DETERMINATION OF NUTRIENT COMPOSITIONS AND UTILIZATION OF PINEAPPLE (*ANANAS COSMOSUS* L.) PEELS AND WATER MELON (*CITRULLUS LANATUS* (THUNB.) RIND WASTE AS ADDITIVES IN ZOBO ENRICHMENT

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Abstract: This work was conducted in the Department of Crop Production and Horticulture, Modibbo Adama University Yola, and it was designed to determine the proximate composition as well as vitamin C component for pineapple peels and watermelon The results revealed higher carbohydrates, fiber and vitamin C content with 10.16 ± 0.226 %, 2.15 ± 0.0707 %, and 17.42 ± 0.260 mg/100g, respectively in pineapple, while watermelon showed higher protein content of 1.775 ± 0.0354 %. The average amount of wastes was 522g and 1600g, with a percentage range of 17.3-24.3 % and 45.5-54.6 % in pineapple and watermelon respectively. There was a significant difference between the means of the amount of pineapple peels and pulp and watermelon rind and pulp with p values of <0.001 and 0.02 respectively. The pineapple peels were used to enrich Roselle calyx drink (zobo) and all the formulations P1-P3 were recommended for zobo enrichment. More research was recommended on the use of watermelon peels.

Key words: Nutrient, utilization, additives, Zobo

Introduction

As reported by Food and Agricultural Organization (FAO, 2014) roughly a third of the food produced in the World for human consumption every year, approximating to 1.3 billion tons, get lost or wasted, amounting to roughly 680 billion US dollars in the industrialized countries and 310 billion US dollars in developing countries, with each consumer in Sub Saharan Africa throwing away 6-11kg of food per year. As insinuated by FAO Safe Food (2015) global quantitative food losses and wastes per year are highest in fruits and vegetables, ranging from 40-50% occurring along the entire supply chain. This unfortunate situation does not only make food unavailable to the ever increasing consumers but also amount to major squandering of resources including water, land, energy, labour and capital and needlessly produce Green House gas emissions, contributing to Global warming and Climate change (FAO, 2019a).

World Economic Forum (WEF,2019) identified food waste reduction as the number 3 (three) way to reverse climate change and that with the expected 9 billion World population by 2050, food security can be guaranteed for every one if we simply distribute the food we produce more efficiently through reducing wastage to minimal. As inscribed in goal 12 of the United Nations' Sustainable Development Goals, halving of the global per capita of food waste at the retail and consumer levels should be a reality by 2030 (Gheoldus, 2019). African leaders also pledged in what is known as the ''Malabo Declaration'' to half postharvest losses by 2025 ((FAO, 2019b).

The total loss and waste in Sub Saharan Africa (SSA), has been reported to be between 5-50 %, with less than 8 % occurring on farm, 8 % at postharvest, 18-38 % during processing, 10 % during distribution, and less than 5 % during consumption (FAO, 2011). In fact, wastes from processing of tropical and subtropical fruits are made up of significantly higher proportions in comparison to the temperate fruits (Schieber *et al*., 2001).

The losses and wastes in fruits include peels which are produced during minimal processing. Fruit vendors produce wastes during minimal processing as they try to make the fruits more convenient for consumption by their customers. Most of these wastes if not all are hardly used (Ajila *et al*. 2010), and therefore becomes a source of land pollution. However, these wastes produced by these fruit vendors can be potential raw materials for the production of other substances. Also, if these wastes are transformed into palatable forms, they can be used for human and animal consumption in countless ways, including in the enrichment of Roselle calyx drink (zobo). Zobo is ideal for enrichment because it is a popular drink and is widely consumed by most Nigerians from different socioeconomic facets and is equally served during special celebrations by different tribes (Bamishaiye *et al*., 2011; Odebunmi and Dosumu, 2005).

