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Nutritional Composition and Sensory Properties of Smoothies Produced from Pineapple (*Ananus Comosus*), Watermelon (*Citrus Lanatus Thumb*) and Mango (*Mangifera Indica L*)

Onodugo, N.G, Agbo, E.C., Ikwumere, C.M., Onwubuya, N.P., Nnadi, I.M., Ezeja, E.P., & Chima, B.
Department of Nutrition and Dietetics, University of Nigeria, Nsukka

Corresponding author: gift.onodugo@unn.edu.ng

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Abstract

Micronutrient deficiencies constitute an enormous global public health burden and increasing the consumption of fruit in form of smoothies can help alleviate this lingering problem. The study assessed the nutritional composition and sensory properties of various samples of smoothies produced from the combinations of pineapple (*Ananus comosus*), watermelon (*Citrus lanatus*) and mango (*Mangifera indica L*). The concentration of each of the fruits was varied in the three major samples while the control comprised an equal proportion of each of the three fruits. The smoothie samples were coded MWP, PMW, WMP and CONT according to the proportion of each fruit contained therein. Proximate, mineral and vitamin composition and sensory properties of the four smoothie samples were assessed using standard methods. The result of the proximate analysis showed that sample MWP contained the highest protein (2.76%) and fat (1.75%). Sample WMP had more ash (1.50%) content, while PMW had higher crude fibre and carbohydrate compositions (2.41± 0.00 mg) and (4.11±0.70 %), respectively. The highest amount of calcium (74±2.82 mg) and potassium (196.25 mg) were found in sample PMW, while WMP had higher iron (9.28±0.03 mg). The sensory evaluation result showed that there was no significant difference in the colour, texture, flavour and general acceptability of the smoothies. The acceptance of smoothies coupled with their ability to furnish humans with essential nutrients shows that people can improve their dietary diversity and nutritional status through their consumption to remain healthy.

Keywords: Fruit smoothie, nutritional composition, sensory properties

Introduction

Fruits are the mature and ripened ovaries of flowers (Roth, 1977). They constitute an essential part of a healthy diet as they provide numerous health benefits including a reduction in the risk of non-communicable chronic diseases and the maintenance of normal body weight. The plausible explanation for these advantageous effects can be attributable to the abundance of micronutrients (vitamins and minerals), phytochemicals, antioxidants, and fibre needed to make the human body function normally. Antioxidants inhibit or delay the oxidation of biologically relevant molecules either by specifically stopping free radicals or by chelation of redox metals. Bailey et al. (2016) defined free radicals as highly unstable atoms, ions or molecules that actively react with other molecules and affect the normal functioning of the deoxyribonucleic acid (DNA) and cell membranes.

The fibre in fruits aids food digestion (Andreson et al., 2010), enhances nutrient absorption and reduces the acid load of the diet (Neul, 2010) and helps to maintain normal body weight (Tohill et al., 2014). Dietary fibre also reduces the risk of cancer, particularly that of proximal colon cancer and rectal cancer (Annema et al., 2011), and urothelial cell carcinomas (Ros et al., 2012); reduces cholesterol level (Southon, 2015); improves the health of the gut, which in turn decreases the prevalence of diverticulosis, constipation and diarrhoea (Klimenko et al., 2018). The World Health Organization (WHO) recommends that individuals should consume at least five servings or 400 g of fruits daily (WHO, 2020; Diaz-Garces et al., 2016). However, people in developing countries are expected to consume above this recommendation in the face of the nutrition transition that has culminated in a phenomenon referred to as the "triple burden" of malnutrition; undernutrition, micronutrient deficiencies and obesity.

Available literature still shows that people consume lower amounts of fruits (Global Burden of Disease Collaborators, 2019). Several factors may be responsible for the inadequate consumption of fruits. According to Fadeiye et al. (2019), factors such as personal likes and dislikes, taste, appearance, smell, health condition, season, available information, texture, price and nutritional benefits, influenced the consumption of fruits. Some of these factors pose serious challenges to the consumption of healthy fruits by some individuals. However, these challenges, particularly those related to the organoleptic potentials and nutritional benefits of these fruits can be overcome through the production of smoothies from various fruits.

