are used as vegetables (Babalola, 2000). Roselle has drawn the attention of food, beverage, and pharmaceutical manufacturers because of its commercial potential as a natural food and coloring agent that can replace some synthetic products (Eslamnejad *et al.*, 2011).

Pineapple (*Ananas comosus* L.) is one of the most important commercial fruit crops in the world and the third most important tropical fruit in the world after Banana and Citrus. It is known as the queen of fruits due to its excellent flavour and taste. Pineapples are consumed or served fresh, cooked, juiced, and can be preserved. This fruit is highly perishable and seasonal. Mature fruit contains 14% sugar; a protein-digesting enzyme, bromelain, and a good amount of citric acid, malic acid, vitamins A and B, and different minerals such as calcium and potassium that are good for the digestive system and aids in maintaining ideal weight and balanced nutrition (Hossain *et al.*, 2015; Botella and Fairbairn, 2005). Its balance of sugar and acid contributes to the fruit's refreshing flavour. Fruits and their value-added products play a crucial role in the human diet because they provide most of the vital nutrients especially vitamins, carbohydrates, protein, and minerals required for normal growth and development of the human body which leads to maintaining a healthy physique and mind. Normal consumption of fruits significantly reduces the risk of heart disease, stress, and premature aging due to the antioxidant properties of fruits (Sindumathi *et al.*, 2015). Nowadays people prefer food or beverage which has physiological benefits besides basic nutrition to reduce the risk of chronic diseases. Beverages have been increasingly gaining popularity throughout the country due to their health and nutritional benefits, apart from pleasant flavour and taste. Fruit-based beverages are rich in essential minerals and vitamins and are delicious with universal appeal. Moreover, consumers are looking for new, healthier alternatives to conventional soft drinks. From the public health point of view, there is also a need to reduce alcohol consumption and minimize the use of additives and heat treatments. A little is being done to market it in varieties as a ready-to-drink beverage that would be easily accessible to consumers. Therefore, despite its great potential as a health drink, acceptability remains a challenge. One is that

roselle extract has a low sugar/acid ratio affecting its taste and making it less desirable to consumers. Adjusting the sugar/acid ratio to enhance the taste would however increase its acceptability. Regular consumption of roselle may reduce nutritional deficiency problems such as night blindness, scurvy, and rickets. Squashes are advantageous in comparison with other synthetic beverages evidently because of their taste, flavour, nutritive value, and their storage ability. So, keeping in view its availability in the land wasteland and importance concerning its quality characteristics, this fruit was exploited for the development of certain value-added products including squash. Improper post-harvest handling methods also lead to deterioration of the fruit. Substantial quantities of pineapple fruits are sorted because of defects, mechanical damages, and pest damages, bruised and partially spoiled fruits, and are discarded as unmarketable by the farmers and traders in the production area. Such huge quantities of waste result in economic and food losses and also cause environmental pollution. This work aims to establish the physicochemical, antioxidant, and microbiological properties of roselle drink concentrate that is flavoured with natural pineapple juice.

2. Materials and Methods

Materials: The dried roselle (*Hibiscus sabdariffa*) calyces (dark red cultivar), pineapple (*Ananas comosus*) – cayenne cultivar, sugar, and other materials required were obtained from the local Mushin market, Lagos, Nigeria.

Preparation of roselle drink using hot water extraction:

The dried roselle calyces were sorted and weighed after which were thoroughly washed and then boiled in hot water at a temperature of 100°C for 15 minutes along with some added spices such as ginger, and cloves. The mixture was then strained properly using a muslin cloth to obtain unsweetened roselle juice. The extract was allowed to cool to about 65°C after which sugar and pineapple flavour was added. The drink was filled into sterilized glass bottles, capped, and stored.

Preparation of roselle drink using cold water extraction:

The dried roselle calyces were sorted and weighed after which were thoroughly washed and then soaked in water at room temperature of 37°C for 15 min. The mixture was then strained properly using a muslin cloth to obtain the roselle drink. The extract was pasteurized at 72°C for 15 s. The spices (ginger and cloves), sugar, and pineapple favour were added and the mixture was strained to obtain a spiced roselle drink. The drink was filled into sterilized glass bottles and then capped and stored.

Preparation of roselle squash using hot water extraction:

Dried roselle calyces, pineapple, sugar and were weighed separately. Fresh, ripe pineapples were washed, cut weighed, blended, and then strained to obtain juice. The dried roselle calyces were weighed, sorted, and thoroughly washed and then soaked in hot water of temperature 100°C for 15 mins along with spices (cloves and ginger), then were allowed to cool to about 65°C and filtered through a muslin cloth. Pineapple and roselle squash were set by integrating pulp, sugar, and water in a ratio of 1:4:1. Citric acid was supplementary to regulate the acidity to one-percent along with 0.05% Carboxyl Methyl Cellulose (CMC) to avoid separation and boiled for 30 mins to

prepare syrup and then filled into sterilized glass bottles and stored.

Preparation of roselle squash using cold water extraction:

Dried roselle calyces, pineapple, and sugar were weighed separately. Fresh, ripe pineapples were washed, cut and was blended, and then strained to obtain juice. The dried roselle calyces were weighed, sorted, and thoroughly washed, and then soaked in water at room temperature for 25 mins to obtain the extract. Pineapple and roselle squash were set by integrating pulp, sugar, and water in a ratio of 1:4:1. Citric acid was supplementary to regulate the acidity to one percent along with 0.05% Carboxyl Methyl Cellulose (CMC) to avoid separation and boiled for 30 mins to prepare syrup and then filled into sterilized glass bottles, capped.

Chemical Analysis

Physicochemical analysis: A digital pH meter was used to determine the pH according to the standard method (AOAC, 2012). Total soluble solids (TSS) were determined by using a hand refractometer at room temperature (AOAC, 2012). Total titratable acidity was determined by the standard method (AOAC, 2012) (AOAC, 2012). Ascorbic acid was determined by the direct colorimetric method using 2,6-dichlorophenol-indophenols as a decolorizing agent by ascorbic acid in sample extract and in standard ascorbic acid solution (AOAC, 2012). Reducing and non-reducing sugars were determined by the Lane Eynon method (AOAC, 2012). Viscosities of the samples were determined using the method of Karangwa et al. (2010) with few modifications using a digital viscometer (NDJ-55, Shangai Nirun Intelligent Tech. Co. Ltd) measured at 60 rpm in mPas.