The enrichment of zobo using wastes can only be done when the nutritional composition and amount of these wastes are determined. Most of the work published on quantitative losses and wastes are on a combination of produce at industrial level of processing rather than on specific produce at the level of minimal processing by fruits vendors. Some works however, have been done on peels (wastes) of pineapple fruits. Boehner and Mindler (1949) used pineapple wastes in the production of sugar, Saraswaty *et al*. (2017) showed the anti-oxidant activity of pineapple peels, Tropea *et al*. (2017) and Koffi and Han (1990) produced alcohol from pineapple wastes. Recently, Akujobi *et al.* (2018) substituted pineapple and orange flavours with pineapple and orange juice. However, to the best of our knowledge, no work has been done on the use of pineapple peels in Roselle calyx drink enrichment. This work was therefore design to determine the proximate composition as well as vitamin C component for pineapple peels and watermelon rind, and also to establish the amount of these wastes, for their potential application in Roselle calyx (zobo) enrichment. This will go a long way to enhance food security especially with persistent challenges on food production systems such as that posed by Covid-19 and will help to prevent environmental pollution as well as mitigate climate change.

Materials and Methods

The experiment was conducted in the Department of Crop Production and Horticulture Modibbo Adama University Yola, Nigeria. Is located on latitude $9^0$20' 43'' N and longitude 12^0 30' 8'' E, at an altitude 203.5m above sea level. Yola has an annual mean minimum and maximum temperature of 15.2^{0}C and 39^{0}C respectively (Adebayo, 1999).

Samples of pineapple and water melon rind waste were collected from 30 randomly selected retailers, each time from Jimeta market in Yola.

Determination of composition of wastes

Proximate analysis

Fresh samples pineapple and water melon rind wastes were carefully cleaned and were prepared for analysis of nutrients composition. This was done in accordance with the Association of Official Analytical Chemists International (AOAC), (2005), where, moisture content was determined by oven drying, ash by sample ignition method at 550°C, fat using Soxhlet apparatus, protein by Kjedahl's method using the formula (N x 6.25), the sample was digested to determine the crude fiber content. The carbohydrate content was determined according to FAO (1982) by difference as follows:

Carbohydrate % = 100 – (moisture % + protein % + ash % + lipid % + crude fiber %).

Determination of dry matter

Dry matter was determined by using the formula;

%Dry Matter = 100 - % Moisture.

Determination of Vitamin C

The vitamin C content was determined by titration, based on the equation below, followed by calculations to determine the concentration of ascorbic acid in mg/100g in accordance Benderitter *et al*. (1998).

Ascorbic acid + $I_2 \rightarrow 2I^-$ + dehydroascorbic acid

Determination of quantity of wastes

Twenty (20) pineapple and watermelon portions each were purchased from 20 randomly selected retailers, each time from Jimeta market in Yola. This was done in two phases, first in December 2019, when prices of these fruits were highest and later on in May 2020, when prices were moderate. A pineapple was purchased at 700 naira and watermelon at 600 naira. The weight in grams of each portion of the fruits was taken in triplicates. Cleaned samples of the vegetables were carefully prepared by removing the non-edible portions, which are traditionally thrown away. The weight in grams of the wastes was equally taken in each of the triplicate portion of the vegetables.

The weight of vegetables was determined by the formula

Weight of vegetables = $\frac{AWV(PT1)+AWV(PT2)}{2}$

The weight of wastes was obtained by using the formula;

Weight of wastes =

$$\frac{AWV(PT1) - AWW(PT1) + AWV(PT2) - AWW(PT2)}{2}$$

Where; AWV=average weight of vegetables, AWW= average weight of wastes, PT1= period of highest price, PT2= period of lowest price. Adapted from Kikulwe *et al*. (2018).

Percentage wastes = $\frac{\text{Weight of wastes}}{\text{Weight of vegetable}} \times \frac{100}{1}$

Preparation of pineapple peels: Pineapple peels were dried at room temperature to prevent the loss in vitamin C. The dried peels were then ground into powder with the aid of an electric blender. The ground peels were then sieved using a 0.45µ sieve and the filtrate obtained were weighed separately to obtain 40 g, 50 g and 60 g, which were then used for the enrichment of zobo.