Smoothies refer to semi-liquid, fruit-based products with a smooth consistency that is prepared from a blend of different fruits in various proportions (Teleszko & Wojdylo, 2014). Smoothies can be produced from different fruits such as pineapple, watermelon, mango, banana and others depending on the availability and seasonality of the fruits and the preference of the consumer. Smoothies prepared from the combination of different fruits would supply more nutrients since no single fruit contains all the essential nutrients. In addition, many fruits are utilized in the production of smoothies to get a beverage with better organoleptic properties. As such, the present study utilized pineapple, watermelon and mango.

Pineapple contains calcium, potassium, carbohydrates, crude fibre and vitamin C (an effective antioxidant

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that aids the body's absorption of iron). It contains copper, which regulates the heart rate and blood pressure (Debnath et al., 2012). It is also a good source of manganese, a mineral that is required for building bones and connective tissues in the body (Hossain et al., 2015). The US Department of Agriculture [USDA], 2019) reported that watermelon is a rich source of energy (30 Kcal), water (91.45 %) vitamin A (569 mg), vitamin C (8.1 mg), Lycopene (4532 µg per 100 g) among other vital nutrients. A hundred grams (100 g) of mango pulp contains 83.46 g of water, 60 kcal of energy, 14.98 g of carbohydrate, 0.82 g of protein, 0.38 g of lipid, 1.6 g of fibre, and 168 mg of potassium among other nutrients (Burton-Freeman et al., 2017; Dar et al., 2016; Maldonado-Celis et al., 2019; Tharanathan et al., 2006; USDA, 2020).

Following the composition of these three fruits, it is believed that their combination would improve the nutritional status of consumers. According to Hill (2020), there are three major types of smoothies which include: fruit smoothies, Green/vegetable smoothies and protein smoothies. Fruit smoothies usually contain one or more types of fruit blended with fruit juice, water or milk. Green smoothies are made from vegetables and fruit blended with water, juice or milk, while protein smoothies normally start with one fruit or vegetable and a liquid, and a major protein source like yoghurt cottage, cheese or protein powder. A fruit smoothie is considered to be one of the cheapest and most effective ways of increasing fruit intake.

Inadequate intake of fruits has many disadvantages which have been reported by several researchers. Micha et al. (2017) reported that low intake of fruit was responsible for 2 million deaths and 65 million Disability-Adjusted Life Years (DALY) in 2017 which was considered one of the leading dietary risk factors for deaths and DALYs globally and in many countries. Wang et al. (2021) found from two prospective cohort studies of US men and women and a meta-analysis of 26 cohort studies, that intake of at least 2 servings of fruits reduced mortality.

The Global Burden of Disease Collaborators (2019) showed that the consumption of fruits in sub-Saharan Africa was still inadequate. This is evident in the prevalence of micronutrient deficiencies across the globe, especially in developing countries like Nigeria. According to the Food and Agriculture Organization of the United Nations Statistics Division, FAOSTAT (2014), more than 2 million people worldwide suffer from hidden hunger. Evidence shows that 40-60% of under-five children in developing countries suffer from vitamin A deficiency (Mohammad (2018); 28 % of under-five children in Nigeria are iron deficient, 29.5 % are vitamin A deficient while 29.6 % suffer from iodine deficiency (Kuku-Shittu et al., 2016). It has been estimated that out of the 3.1 million child deaths that occur each year as a result of undernutrition, micronutrient deficiencies are responsible for 1.1 million deaths (Black et al., 2013).

Deficiency of iron, folic acid, iodine, vitamin A and zinc are the most common micronutrient deficiencies and can lead respectively to anaemia, neural tube defects, cognitive impairment, morbidity and mortality (Diedhiou & Jalal, 2015). These deficiencies affect mostly children, adolescent girls and

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pregnant women. Besides, various reviews have correlated low intake of fruits with the increasing prevalence of chronic non-communicable diseases such as cardiovascular diseases, low blood pressure, hypercholesterolemia, osteoporosis, cancers, chronic obstructive pulmonary diseases, respiratory problems and mental health (Adebawo et al., 2012; Rosario et al., 2018).