Determination of specific gravity: The juice (10ml) was measured using a 50ml measuring cylinder to a previously weighed 10ml beaker and weight W_1 was taken. 10ml of water was also measured into the same 10ml beaker of weight W_0 and the overall weight was taken on the analytical weighing balance. The specific gravity of the juice was obtained by using the formula.

$$\text{Specific Gravity} = \frac{W_1 \text{ of 10ml of juice } (W_1 - W_0)}{W_1 \text{ of an equal volume of water } (W_2 - W_0)}$$

Determination of colour: Tri-stimulus colorimeter will be used to take colour measurements (Duangmal *et al.*, 2004). The instrument expresses colour measurement in the CIELAB (L^* , a^* , b^*) form. The instrument will first be calibrated using standard black and white plates (with transparent papers placed on the standard plates). L , a , b , coordinates were obtained using Adobe Photoshop 6.0 software (Adobe Systems Inc., California, USA) which were thereafter normalized to L^* , a^* , b^* according to the following equations which were explained by Yam and Papadakis (2004).

$$L^* = \frac{L}{255} \times 100$$

$$a^* = a^* \frac{240}{255} - 120$$

$$b^* = b^* \frac{240}{255} - 120$$

Also, the colour difference between the cold and hot extraction of Roselle drink and squash was determined by taking the

Euclidean distance between them according to the equation given below:

$$DE^* = [L_0 - L^*]^2 + [a_0 - a^*]^2 + [b_0 - b^*]^2$$

The colour attributes such as lightness (L^*), redness (a^*) and yellowness (b^*) will then be recorded.

Antioxidant properties

Reducing power assay: Various concentrations of the extracts (20 to 100 μ g/ml) in 1.0 ml of deionized water were mixed with phosphate buffer (2.5 ml) and potassium ferricyanide (2.5 ml). The mixture was incubated at 50 $^{\circ}$ C for 20 min. Aliquots of trichloroacetic acid (2.5 ml) were added to the mixture, which was then centrifuged at 3000rpm for 10 min. The upper layer of solution (2.5 ml) was mixed with distilled water (2.5 ml) and a freshly prepared ferric chloride solution (0.5 ml). The absorbance was measured at 700 nm. A blank was prepared without adding extract. Ascorbic acid at various concentrations (1 to 16 μ g/ml) was used as standard.

Total phenolics: Weigh 0.5g sample of extract dissolved in 50 ml of water. Take 0.5 ml add 0.1 ml of Folin- Ciocalteu reagent (0.5 N) mix and incubate at room temperature for 15 minutes. After this, add 2.5 ml sodium carbonate solution (7.5% w/v) and further incubate for 30 minutes at room temperature. The absorbance of the solution was measured at 760 nm. The concentration of total phenol was expressed as gallic acid equivalent (GAE) (mg/g of dry mass) which is a commonly used reference value'.

DPPH radical scavenging activity assay: An aliquot of 0.5 ml of extract in ethanol (95%) at different concentrations (25, 50, 75, 100 μ g/ ml) was mixed with 2.0 ml of reagent solution (0.004 g of DPPH in 100 ml methanol). The control contained only DPPH solution in place of the sample while methanol was used as the blank. The mixture was vigorously shaken and left to stand at room temperature. After 30 minutes the decrease in absorbance of the test mixture (due to quenching of DPPH free radicals) was read at 517 nm. The scavenging effect was calculated using the expression:

$$\% \text{ inhibition} = [A_0 - A_1] \times 100 / A_0$$

Where A_0 is the absorption of the blank sample and A_1 is the absorption of the extract

Total anti-oxidants: The solution of the sample extract (1 ml) was mixed with 3 ml of reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate). The tubes were capped and incubated in a boiling water bath at 95 $^{\circ}$ C for 90 minutes. After the samples had cooled to room temperature, the absorbance of the aqueous solution of each was measured at 695 nm. The total antioxidant capacity was expressed as equivalent to ascorbic.

Total flavonoid content estimation: 1 ml of sample solution (100 μ g/ ml) was mixed with 3 ml of methanol, 0.2 ml of 10% Aluminium chloride, 0.2 ml of 1 M potassium acetate, and 5.6 ml of distilled water. The resulting mixture was incubated at room temperature for 30 minutes and the absorbance of the reaction mixture was measured at 415 nm. The calibration curve was prepared by preparing quercetin solutions at various concentrations in methanol.

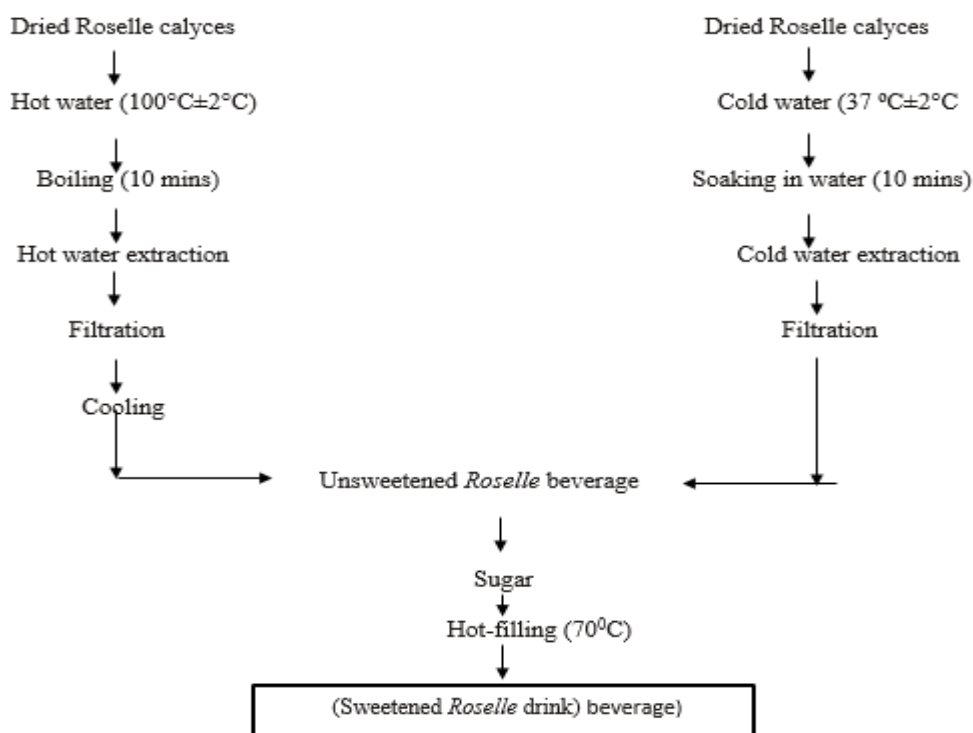


Figure 1: Flowchart for the production of Roselle drink
Source: Modified method of Karanja (2009).