Preparation of Roselle calyx drink (zobo): This was done by extraction in boiled water, in accordance with Adesokan *et al*. (2013). Dark red dry Roselle calyces were sorted to remove unwanted materials, and were then ground into powder using an electric blender. The ground calyces were then filtered using a 0.45µ sieve. The powder obtained (150 g) was then added into five liters of boiled water and allowed for 12 minutes for complete absorption to form Roselle calyx drink (zobo). Three of such solutions were prepared again, with the formulations added after 8 minutes of mixing the Roselle powder with boiled water in each case. Each was then allowed to stand for 4 minutes. In the first Roselle solution, 40 g (P1) of pineapple peels powder was added, 50 g (P2) was added in the next and 60 g (P3) in the last solution. The pineapple peels powder was not added to the control (P4).

Determination of sensory attributes: Sensory attributes of the Roselle calyx drink (zobo) in terms of taste, colour, flavor, texture, appearance as well as the general acceptability, were evaluated by a 10 member panelists (food scientists) from the Modibbo Adama University of Technology Yola, Nigeria. The sensory attributes were evaluated using Nine Hedonic scale (1 to 9 for dislike extremely, dislike very much, dislike very moderately, dislike slightly, neither like nor dislike, like slightly, like moderately, like very much, like extremely, respectively). The Roselle calyx drink (zobo) was served to the panelists at the same time, and their judgements were recorded.

Determination of the composition of Roselle calyx drink (zobo): Samples were taken from each formulation and various tests were carried out. Proximate analysis was done in accordance with prescriptions of the Association of Official Analytical Chemists International (AOAC), (2005), where, fat content was determined using Soxhlet apparatus, protein by Kjedahl's method using the formula (N x 6.25). The carbohydrate content was determined according to FAO (1982) by difference as follows:

Carbohydrate % = 100 – (moisture % + protein % + ash % + lipid % + crude fiber %).

The energy content was established following the method employed by Emmanuel and Folasade, (2011) by applying the formula;

Energy (K cal /100g) = (Crude lipid X 8) + (Crude protein X 2) + (Carbohydrate X 4).

The vitamin C content was determined by titration, based on the equation below, followed by calculations to determine the concentration of ascorbic acid in accordance with Benderitter *et al*. (1998) methods.

Ascorbic acid + $I_2 \rightarrow 2I^-$ + dehydroascorbic acid

Data analysis

Data were analyzed by one-way Analysis of Variance (ANOVA). The Duncan New Multiple Range Test was used to separate the means of quantitative samples. Results were reported as mean ± standard Error (SE) of triplicate measurements.

Results

Pineapple peels and watermelon rind composition: The results of the analysis of the fruit wastes from pineapple and watermelon are presented in Table 1. The analysis of pineapple peels revealed very rich in carbohydrates and vitamin C with 10.16 ± 0.16 % and 17.42 ± 0.411 mg/100g respectively, and less ash content and protein of 0.7 ± 0.1 % and 0.79 ± 0.154 % respectively, though watermelon had a comparatively low content of carbohydrates and vitamins with 2.1 ± 0.11 % and 5.2 ± 0.758 mg/100g respectively. Watermelon rind was observed to have low levels of ash and fat of 0.9 ± 0.1414 % and 0.15 ± 0.0707 % respectively. The dry matter, crude fiber and fat content of pineapple peels were higher than those in watermelon with 16.00 ± 0.721 %, 2.15 ± 0.05 %, 1.35 ± 0.0.05 % against 6.60 ± 0.412 %, 1.1 ± 0.01 %, 0.15 ± 0.0707 % respectively. Watermelon rind had higher moisture (93.4 ±0.57) content than pineapple peels (84.0 ± 0.849).The ash content of the two fruits was relatively.