Interventions to prevent micronutrient malnutrition, according to Miller and Welch (2013), can be categorised into three basic groups namely: (1) Agricultural production strategies, (2) Food processing strategies and (3) Economic and consumer education strategies. Others include food-based and micronutrient supplementation, food fortification, bio-diversification and dietary diversification through home gardens. Although micronutrient supplementation is generally preferred as a strategy to combat micronutrient deficiencies; they are most suitable when used as a measure to combat severe deficiencies. Food-based strategies such as food fortification and dietary diversification are more effective than micronutrient supplementation which should only be employed as a short-term measure. A basic tenet of a nutritionally adequate diet is that it must contain a variety of foods from all the food groups. The production of smoothies in this study was intended to promote dietary diversification among the population. Since smoothies can be used as a breakfast meal, they will encourage dietary diversity by helping people to incorporate more healthy foods into their diet and as such increase the intake of fibre, vitamins and minerals among other nutrients contained in them.

Objectives of the study: This study assessed the nutritional composition and sensory properties of smoothies produced from pineapple, watermelon, and mango. The specific objectives of the study were to:

1. formulate smoothies from three different fruits;
2. determine their proximate composition;
3. determine their micronutrient composition (calcium, potassium, iron, pro-vitamin A and vitamin C) and
4. evaluate the sensory properties (colour, flavour, texture, taste, and general acceptability) of the smoothies

Materials and methods

Source of raw materials: The raw materials used for the production of smoothies were fresh ripe pineapple (*Ananus comosus)*, watermelon (*Citrullus lanatus)* and mango (*Mangifera indica)*. These fruits were procured from a local (Ogige) market in Nsukka Local Government Area of Enugu State, Nigeria.

Smoothie production: Fresh watermelon, mango and pineapple were selected and properly washed under running tap water, peeled using a sterile stainless knife and diced. Seeds were removed from the diced fruit pulps with a clean spoon. The diced seedless fruit was weighed with a food weighing scale and combined in the appropriate quantity of each of the fruits to get the ratios as presented in Table 1. The mixture was carefully poured into an

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aseptically hygienic Binatone 1.5L blender with Grinder BLG-410 to produce smoothie samples. The smoothies contained no additives such as sugar, water and/or acid. They were homogenized, bottled and kept in the refrigerator until analysis was carried out.

Watermelon, mango and pineapple
↓
Sorting
↓
Washing
↓
Peeling
↓
Dicing
↓
Deseeding
↓
Blending for 30-40 seconds
↓
Smoothie samples

Fig 1: Flow chart of smoothie production

Table 1 presents the blending ratios of the smoothies. The smoothie sample coded MWP was made by combining 50 %: 25 %: 25 % mango: watermelon: pineapple. Sample code with PMW was in the ratio of 50 %:25 %:25 % pineapple: mango: watermelon. The sample coded WMP had 50 %: 25 %:25 % watermelon: mango: pineapple, while CONT which served as the control contained equal amounts (33.33 %: 33.33 %: 33.33 % mango: watermelon: pineapple) of the three fruits. The combination ratio was adapted from a previous work conducted by Victor-Aduloja et al. (2020). An equal amount of the three fruits was chosen to assess the preferred combination of these fruits as compared to the varying quantities.

Table 1: Blending ratios of fruits used for the production of smoothies (%)

Samples	Mango	Pineapple	Watermelon	Total
MWP	50	25	25	100
PMW	25	50	25	100
WMP	25	25	50	100
CONT	33.33	33.33	33.33	100

Source: Victor-Aduloja et al. (2020).

Proximate analysis: The proximate composition of samples of smoothies was determined using the air method described by the Association of Official Analytical Chemists of AOAC. The carbohydrate content was determined by difference. This means that the carbohydrate content of the smoothies was determined by subtracting the amounts of moisture, protein, fat, crude fibre and ash from 100%.

Mineral determination: The mineral components (potassium, iron, calcium) were analysed using the method described by the Association of Official Analytical Chemists of AOAC.

Vitamin determination: The vitamin components (vitamin C and beta-carotene) were analysed using the method described by the Association of Official Analytical Chemists of AOAC.

Sensory evaluation: The organoleptic test of the smoothies was done using a 9-point hedonic scale (Iwe, 2002). The panellists comprised thirty semi-trained students of the Nutrition and Dietetics

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Department, University of Nigeria, Nsukka. Each attribute was rated according to its intensity scaled on a 9-point hedonic scale quality with 9 = liked extremely, 8 = liked very much, 7 = liked moderately, 6 = liked, 5 = neither like nor dislike, 4 = disliked moderately, 3 = disliked, 2 = disliked very much and 1 = disliked extremely.