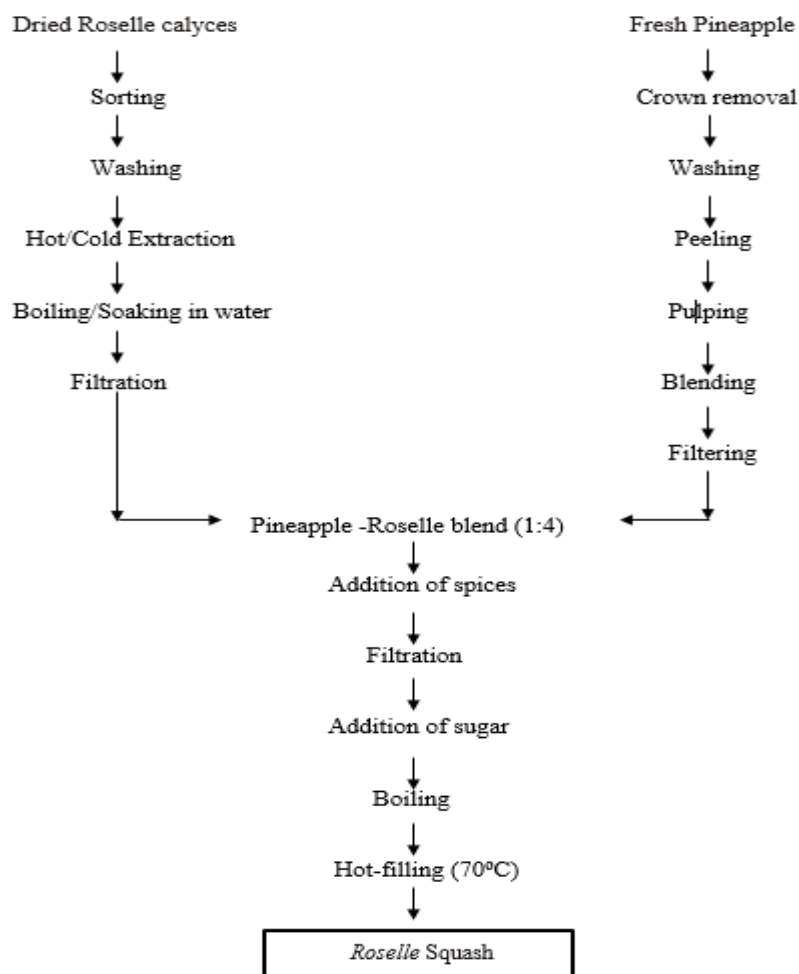


Figure 2: Flowchart for the production of Roselle squash
Source: Modified method of Karanja (2009).

Nitric oxide scavenging activity assay: 4 ml sample of plant extract or standard solution of different concentrations (25, 50, 75, 100 µg/ml) were taken in different test tubes and 1 ml of Sodium nitroprusside (5 min phosphate buffered saline) solution was added into the test tubes. They were incubated for 2 hours at 30 °C to complete the reaction. A 2 ml sample was withdrawn from the mixture and mixed with 1.2 ml of Griess reagent (1% Sulphanilamide, 0.1% naphthylethylenediamine dihydrochloride in 2% H₃PO₄). The absorbance of the chromophore formed during the diazotization of nitrite with sulphanilamide and its subsequent coupling with naphthyl ethylenediamine was measured at 550 nm (Alisi et al., 2008). Ascorbic acid was used as standard. The percentage (%) of inhibition activity was calculated from the following equation:

$$[(A_0 - A_1)/A_0] \times 100.$$

Where A₀ is the absorbance of the Control and A₁ is the absorbance of the extract or standard.

Microbiological Analysis: Roselle drink and squash were subjected to microbiological analysis after three weeks of storage at room temperature using Lynne Mclands Borough's method.

Statistical Analysis: All analysis was carried out in duplicate. Values obtained were subjected to analysis of variance (ANOVA) using a Microsoft Excel spreadsheet and the difference in mean significance using the LSD test which was defined at (p<0.05).

3. Results and Discussion

Physicochemical properties of roselle drink and squash

Table 4:1 presents the physicochemical properties of the 4 samples under hot and cold methods of extraction via measurements for viscosity, pH, TTA, specific gravity, ascorbic acid, and colour. The pH has great importance in maintaining shelf stability; pH can also influence the flavour and processing requirements of beverages. The pH value of the drinks and squashes ranged from 3.99 – 4.44. Squash extracted using cold water (CPSS) had the highest pH value (4.44) while drink extracted with cold water (CSS) had the lowest pH value (3.99). Added sugars contributed to an increase in the sugar-to-acid ratio. Added sugars also played a role in lowering the water activity of the beverage with a positive impact on the quality. The obtained values were within the range of 3.0 – 5.0 as reported by Akusu *et al.* (2016) for fruit drinks, pineapple juice (3.97), and orange juice (3.50). Yapo *et al.* (2011) and Islam *et al.* (2013) also reported similar values for pineapple juice and mango juice respectively. The pH values observed for the drinks were in the range of normal pH for fruit juices. A low pH is favorable for microbial stability in juices; moreover, low pH values have been reported to inhibit bacterial growth in fresh unpasteurized fruit juices by Nwachukwu *et al.* (2013). Microorganisms have optimal pH requirements for their growth however, the storage or shelf life of a fruit juice or drink is dependent on its pH (Olagunju and Sandewa, 2018). It was also observed that the increasing acidity influenced the pH content of the drinks and squashes (Yadav *et al.*, 2014). Titratable acidity is a measure of the total acid present in a juice (Sawant *et al.*, 2015). Acidity is also an important attribute because of the mild sour taste attributed to roselle beverages. The predominant acid naturally occurring in orange

juice is malic acid. There are also small amounts of citric acid and tartaric acid. The total acid may not be measured by pH because the acids concerned are “weak acids” and not completely ionized. The acid content was therefore measured using a titration with 0.1N sodium hydroxide. From the results observed, the total titratable acidity ranged from 0.62 to 1.40. CSS (cold water extracted drink) had the highest titratable acidity of 1.40 > CPSS (cold water extracted squash) had 0.79 > HSS (hot water extracted drink) had 0.65 > and HPSS (hot water extracted squash) had the lowest acidity. Roselle extract is known to be highly acidic with low sugar content (Tsai, 2002). The addition of sugar may have caused a decrease in acidity. This could be due to the ability of sugar to reduce acidity. There is a correlation between pH (low) and TTA (high) which may have led to the increase in acidity levels. The low amount of acid in it was neutralized by a strong alkali in the formulated drink. The viscosity of the drinks and squashes ranged from 5.5 to 128.5 mPa.s. Higher viscosities were observed in the squashes HPSS (128.5 mPa.s) and CPSS (23.0 mPa.s) which could be attributed to the addition of sugar and the addition of pineapple (almost ripened) which is higher in pectin. The addition and heating up of sugar and pineapple during processing may have led to a reduction in the free flow of the squashes and consequently, increased viscosity. CSS had the lowest viscosity and this may be attributed to the extraction rate. The ascorbic acid levels of the drinks and squashes were lower than the content observed from the fresh extract. This could be a result of the introduction of other components and processing methods as well as the dilution ratio of these beverages. It could also have been due to the addition of pineapple to the formulation of the squashes. Ascorbic acid prevents scurvy and protects the body against oxidative stress (Padayatty *et al.*, 2003). The high amount of ascorbic acid showed that the fruit is a good source of ascorbic acid as it could meet over 50% of the recommended daily intake of ascorbic acid for both adults (65mg/day) and children (25mg/day) as reported by The National Institutes of Health (retrieved, 2018). Colour is the most important quality attribute influencing consumer acceptability of food as it gives the first impression of food quality (Abou-Arab *et al.*, 2001). The red colour is due to the presence of anthocyanins (Tsai and Huang, 2004) in the roselle samples. From the results, as the concentration of roselle extract increased as a result of the extraction method, the redness decreased. The yellow colour is due to the presence of carotenoids in the pineapple. The yellowness increased significantly in the squashes containing pineapple.