Table 1: Showing proximate composition and vitamin C content (%) of pineapple and watermelon wastes

	Pineapple peels/mean ± SE	Watermelon rind mean± SE
Moisture content	84.0 ± 0.849	93.4 ± 0.566
Dry matter	16.00 ± 0.849	6.60 ± 0.566
Ash	0.7 ± 0.141	0.9 ± 0.141
Carbohydrates	10.16 ± 0.226	2.1 ± 0.000
Fiber	2.15 ± 0.0707	1.1 ± 0.141
Protein	0.79 ± 0.1273	1.775 ± 0.0354
Fat	1.35 ± 0.0707	0.15 ± 0.0707
Vitamin C	17.42 ± 0.260	5.2 ± 1.040

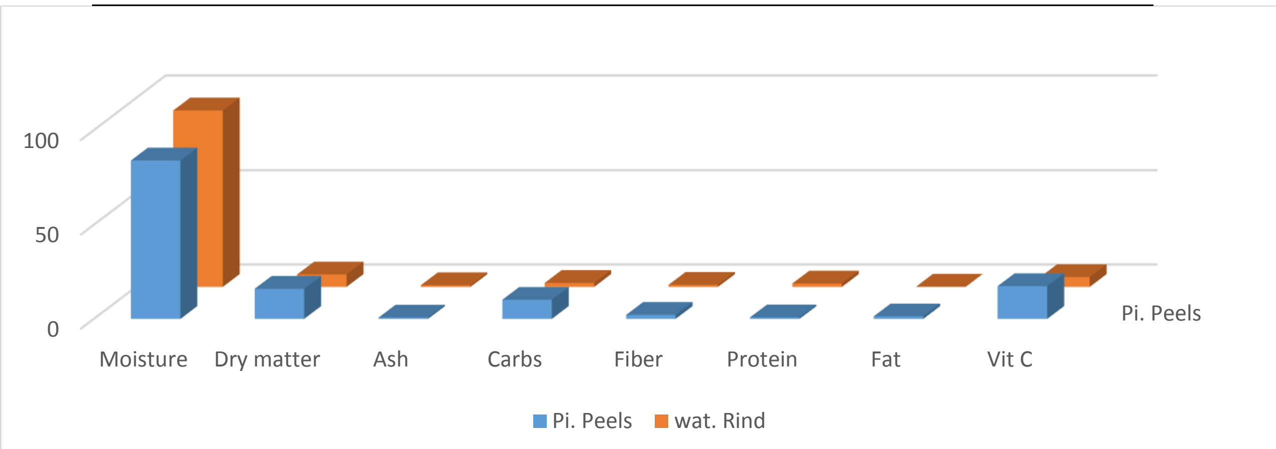

Figure 1:Proximate analysis and vitamin C content for pineapple and watermelon wastes

Quantitative losses in pineapple and watermelon: The percentage weight loss of pineapple during minimal processing was in the range of 17.3-24.3 %, as shown in Table 2. There was between the means of watermelon rind and the pulp, with the wastes having much weight than the pulp, with p-value of 0.02 as shown in figure 2 below. There was a high significance difference between the means in the pineapple peels and pulp, with p-value of <0.001 with the weight of pulp higher than that in the peels.

Table 2: Mean quantities in grams of pineapple and watermelon wastes

Fruits	Mean waste/g	% Loss range
Pineapple	522g	17.3 – 24.3 %
Watermelon	1600g	45.5 – 54.6 %