Statistical analysis

The data obtained were statistically analysed using Statistical Product and Service Solution (IBM-SPSS) version 23. Descriptive statistics (means and standard deviations) were used to present the data. Analysis of variance (ANOVA) was used to compare the means of variables while the Turkey test was used to separate means. The significance level was accepted at $p < 0.05$.

Results

The proximate composition of the smoothie samples, presented as means and standard deviations, was shown in table 2. Moisture was significantly higher (90.80±0.35 %) in WMP compared with other samples. The smoothie sample coded MWP had the highest protein (2.76±0.18%) and fat (1.75±0.35%) content. The crude fibre contents of the smoothies ranged from 2.41±0.00% to 2.01±0.17%. The sample prepared with 50 % watermelon had the highest ash of 1.50±0.00 % while the smoothie with 50 % pineapple contained more carbohydrates (4.11±0.70 %) followed by CONT (3.07±0.20), WMP (2.13±0.23 %) and lastly MWP (2.08±0.25 %.

Table 2: Proximate composition of smoothies made from mango, watermelon and pineapple (100 g wet weight)

Samples	Moisture (%)	Protein (%)	Fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
MWP	90.40±0.08^{b}	2.76±0.18^{c}	1.75±0.35^{a}	2.01±0.17^{c}	1.00±0.00^{ab}	2.08±0.25^{a}
PMW	89.04±0.35^{ab}	2.19±0.00^{ab}	1.25±0.35^{a}	2.41±0.00^{b}	1.00±0.00^{ab}	4.11±0.70^{b}
WMP	90.80±0.35^{b}	2.01±0.12^{a}	1.50±0.00^{a}	2.06±0.00^{a}	1.05±0.00^{b}	2.13±0.23^{b}
CONT	90.51±0.08^{a}	2.58±0.07^{bc}	1.00±0.00^{a}	2.09±0.25^{a}	0.75±0.35^{a}	3.07±0.20^{ab}

Values = mean ± standard deviation, Mean values on the same row with different superscripts were statistically different at $p < 0.05$, MWP = smoothie made from 50%:25%:25% of mango-watermelon-pineapple, PMW = smoothie made from 50%:25%:25% pineapple-mango-watermelon, WMP = smoothie made from 50%:25%:25% watermelon-mango-pineapple CONT = smoothie made from 33.33 % of mango, 33.33 % of watermelon and 33.33 % of pineapple

The mineral content of the smoothie samples was presented in Figure 1. Sample PMW had the highest calcium and potassium corresponding to 74±2.82 mg and 196.25±1.76 mg, respectively. The smoothie sample with the code WMP contained the highest (9.28±0.03 mg) amount of iron followed by CONT (9.10±0.14 mg) followed by MWP (8.36±0.30 mg) and lastly PMW (7.50±0.03 mg).

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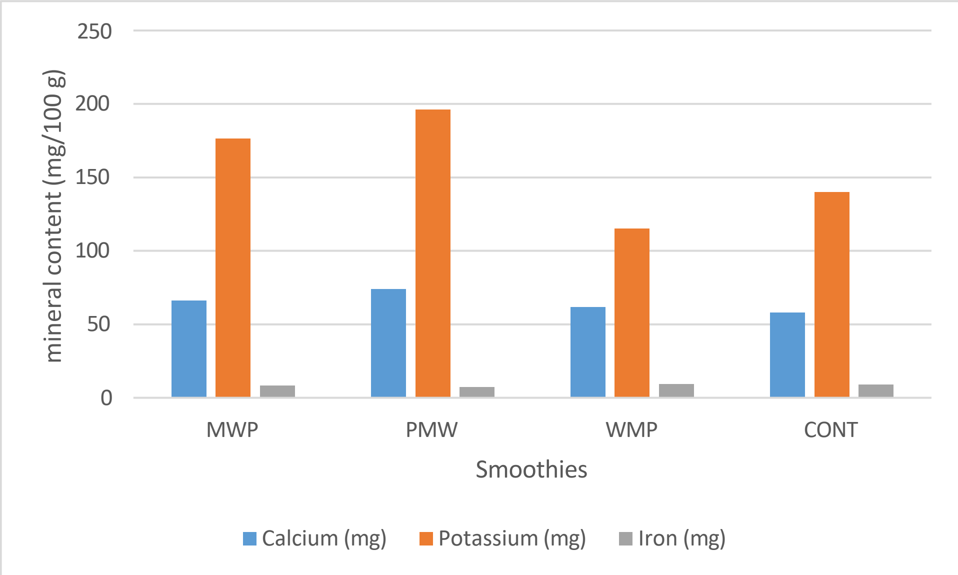