Antioxidant properties of roselle drink and squash

DPPH (1-diphenyl-1-picrylhydrazyl assay)

In this study, the antioxidant properties of the hot and cold extracted roselle drink and squash samples were tested and compared with the activity of the well-known antioxidant, ascorbic acid.

Antioxidants act as free radical scavengers and inhibit lipid peroxidation and other free radical-mediated processes, thereby helping to protect the human body from several diseases attributed to the reactions of radicals (Atoui *et al.*, 2005). The DPPH antioxidant assay is based on the ability of DPPH, a stable free radical, to decolorize in the presence of antioxidants. The DPPH radical contains an odd electron that is responsible for the absorbance at 517 nm and also for the visible deep purple colour. When DPPH accepts an electron donated by an antioxidant compound, the DPPH is decolorized, which can be quantitatively measured from the changes in absorbance. The sequence for DPPH radical scavenging abilities of the beverages and ascorbic acid are shown in Figure 1: cold water extracted drink (CSS) >

hot water extracted drink (HSS) > hot water extracted squash (HPSS) > cold water extracted squash (CPSS) for concentrations 25 µg/m and 50 µg/m. For 75 µg/m, CSS (cold water-extracted drink) > CPSS (cold water extracted squash) > HPSS (hot water extracted squash > HSS (hot water extracted drink). For 100µg/m, CSS (cold water extracted drink) > HPSS (hot water extracted squash) > HSS (hot water extracted drink) > CPSS (cold water extracted squash). The scavenging effects showed that CPSS (cold water extracted squash) had the lowest antioxidant activity (23.02±0.70) meanwhile CSS (cold water extracted drink) had the highest antioxidant activity (28±0.88) in 25µg/m and 50µg/m. The scavenging effect in 75 µg/m showed that HSS (hot water extracted) had the lowest antioxidant activity (59.41±0.70) while CSS (cold water extracted drink) had the highest (66.84±0.70). The scavenging effect under 100µg/m showed that CPSS (cold water extracted squash) had the lowest antioxidant activity (73.64±0.52) while CSS (cold water extracted drink) had the highest antioxidant activity (79.58). The presence of antioxidants

in the roselle drink and squashes was significant. Thus, the drink may possess possible beneficial potential as a free radical scavenger. The highest antioxidant values were found among the unprocessed tea leaves, tea powders, and coffee beans. We find that plant-based foods are generally higher in antioxidant content than an animal-based foods and mixed food products (Carlsen *et al.*, 2010). Roselle has been reported to exhibit significant antioxidant activities. In this study, the antioxidants present when compared with ascorbic acid (a well-known antioxidant) in these beverages were lower but almost as much as in ascorbic acid. Roselle is rich in anthocyanins and is traditionally used to prepare a bright red beverage. However, heat treatment and different pH environments are often encountered during food processing, and these factors are often detrimental to anthocyanins. There is a positive correlation between the total content of phenolic compounds and the antioxidant activity of an extract, and over 95% of the antioxidant capacity of extracts is due to their phenolic components (Turkmen *et al.*, 2007; Wang *et al.*, 2017).

Table 1: Physicochemical study on roselle drinks and squashes

	HSS	HPSS	CSS	CPSS
Total soluble solid(°Brix)	6.3±0.02 ^a	6.7±0.26 ^a	5.88±0.00 ^a	5.60±0.10 ^a
Viscosity	6.1±0.14 ^c	28±5.66 ^a	5.5±0.14 ^d	23.0±1.41 ^b
pH	4.01±0.04 ^{ab}	4.28±0.99 ^a	3.89±0.06 ^b	4.44±0.01 ^a
TTA (%)	0.65±0.01 ^b	0.62±0.01 ^{ab}	1.40±0.03 ^c	0.79±0.10 ^a
Specific gravity	0.8997 ^c	1.019 ^a	0.7865 ^d	1.0054 ^b
Ascorbic acid(mg/100g)	47±0.06 ^a	43±0.07 ^b	44±0.03 ^{ab}	45±0.12 ^b
L*	21.9±0.05 ^a	16.4±0.01 ^b	15.1±0.22 ^a	14.3±0.50 ^a
a*	14.3±0.15 ^d	17.15±0.11 ^c	19.25±0.99 ^a	18.6±0.25 ^b
b*	8.0±0.05 ^a	6.42±0.12 ^b	4.6±0.05 ^c	3.89±0.15 ^d

Values are expressed as mean ± SD. HSS (hot water extracted roselle drink); HPSS (hot water extracted roselle squash); CSS (cold water extracted roselle drink); CPSS (cold water extracted roselle squash).

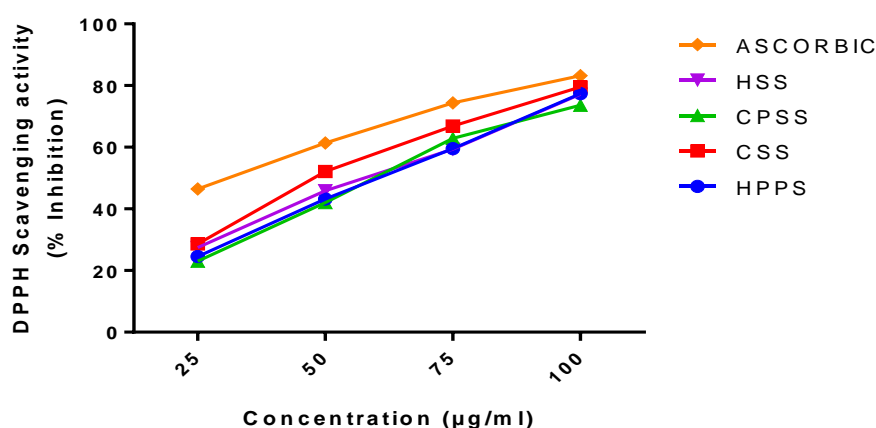


Figure 1: DPPH scavenging activity of roselle drink and squash

Reducing power assay

The sequence for reducing power activity is shown in Figure 2. HSS (hot water extracted drink) > HPSS (hot water extracted squash) > CPSS (cold water extracted squash) > CSS (cold water extracted drink) for 25µg/ml. For 50µg/ml, HSS (hot water extracted drink) > HPSS (hot water extracted squash) > CSS (cold water extracted drink) > CPSS (cold water extracted squash), at 75µg/ml concentration, HSS (hot water extracted drink) > CPSS (cold water extracted squash) > CSS (cold water extracted drink) > HPSS (hot water extracted squash) and at 100µg/ml, HSS (hot water extracted drink) >

HPSS (hot water extracted squash) > CPSS (cold water extracted squash) > CSS (cold water extracted drink). The reducing power activity effect showed that HSS had the highest antioxidant activity (0.137±0.004) at 25µg/ml. Meanwhile, CSS had the lowest. The effect showed that in 50µg/ml HSS had the highest (0.276±0.003) while CPSS had the lowest (0.241± 0.004). The reducing power activity showed in 75µg/ml that HSS had the highest antioxidant activity (0.373±0.003) meanwhile HPSS had the lowest (0.335±0.074). The reducing power activity effect in 100µg/ml

showed that HSS had the highest (0.544 ± 0.004) antioxidant activity while CSS had the lowest (0.431 ± 0.003).