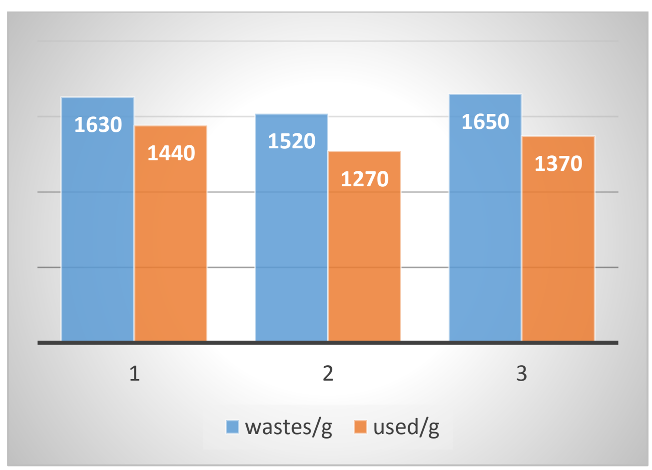

Figure 2: showing watermelon rind and pulp quantities

Composition of zobo from various formulations P1-P4: The results revealed that the vitamin C, crude fats and energy content of the enriched zobo samples were higher than the control, as presented in Table 3. The results in Table 3 revealed that the highest Vitamin C content was observed in P3 (60 g) of peels powder and the vitamin C content appeared to be increasing with the amount of pineapple peels powder. Though the amount of crude fat, vitamin C, protein and energy were similar among the enriched samples, P3 was significantly higher in carbohydrates than that of P1, but similar to that of P2. The amount of proteins in all the formulations was similar.

Table 3: Proximate composition (%) vitamin C (mg/100ml) and energy (Kcal/100ml) content in treatments P1-P4

Content	P1	P2	P3	P4
Carbohydrates	10.23 ± 0.280[b]	11.11 ± 0.350[ab]	11.82 ± 0.73[a]	10.51±0.977[ab]
Protein	1.72 ± 0.507[a]	1.41 ± 0.1015[a]	1.92 ± 0.702[a]	1.65 ± 0.282[a]
Crude fat	3.13 ± 0.1153[a]	2.81 ± 0.354[a]	3.21 ± 0.246[a]	1.56 ± 0.279[b]
Vitamin C	8.11 ± 0.852[a]	8.32 ± 0.370[a]	9.75 ± 1.75[a]	4.48 ± 1.226[b]
Energy Kcal/100g	69.4 ± 6.74[a]	69.2 ± 1.005[a]	76.8 ± 3.83[a]	57.8 ± 6.57[b]

Values are means ± standard error of three replicate amount, the means that do not share a letter, written as superscript on the same row, are significantly different at $P < 0.05$. P1 = 40 g, P2 = 50 g, P3 = 60 g and P4 = control, of pineapple peels powder.

Sensory characteristics of zobo enriched with pineapple peels powder: The results revealed that the taste and aroma of the enriched samples were much higher than that of the control, making the enriched samples more generally accepted than the control. The colour, texture and the appearance of the enriched samples were equally as good as that of unenriched sample.

Table 4: Sensory attributes of P1 – P4, pineapple peels powder enriched zobo

Sensory attribute	P1	P2	P3	P4
Colour	6.81 ± 1.257[a]	7.11 ±0.40[a]	7.24 ± 0.226[a]	6.92 ± 1.720[a]
Taste	7.32 ± 0.267[a]	7.25 ± 0.239[a]	7.82 ± 1.199[a]	5.81 ± 0.368[b]
Texture	6.91 ± 0.246[a]	7.44 ± 1.005[a]	7.83 ± 0.538[a]	6.84 ± 0.295[a]
Aroma	8.12 ± 0.745[a]	7.92 ± 0.282[a]	8.51 ± 0.369[a]	6.21 ± 0.484[b]
Appearance	6.74 ± 0.632[a]	7.12 ± 0.263[a]	7.32 ± 0.1153[a]	6.81 ± 0.60[a]
General acceptability	8.34 ± 0.445[a]	8.12 ± 0.522[a]	8.54 ± 0.354[a]	6.94± 0.929[b]

Values are means ± standard error of three replicate amount, the means that do not share a letter, written as superscript on the same row, are significantly different at $P < 0.05$. P1 = 40 g, P2 = 50 g, P3 = 60 g and P4 = control, of pineapple peels powder.