Figure 1: Mineral contents of the smoothies

Figure 2 presents the vitamin contents of the smoothie samples. All the samples contained appreciable amounts of Pro-vitamin A and vitamin C. There was a significant difference ($p < 0.05$) in the vitamin contents of the smoothies. Pro-vitamin A profile of samples WMP (459.57± 5.67 IU) was comparable to that of the CONT (460.56±11.01 IU), and both were significantly ($p < 0.05$) higher than the pro-vitamin contents of MWP and PMW. The Smoothie sample made from 50 % pineapple (PMW) had significantly ($p < 0.05$) higher vitamin C (346.50±0.70) than the other samples.

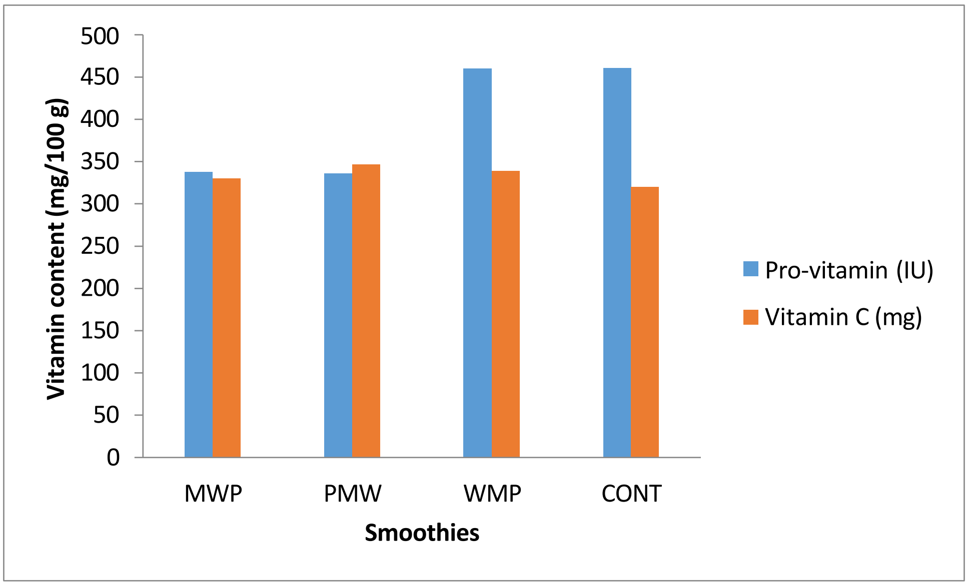

Figure 2: Vitamin contents of smoothies

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The sensory scores (colour, texture, taste, flavour and general acceptability) of the smoothies are presented in table 5. The smoothie samples were not statistically different ($p > 0.05$) in all the sensory properties except in taste. The control (CONT) was rated higher (7.55±1.08) in taste followed by MWP (7.27±1.78) and WMP (7.17±1.14) which were also statistically the same, while PMW had the lowest taste score (6.47±1.63).

Table 3: Sensory properties of smoothie made from mango, watermelon and pineapple

Sample	Colour	Texture	Taste	Flavour	General acceptability
MWP	7.83±1.26[a]	7.33±1.09[a]	7.27±1.78[b]	7.00±1.53[a]	7.07±1.92[a]
PMW	7.00±1.78[a]	7.00±1.76[a]	6.47±1.63[c]	6.27±2.13[a]	6.40±1.94[a]
WMP	7.63±1.24[a]	7.30±1.26[a]	7.17±1.14[b]	6.90±1.44[a]	6.57±1.81[a]
CONT	7.7±1.13[a]	7.17±1.60[a]	7.55±1.08[a]	6.97±1.45[a]	7.14±2.18[a]

Values = mean ± standard deviation, Mean values on the same row with different superscripts were statistically different at $p < 0.05$, MWP = smoothie made from 50%:25%:25% of mango-watermelon-pineapple, PMW = smoothie made from 50%:25%:25% pineapple-mango-watermelon, WMP = smoothie made from 50%:25%:25% watermelon-mango-pineapple CONT = smoothie made from 33.33 % of mango, 33.33 % of watermelon and 33.33 % of pineapple.