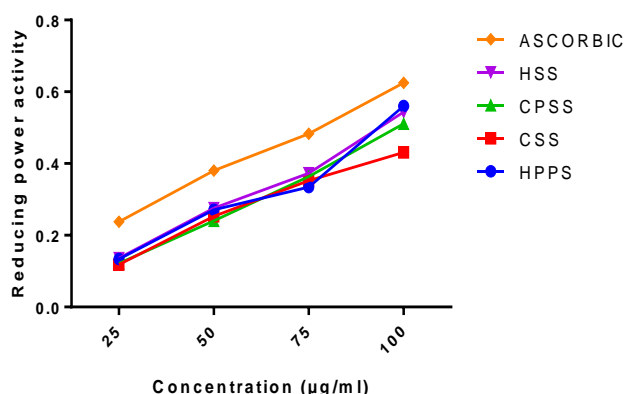


Figure 2: Reducing power activity of roselle drink and squash.

Nitric oxide activity of roselle drinks and squashes

The sequence for nitric oxide activity is shown in Figure 3. CSS (cold water extracted drink) > HSS (hot water extracted drink) > HPSS > CPSS (cold water extracted squash) in 25µg/ml, 50µg/ml, and 75µg/ml. At 100µg/ml, CSS (cold water extracted drink) > CPSS (cold water extracted squash) > HSS (hot water extracted drink) > HPSS (hot water extracted squash). Nitric oxide activity effect showed that CSS (cold water extracted drink) had the highest antioxidant activity (30.95 ± 0.66 , 45.63 ± 0.40 , 60.13 ± 0.40) in 25µg/ml, 50µg/ml, and 75µg/ml respectively while CPSS had the lowest (27.33 ± 0.53 , 40.43 ± 0.66 , 54.37 ± 0.66) in 25µg/ml, 50µg/ml and 75µg/ml respectively. The nitric oxide activity effect in 100µg/ml showed that CSS (cold water extracted drink) had the highest (77.60 ± 0.40) while HPSS (hot water extracted squash) had the lowest (70.35 ± 0.40) antioxidant activity.

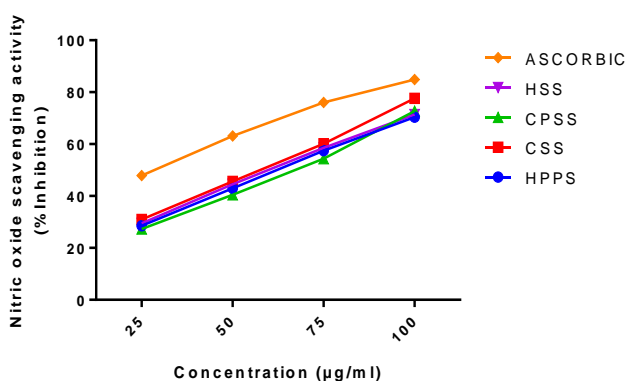


Table 2: Phenolic, flavonoid and total antioxidant capacity of roselle drink and squash

	Phenol (mg/100g)	Flavonoid (mg/100g)	Total Antioxidant Capacity (mg/100g)
HPSS	65.46 ± 0.28^b	29.61 ± 0.77	70.83 ± 0.58
CSS	79.59 ± 0.16^a	50.14 ± 0.39	75.03 ± 0.52
CPSS	58.51 ± 0.28^d	31.43 ± 0.77	70.67 ± 0.35
HPSS	61.52 ± 0.33^c	22.62 ± 0.13	72.18 ± 0.17

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

Fig. 3: Total antioxidant capacity of roselle drink and squash

Phenolic, flavonoid, and antioxidant activity of roselle drink and squash

The sequence for phenolic activities was shown in Table 2, CSS (cold water extracted drink) > HPSS (hot water extracted squash) > HSS (hot water extracted drink) > CPSS (cold water extracted squash) extract in 100µg/ml. The phenolic activity showed that CSS (cold water extracted drink) had the highest (79.59 ± 0.16) antioxidant activity while CPSS had the lowest (58.51 ± 0.28). Foods with higher phenolic content generally show stronger antioxidant activities (Onyechi *et al.*, 2012). The concept of antioxidant activities which describes the ability of different food antioxidants in scavenging preformed free radicals is a tool for investigating the health effects of antioxidant-rich foods. Flavonoids are a large group of compounds that are widely distributed in plant foods. They have antioxidant properties that protect the body against cardiovascular diseases and some forms of cancer (Onyechi *et al.*, 2012). The antioxidant potential of the drink was evaluated by total flavonoid. The sequence for flavonoid activity were shown in Table 2: CSS (cold water extracted drink) > CPSS (cold water extracted squash) > HPSS (hot water extracted squash) > HSS (hot water extracted drink) in mg/100g. The result showed that CSS (cold water extracted drink) had the highest (50.14 ± 0.39) antioxidant activity while HSS had the lowest (22.62 ± 0.13) antioxidant activity. The presence of flavonoid in roselle beverages is desirable as flavonoids display antioxidative properties through several mechanisms including the chelation of metal ions, scavenging of free radicals and inhibition of enzymes that propagate the generation of free radicals (Vinson, 2005). The total antioxidant capacity also as shown in Table 2 CSS (cold water extracted drink) > HSS (hot water extracted drink) > HPSS (hot water extracted squash) > CPSS (cold water extracted squash) in mg/100g. The result showed that CSS (cold water extracted drink) had the highest (75.03 ± 0.52) antioxidant activity while CPSS (cold water extracted squash) had the lowest (70.67 ± 0.35) antioxidant activity.

Microbiological analysis (in cfu/ml) of roselle drink and squash

Table 3 shows the results of the microbiological study for yeast and mould count, total viable count of bacteria and coliform of roselle drink and squash which was carried out to ascertain its safety by comparing the microbial load with bacteriological standards. The results after 24 h revealed that the hot water extracted squash (HPSS) had no growth, HSS (hot water extracted drink) had a total viable count of 2.01×10^3 cfu/ml, CPSS (cold water extracted squash) had a total viable count of 2.5×10^4 cfu/ml, and CSS (cold water extracted drink) had the total viable count of 1.4×10^4 cfu/ml. The total plate count of the samples was less than 1.0×10^5 cfu/ml which is the total plate count level permitted in food according to the Codex Alimentarius Commission of the Food and Agricultural Organization (2003). This low microbial population may be attributed to the positive effect of pasteurization in destroying microorganisms in liquid foods. The addition of a high quantity of sugar is known to favor microbial stability. However, this high pH (low acid) is known to favor the growth of yeast and may be responsible for the high microbial count (4.5×10^5 cfu/ml) observed in CPSS with the highest pH of 4.54. The result from the microbial assessment of the beverages suggests that they are safe for human consumption

and are not likely to cause any health-related microbiological hazard. The results after 48 h revealed a total viable count of hot water extracted squash (HPSS) of 5.1×10^2 cfu/ml, HSS (hot water extracted drink) had a total viable count of 2.18×10^4 cfu/ml, CPSS (cold water extracted squash) had a total viable count of 3.4×10^4 cfu/ml, and CSS (cold water extracted drink) had the total viable count of 1.8×10^5 cfu/ml. The total plate count of the samples was less than 1.0×10^5 cfu/ml except for sample CSS which may have been due to further growth of the bacteria. *E. coli* is commonly used as an indicator organism to reflect the hygienic quality of food. Its presence in food generally indicates direct or indirect faecal contamination. A substantial number of bacteria in food suggest a general lack of cleanliness in handling and improper storage. Food-borne pathogens do not generally grow at pH 4.6 or below, which has been set as an official borderline between acid and low-acid foods (Lawlor *et al.*, 2009). Therefore, the pH of soft drinks and alcoholic beverages is usually adjusted below this value (Sperber, 2009). Low pH alone does not ensure the product safety and stability. The minimum pH for growth and the rate of inactivation depend on the nature of the acidulant, the presence of other inhibitors and the acid resistance mechanisms of an organism (Lücke, 2003).