Discussion

The moisture content in pineapple peels was comparable to 82.7 ± 0.7 % reported by Morais *et al.* (2017). The ash content of pineapple peels observed were not in harmony with 5.0 ± 0.4 %, 4.39 ± 0.14 %, 1.32-1.92g reported by Morais *et al.* (2017); Feumba *et al*. (2016) and Tortoe *et al.* (2013). The carbohydrates content observed was not coherent with earlier works of Feumba *et al.* (2016) and Tortoe *et al.* (2013) who reported 55.52 ± 092 % and 61.02-65.74g respectively. The crude fiber content in pineapple peels did not concur with the works of Feumba *et al*. (2016) and Tortoe *et al.* (2013) who detected 14.80 ± 0.01 % and 0.42-0.51g. The protein content reported was not in harmony with earlier works of Feumba *et al.* (2016), Morais *et al.* (2017), Sharma *et al*. (2016) and Tortoe *et al.* (2013) who detected 5.11 ± 0.02%, 8.8 ± 0.06 %, 8.7g and 1.49-2.05g respectively. The fat content of pineapple peels observed was not in accordance with results obtained by Feumba *et al.* (2016) and Tortoe *et al.* (2013) who reported 5.31 ± 0.74 % and 0.73- 0.85g respectively. The vitamin C content observed, 17.42 ± 0.411 % highly contrasted the earlier works by Tortoe *et al.* (2013) who detected vitamins in pineapple peels in a range of 2.25mg/100g-2.61mg/100g. The high level of vitamin C in pineapple peels can be a cheap source of anti-oxidant for the prevention against cancer and hypertension among other uses and can therefore be used a part of human diet in combination with other food or converted into more palatable food.

The high moisture content observed in watermelon rind was coherent with, 92.85 ± 4.55 % and 92.6± 0.6 %, reported by Morais *et al.* (2017) and Kamau *et al.* (2020), but concur with the work of Olayinka and Etejere (2018) who reported 93.65 ± 0.03 % in watermelon rind. The ash content observed, 0.9 ± 0.1414 %, was not in harmony with earlier works by Morais *et al.* (2017), who reported 10.2 ± 2.4 %, but however, this results obtained, partially concurred with 0.74 ± 0.04 % detected by Kamau *et al.* (2020) in water melon rind. The carbohydrates content of the rind obtained was not in accordance with the results of Feumba *et al.*(2016) and Kamau *et al.* (2020), who reported 32.16 ± 1.22 and 4.42 ± 0.88 % respectively. The crude fiber obtained, 1.1 ± 0.01 % was not in accordance with earlier works of Morais *et al.* (2017), Olayinka and Etejere (2018) and Feumba *et al.* (2016) who reported respectively 0.76 ± 0.09 %, 0.23 ± 0.01 % and 26.31 ± 0.01 % of crude fiber in water melon rind. The crude protein observed, 1.775 ± 0.0650 %, was incoherent with the works of Morais *et al.* (2017), Kamau *et al.* (2020), Olayinka and Etejere, (2018) and Feumba *et al.* (2016), who reported 10.2 ± 1.1 %, 0.90 ± 0.09 %, 0.53 ± 0.02 % and 12.42 ± 0.08 respectively. The crude fat content of water melon rind observed was not in accordance with results detected by Morais *et al.* (2017) and Feumba *et al.* (2016), who reported 24.1 ± 4.1 of crude fat, 12.61 ± 0.63 respectively. The vitamin C content of 5.2 ± 0.758 mg/100g registered concurred with 5.32 ± 0.02 % reported by Olayinka and Etejere (2018) in water melon rind. The discrepancies observed in the above results could have been due to differences in the fruits parts used by the different authors and also because of differences in cultural activities involved in the growth of the plant as well as the possible differences in the watermelon and pineapple cultivars used by different authors. This could have also been due to geographical factors and consumption habits of the people in the various places where the studies were done.