Table 3: Microbiological analysis (cfu/ml) of roselle drinks and squashes

	Total plate count	Coliform	Yeast and mould
HPSS ^a	No growth	4.1×10^4	1.6×10^4
HSS ^a	2.01×10^3	3.4×10^4	2.3×10^5
CPSS ^a	2.5×10^4	1.43×10^4	4.5×10^5
CSS ^a	1.4×10^3	4.0×10^4	2.8×10^4
HPSS ^b	5.1×10^2	2.1×10^4	4.3×10^5
HSS ^b	2.18×10^3	4.1×10^4	3.9×10^5
CPSS ^b	3.4×10^4	1.53×10^4	4.2×10^5
CSS ^b	1.8×10^4	3.0×10^4	3.6×10^4

^a represents the count after 24 hours; ^b represents count after 48 hours

4. Conclusion

The study shows that drinks and squashes of acceptable quality can be produced from roselle using hot and cold extraction methods without any significant changes in physicochemical properties. The production of roselle drink and squash from a combination of roselle calyx and pineapple rich in essential minerals and vitamin C could replace the existing commercially available non-alcoholic beverages in stores and supermarkets. The consumption of roselle-pineapple juices with high flavonoids and high phenolic activity will protect the human body from several diseases attributed to the reactions of free radical radicals. The formulated roselle drink and squash is an ideal low-cost blended beverage as the addition of pineapple in the roselle extract could bring down cost of production as these tropical fruits are sold at a throw-away price during their seasons and reduce seasonal losses of these fruits. It is an opportunity for exploring the possibility of producing other value-added food products to preserve the fruit during off seasons and also to reduce postharvest losses.

Acknowledgement

The authors are deeply grateful to Mr. Benjamin Ayoola of Food Chemistry Laboratory of the Department of Food Technology, University of Ibadan, for his technical assistance

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

Orcid

O.P. Olatidoye ID <https://orcid.org/0000-0002-6926-9724>
S.S. Sobowale ID <https://orcid.org/0000-0002--1051-1133>

Authors' contributions

This work was carried out in collaboration among all authors. Author Olatidoye, O.P. designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors Onipede, G.O. and Sobowale, S.S. managed the analyses of the study and validation. Authors

Alabi, A.O. and Adeoti, O.A. managed the literature searches and data collection. All authors read and approved the final manuscript

Conflict of interest

The authors declare no conflict of interest.

References

- Abou-Arab A.A., Abu-Salem F.M. and Abou-Arab E.A. (2001). Physicochemical properties of natural pigments (anthocyanin) extracted from Roselle calyces (*Hibiscus sabdariffa*). *Journal of American Science*; 7 (7): 445-456.
- Ahmed M.S.U., Nasreen T., Feroza B., Parveen S. (2009). Microbiological Quality of Local Market Vended Freshly Squeezed Fruit Juices in Dhaka City, Bangladesh. *Bangladesh J Sci Ind Res* 44(4):421-424
- Akusu O.M. *et al.*, (2016). Quality characteristics of orange/pineapple fruit juice blends. *Am. Journal of Food Science and Technology*; 4, 425-433
- Al-Wandawi H. (2015). Organic acids composition of different parts of the medicinal plant –roselle (*Hibiscus sabdariffa*). *Int'l Journal of Bio Pharma Res*, 6(10): 808-813.
- Ali B.H., Al Wabel N., Blunden G. (2005). Phytochemical, pharmacological and toxicological aspects of *Hibiscus sabdariffa* L.: a review. *Phytother Res*, 19(5): 369-375.
- Amusa N.A., Adegbite A.A., Oladapo M.O. (2005). Vascular Wilt of Roselle (*Hibiscus sabdariffa* L. var. *sabdariffa*) in the Humid Forest Region of South-western Nigeria. *Plant Pathology*;4(2):122-5.
- AOAC (2012). Official methods of analysis association of official & analytical chemist's 13th edn. Washington, DC.
- Atoui A.K.; Mansouri A., Boskou G., Kefalas, P. (2005). Tea and herbal infusions; their antioxidant activity and phenolic profile *Food Chemistry*, 89, 27-36.
- Babasaheb B.D. (2000). *Handbook of nutrition and diet*. Taylor & Francis Inc, New York, United States, pp. 231-233
- Botella J.R., and Fairbairn D.J. (2005). Present and future potential of pineapple biotechnology. *Acta Hort* 666:23-28
- Carlsen *et al.*, (2010). The total antioxidant content of more than 3100 foods, beverages, spices, herbs and supplements used worldwide. *Nutrition Journal* 2010 9:3
- Centre for Food Safety (2011). Microbiological quality of non-pre-packaged beverages mixed or topped with solid ingredients in Hong Kong; Risk Assessment Studies Report No. 46, Hong-Kong.
- Duangmal, K., Saicheua, B. and Sueeprasan, S. (2004). Roselle anthocyanins as a natural food colorant and improvement of its colour stability. In: *Color and Paints. Proceedings of the Interim Meeting of the International Colour Association, Porto Alegre, Brazil, 3-5 Nov., 2004* (Caivano, J.L. ed). Pp. 155-158.
- Eslaminejad T., Ansari M., Elaminejad T. (2012). Evaluation of the potential of *Trichoderma viride* in the control of fungal pathogens of Roselle (*Hibiscus sabdariffa* L.) in vitro. *Microbial Pathogenesis*. 2012; 52(4):201-5.
- Eslaminejad T., Zakaria M. (2011). Morphological characteristics and pathogenicity of fungi associated with Roselle (*Hibiscus Sabdariffa*) diseases in Penang, Malaysia. *Microbial Pathogens*, 51(5): 325-37.
- FAO (Food and Agricultural Organisation) of the United Nations W.H.O Rome (1992). Joint FAO/WHO foods standards programme for fruit juices and related products. Codex Alimentarius Commission. Vol. 6. pp 1-5.
- Gupta, R.K. (1993). *Handbook of Export Oriented Food Processing Projects*. SBP Consultants and Engineers. Pvt Ltd. 314- 315
- Halimatul S.M.N., Amin I., Mohd.-Esa N., Nawalyah A.G., Siti Muskinah M. (2007). Protein quality of Roselle (*Hibiscus sabdariffa* L.) seeds. *ASEAN Food Journal*; 14(2):131-40
- Hassan M.K., Beman-Ali J.K., Mohammad A.A., Farhad F (2009). Effects of Sour Tea (*Hibiscus sabdariffa*) on Lipid Profile and Lipoproteins in Patients with Type II Diabetes. *J Altern Complement Med* 15: 899-903.
- Hirunpanich V., Utaipat A., Molales N.P., Bunyapraphtsala N,Sato H., Herunsale A., (2006). Hypocholesterolemic and antioxidant effects of aqueous extracts from the dried calyx of *Hibiscus sabdariffa* L. in hypercholesterolemic rats. *J Ethnopharma*, 103: 252-260.
- Islam M.K.; Khan M.Z.; Sarkar M.A., Absar N., Sarkar S.K. (2013). Changes in acidity, TSS, and sugar content at different storage periods of the postharvest mango (*Mangifera indica* L.) influenced by Bavistin DF. *Int. J. Food Sci.*
- Ismail A., Ikram E.H.K., Nazri H.S.M. (2008). Roselle (*Hibiscus sabdariffa* L.) seeds-nutritional composition, protein quality and health benefits. *Food*, 2: 1-16.
- Iwalokun B.A., Shittu M.O. (2007). Effect of *Hibiscus Sabdariffa* (Calyx) Extract on Biochemical and Organoleptic Properties of Yogurt. *Pak J Nutrition*, 6 (2): 172-182.
- Jain, S., Sushmita S, Mohanan A. Quality evaluation of herbal squash developed from rosemary herb and amla. *International Journal of Home Science*, 2016; 2(1): 210-213.
- Joseph, J., and Shukla S.(2015). Preparation and quality evaluation of mixed fruit squash. *International Journal of Advance Industrial Engineering*, 3(3): 1-5.
- Jothi, J.S., Karmoker, P, and Sarower, K.(2014). Quality assessment of mixed fruit squash: Physico-chemical analysis, sensory evaluation and storage studies. *Journal of Bangladesh Agriculture University*. 12(1): 195-201.
- Kays, S.J. (2011). *Cultivated vegetables of the world: A multilingual onomasticon*. University of Georgia. Wageningen Academic Publishers, The Netherlands, p. 184.
- Khalil K, Lindblom GB, Mazhar K, Kaijser B (1994) Flies and water as reservoirs for bacterial enteropathogens in urban and rural areas in and around Lahore Pakistan. *Epidemiol Infect* 113:435-444
- Malekian L.C., F., Berhane M., and Gager, J. (2005). Biological Characteristics, Nutritional and Medicinal Value of Roselle, *Hibiscus Sabdariffa*. Circular – Urban Forestry Natural Resources and Environment, 604p.
- Lin, H.H., Chen J.H., Kuo W.H., Wang C.J. (2007). Chemo-preventive properties of *Hibiscus sabdariffa* L. on human gastric carcinoma cells through apoptosis induction and JNK/p38 MAPK signaling activation. *Chem Biol Interact*, 165(1): 59-75.
- Mahadevan, N., Shivali, K.P. (2009). *Hibiscus sabdariffa* Linn: An overview. *Natural Product Radiance*, 8: 77-83.
- Mgaya Kilima B., Remberg S.F., Chove B.E., Wicklund T. (2014). Physico-chemical, mineral composition and antioxidant properties of roselle (*Hibiscus sabdariffa* L.) extract blended with tropical fruit juices. *African Journal of Food Agricultural and Nutrition Development*, 14(3): 8963-8978.
- Miranda A.C., Moreno J.G.R., Jiménez J.M., Moody J.A.O., Ruiz G.H., Perea M.T. (2014). A continuous production roselle (*Hibiscus sabdariffa* L.) dryer using solar energy. *J Food Agric Environ*, 12(1): 96-104.
- Mohamadou, B.A., Mbofung and Thouvenot, D. (2007). Functional potential of a product from Traditional Biotechnology: antioxidant and probiotic potential of Mbuja, produced by fermentation of *Hibiscus sabdariffa* seeds in Cameroon. *Journal of food technology* 5(2): 164-168.
- Morris, J.R., Grandell, P.G. and Bates, R.P. (2001). Principles and practices of small and medium scale fruit juice processing. *Food and Agricultural Organization of the United Nations*. Pp 3-20.
- Morton J.F. (1999). Roselle, *Hibiscus sabdariffa* L. Retrieved on 26th July, 2019.
- Muhammad F.S., Umar B.M. (2007). Production and Organoleptic Assessment of Sweetened Sorrel Powder. *Namoda Tech-Scope Journal of Applied Science and Technology* 7: 7-13.
- Mungole A. and Chaturvedi A. (2011). *Hibiscus sabdariffa* L. is a rich source of secondary metabolites. *International Journal of Pharmaceutical Sciences, review and research*. Volume 6 (1):83-87.
- Munoz, A.M and King S.C. (2007) International consumer product testing across cultures and countries. *General Principles*.
- Nakpong P, Wootthikanokkhan S. (2010). Roselle (*Hibiscus sabdariffa* L.) Oil as an alternative feedstock for biodiesel production in Thailand. *Fuel*, 89: 1806-1811.
- National Institutes of Health, Office of Dietary Supplements. Vitamin C Fact Sheet for Consumers. pp. 1-3. Available online: <https://ods.od.nih.gov/pdf/factsheets/VitaminC-Consumer.pdf> (accessed on 15 February 2018).