Quantitative losses in pineapple and watermelon: The percentage weight loss of pineapple during minimal processing was in the range of 17.3-24.3 %, concurred with the description by EU Fusions Food Waste Quantification Manual (2016) who reported that 19 % in fruits from processing and Ayala-Zavala *et al*. (2010) and Joshi *et al*. (2012) who reported that 23 % of wastes were generated during processing. This result was incoherent with 9.17 ± 0.67 % reported by Feumba *et al*. (2016). The observed difference could be due to geographical factors as well as cultural activities employed during fruit cultivation. This could also be due to the consumption habit of the people in Adamawa State, in relation to what they considered as wastes. The 45.5-54.6 % wastes, reported in watermelon as shown in Table 2 was not in accordance with 6.44 ± 0.02 % described by Feumba *et al*. (2016). The discrepancy in the results in watermelon wastes was because Feumba *et al.* (2016) used only the green part of the fruit, while our work dueled on the inedible part of the fruits. There was no data available in literature to do comparisons between mean quantities of watermelon rind and pulp as well as quantities of pineapple peels and pulp.

Composition of zobo from various formulations P1-P4: The high vitamin C content was in agreement with the works of Adesokan *et al*. (2013) and Akujobi *et al.* (2018), who reported high vitamin C content, compared to the control, in zobo. Adesokan *et al*. (2013) observed high vitamin C content in zobo enriched with ginger and garlic, and Akujobi *et al.* (2018), in zobo with pineapple and orange flavours substituted with pineapple and orange juice. The observations however, contrasted the works of Puro *et al.* (2017) who reported very low amounts of vitamin C in zobo. The high level of energy was possibly due to the relative high amount of crude fat in the enriched zobo than in the control. The high crude fat samples observed, contrasted sharply with the observation of Egbere *et al.* (2007) and Olayemi *et al.* (2011). This could be explained by the fact that pineapple peels are comparably higher in crude fats than their own enrichments substances, with garlic as low as 0.12-0.37 (g/100g f.w) (Petropoulos *et al.* 2018). The amount of proteins in all the formulations was similar, possibly due to the low protein content in pineapple peels. Despite similar amount of protein, it was higher than those observed by Egbere *et al*. (2007) and Olayemi *et al.* (2011) but was comparable to 2.32 % observed by Ibeabuchi *et al*. (2019) in zobo. Though the amount of crude fat, vitamin C, protein and energy were similar among the enriched samples, P3 was significantly higher in carbohydrates than that of P1, but similar to that of P2. Zobo enriched with pineapple peels could be recommended as an energy drink, due to high crude fat, moderate protein and high energy compared to unenriched zobo. The high vitamin C content in the enriched samples show that enriched samples can help reduce risk of cardiovascular diseases and some forms of cancer.

Sensory characteristics of zobo enriched with pineapple peels powder: The higher taste and aroma of the enriched samples, confirms to earlier works by Adesokan *et al*. (2013) who reported that samples enriched with ginger and garlic were generally more accepted as well. Pineapple is known for its great flavor in drinks (Chaudhary *et al.*, 2019), this was also confirmed in our study, that pineapple peels equally has very good flavor and helped to improve on the aroma of the enriched zobo, making them better than the control. The taste of the enriched samples was better than that of the control, concurring with the works of Ibeabuchi *et al*. (2019) who reported that the taste of zobo enriched with moringa, ginger and garlic was better than that of the control. The better colour, texture and the appearance of the enriched samples made the enriched samples more acceptable than the samples that were not enriched. Ibeabuchi *et al*. (2019) also reported that most enriched formulations of zobo had colour similar to that of the control. The fact that all the enriched samples were generally accepted shows that P1, P2 and P3 formulations were all good in the enrichment of zobo with pineapple peels powder due to its high vitamin C and energy.

Conclusion

The findings from our study revealed that pineapple peels and watermelon rind were high in quantity and very rich in nutrients and can therefore be a cheap source of minerals, proteins, fiber, carbohydrates as well as vitamins C. The pineapple peels were transformed into powder and used to enrich zobo. All the supplemented formulations, P1-P3 were found to be generally accepted by our panelists and were therefore recommended for the enrichment of zobo. This will go a long way to reduce this nutritional and quantitative losses and wastes in this fruit and will help to attain Sustainable Development Goals (SDGs) agenda 2030 and also to fight food security especially with new challenges like that posed by Covid-19. The fight against climate change as well as pollution will be enhanced. More research was recommended on the use of watermelon peels.

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