- Ngamjarus C., Pattanittum P., Somboonporn C. (2010). Roselle for hypertension in adults. In Ngamjarus, Chetta. Cochrane Database of Systematic Reviews (doi:10.1002/14651858.CD007894.pub2).
- Nwachukwu E, Ezeama CF, Ezeanya BN (2008) Microbiology of polyethylene packaged sliced watermelon (*Citrullus lanatus*) sold by street vendors in Nigeria. *African Journal Microbiol Res* 2:192–195
- Nwachukwu E., Onovo O.M., Eadie T (2007). Effect of Lime Juice on the Bacterial Quality of Zobo Drinks Locally Produced in Nigeria. *Res J Microbiology* 787-891.
- Nwachukwu, E., Ezeigbo, C.G. (2013). Changes in the microbial population of pasteurized sour sop juice treated with benzoate and lime during storage. *Afr. J. Microbiol. Res.*, 7, 3992–3995.
- Olatidoye Olawale Paul., Olayemi, Wasii Ajani, and Igwe, U.N. (2020) Effect of cooking methods on antioxidant activity, nitric oxide scavenging activity and phenolic contents of groundnuts varieties grown in Nigeria. *Journal of Agricultural Studies*, Vol. 4, pp. 27-43 DOI: <https://doi.org/10.31058/j.as.2020.41003>
- Olatidoye, O.P., Sobowale, S.S., Balogun, I.O. and Agbodike, V.C. (2019). Total Antioxidant Potential of Some Selected Beverages Consumed in Lagos State, Nigeria *EC Nutrition* 14.3: 261-272.
- Onyechi, A.C., Ibeanu, V.N., Eme, P.E., Kelechi, M. (2012). Nutrient, phytochemical composition and sensory evaluation of soursop (*Annona muricata*) pulp and drink in south eastern Nigeria. *Int. J. Basic Appl. Sci.*, 12, 53–57.
- Padayatty *et al.*, (2003). Vitamin C as an antioxidant: Evaluation of its role in disease prevention. *J. Am. Coll. Nutr.*; 22, 18-25.
- Persad C., Fortune M. (2009). A new disease of sorrel (*Hibiscus sabdariffa* var. *sabdariffa*) caused by *Coniella musaiaensis* var. *hibisci* from Trinidad and Tobago. *Plant Pathology* [Internet]. 1989; 38(4): [615-7 pp.]. Available from: <http://www3.interscience.wiley.com/cgi-bin/fulltext/119434036/PDFSTART>.
- Prasongwatana V., Woottisin S., Sriboonlue P., Kukongviriyapan V. (2008). Uricosuric effect of roselle (*Hibiscus sabdariffa*) in normal and renal-stone former subject. *J Ethnopharma*, 117(3): 491-495.
- Prescott L.M., Harly J.P., Kleen D.A. (2002) *Food Microbiology*, 5th ed. McGraw Hill Book Co., New York, pp 352–627
- Rashed N., Md A., Md U., Azizul H., Saurab K.M., Mrityunjoy A.M., Majibur R. (2013) Microbiological study of vendor and packed fruit juices locally available in Dhaka city, Bangladesh. *Int Food Res J* 20(2):1011–1015
- Sawant A.A, Salkar P.P., Rane P.P., Gauns V.R. (2015). Effect of various preservatives on nutritive value of fruit juice. *Dhempe College of Arts and Science, Panaji, Goa*. pp no. 24
- Sindumathi, G. and Premalatha, M.R. (2015). Development and storage studies of naturally flavored papaya pineapple blended ready-to-serve (RTS) Beverage. *International Journal of Science and Research*. 4(2): 856- 860.
- Srivastava R.P., Sanjeev Kumar, (2008). *Fruit and vegetable preservation, Principles and practices*. 3rd revised and Enlarged Edition, Page no.192.
- Sulistiyani H., Fujita M., Miyakawa H., Nakazawa F. (2016). Effect of roselle calyx extract on in vitro viability and biofilm formation ability of oral pathogenic bacteria. *Asian Pacific J Trop Med*, 9(2): 119–124.
- Tsai J.P., McIntosh J., Pearce P., Camden B., and B.R. Jordan. (2002). Anthocyanin and antioxidant capacity in Roselle (*Hibiscus Sabdariffa* L.) extract. *Food Research International* 2002; 35: 351–356.
- Tsai P.J. and Huang, H.P. (2004). Effect of polymerization on the antioxidant capacity of anthocyanins in Roselle. *Food Research International* 2004; 37: 313–318.
- Turkmen, N., Velioglu, Y.S., Sari, F., Polat, G. (2007). Effect of extraction conditions on measured total polyphenol contents and antioxidant and antibacterial activities of black tea. *Molecules*. PpPp 12, 484–496. [CrossRef] [PubMed]
- Ukwuru M.U., Uzodinma C.C. (2010). Preservative Effect of Spices and their Flavour Acceptability in Zobo Drink. *Niger Food J* 28: 265-274.
- Vinson, J.A., Zubik, L., Bose, P., Samman, N., Proch, J. (2005). Dried fruits: Excellent in vitro and in vivo antioxidants. *J. Am. Coll. Nutr.*, 24, 44–50.
- Wang S., Chu Z., Ren M., Jia R., Zhao C., Fei, D., Su H., Fan X., Zhang X., Li Y. (2017). Identification of anthocyanin composition and functional analysis of an anthocyanin activator in solanum nigrum fruits. Pp 22, 876. [CrossRef] [PubMed].
- Wong, P.K., Yusof S., Ghazali H.M., and CheMan Y.B. (2002). Physico-chemical characteristics of roselle (*Hibiscus sabdariffa* L.). *Nutr. Food Sci.* 32:68–73.
- Yadav S.R., Gehlot S., Siddiqui, Grewal R.B. (2014). Changes in chemical constituents and overall acceptability of guava- mango ready-to-serve (RTS) drink and squash. *Beverage and Food World*; 41(4):30-33
- Yapo, E.S.; Kouakou, K.L.; Bognonkpe, T.P.; Kouame, P.; Kouakou, T.H. (2011). Comparison of pineapple fruit characteristics of plants propagated in three different ways: by suckers, micropropagation and somatic embryogenesis. *J. Nutr. Food Sci.* 2011, 1, 110–118.
- Sperber W.H. (2009). Introduction to the, In: Sperber, W.H. and Doyle, M.P. (eds.) *Compendium of the Microbiological Spoilage of Foods and Beverages*, Food Microbiology and Safety, p. 1–39, Springer, New York.
- Lawlor K., Schuman J., Simpson P. and Taormina J. (2009). In: Sperber, W.H. and Doyle, M.P. (eds.) *Compendium of the Microbiological Spoilage of Foods and Beverages*, Food Microbiology and Safety, pp. 245–283, Springer, New York.
- Lüick, F.K. (2003). The control of pH. In: Zeuthen, P., and Bøgh-Sørensen, L. (eds.) *Food preservation techniques*. Cambridge, UK: Woodhead Publishing Limited. Part II, pp. 109–125.
- Mentz, G., Vriesekoop, Zarei, M., Zhu, B. and Aldred, P. (2010). The growth and survival of food-borne pathogens in sweet and fermenting brewers' wort. *International Journal of Food Microbiology*, Vol. 140, pp. 19–25.
- Vijayan, K., and Prabhat A. (2015). Formulation, standardization and shelf life study of water melon incorporated grape squash. *Current Research in Nutrition and Food Sciences*, 3(2): 150-155.

Intelligentsia Publishing Services
The publisher you need

HOME ABOUT JOURNALS IPS BOOKS ARCHIVES SUBMISSION SERVICES CAREER CONTACT US

PUBLISH WITH US FOR WORLDWIDE VISIBILITY

Call for Papers

Open Access

FEATURED PUBLICATIONS

Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour

This study found that adding banana peel flour to wheat flour can improve the nutritional value of noodles, such as increasing dietary fiber and antioxidant content, while reducing glycemic index.

DOI: <https://doi.org/10.54117/ijnfs.v2i2.24>

Cite as: Oguntoyinbo, O. G., Oluwarewa, J. A. Y., & Osooba, O. S. (2023). Antioxidant and Dietary Fibre Content of Noodles Produced From Wheat and Banana Peel Flour. *IPS Journal of Nutrition and Food Science*, 2(2), 46-51.

Impact of Pre-Sowing Physical Treatments on The Seed Germination Behaviour of Sorghum (*Sorghum bicolor*)

This study found that ultrasound and microwave treatments can improve the germination of sorghum grains by breaking down the seed coat and increasing water diffusion, leading to faster and more effective germination.

Submit your manuscript for publication: [Home - IPS Intelligentsia Publishing Services](#)

*Thank you for publishing with us.