Discussion

This study accessed the nutritional composition and sensory properties of smoothies produced from pineapple (*ananus comosus*), watermelon (*citrus lanatus thumb*) and mango (*mangifera indica*). The moisture content of the smoothie sample made from 50 % of watermelon was higher than others The high moisture content of this sample was not surprising because watermelon contains a lot of water. The result of the current study differed from the report of Aderinola (2018) who found lower moisture content within the range of 49.24 to 78.62 in a similar study. This difference in moisture content might be attributable to the different fruits (i.e., pineapple, banana and apple) used by the previous author which has less moisture than the fruits used in the current study. The protein and fat contents of the smoothies were generally low and these may be attributable to the fact that fruits have low protein and fat contents. However, the sample made with 50 % mango, 25 % pineapple and 25 % watermelon had higher protein and fat compared to the other samples suggesting that this sample could be prescribed for individuals requiring to consume an appreciable amount of plant-based protein and fat. The protein value from the present study was lower than the protein values reported by Uzodinma et al. (2020) in a similar study on smoothies produced from pineapple, watermelon and banana. This may be attributable to the different kinds of fruits used in the two studies.

The lower crude fibre in sample MWP with a higher proportion of mango, was surprising because mango has been shown to contain a higher amount of fibre than watermelon and pineapple. Fruit fibres have been shown to reduce intestinal passage rates by forming a bulk, leading to a more gradual nutrient absorption (Andreson et al., 2010), maintaining normal body weight (Schwingshacki et al., 2015), reducing blood cholesterol and oxidative damage (Southon, 2015). Smoothie prepared with 50 % pineapple had the highest carbohydrate value owing to the high (13.12 g) quantity of carbohydrates in 100 g of the fruits (USDA, 2019). Carbohydrate in the body plays a major role in providing readily available fuel for physical performance and regulating nerve tissues. However, the carbohydrate contents of smoothie samples in this study differed from the report of Uzodinma et al. (2020) who found as high as 18.79 % carbohydrate in their smoothie samples.

Smoothie sample containing more proportion of pineapple had significantly higher amounts of calcium and potassium and the lowest iron contents compared to its counterparts. Calcium plays a major role as a constituent of bones and teeth, regulation of nerve and muscle function and takes part in milk clotting; potassium is a major intracellular ion that aid in nerve transmission and muscle contraction (Gbarakoro et al., 2021). While the calcium content of this sample was expected to be higher than others, the highest amount of potassium in this sample was surprising as pineapple which constituted 50 % of this smoothie sample had the lowest (109 mg) quantity of potassium when compared with watermelon (112 mg) and mango that had 156 mg per 100 g pulp. The mineral composition of smoothies in this study did not agree with the report of Alake et al. (2022) who obtained higher values on the production and evaluation of smoothies made from various fruits sold in the Lagos market. They showed that smoothies prepared with blends of watermelon and pineapple had 254.09±0.28 and 54.45±0.00 of calcium and iron, respectively. Conversely, the present study found higher potassium compared with Alake et al. (2022) who obtained lower potassium of 34.63±0.01 mg/100 g. Reasons for the variation in the mineral composition of the smoothies might be a result of different methodologies and environmental conditions under which the fruits are grown and stored.

The vitamin content of the smoothies varied among samples. The control and thesample made with 50 % watermelon had the highest pro-vitamin contents while the sample produced from a greater percentage of pineapple had the highest vitamin C. The high vitamin C content of this sample was expected because pineapple has been shown to contain more of the vitamin compared to the other two fruits. Vitamin C is an important antioxidant that boosts the immune system and helps in the absorption of iron for the normal functioning of the body and the proper formation of collagen. Pro-vitamin is necessary for good eye health and improves the proliferation of red blood cells in the bone marrow. The high pro-vitamin of CONT and high vitamin C in PMW agrees with the report of Ufot (2018). In addition, Victor-Aduloju et al. (2020) reported higher vitamin A ranging from 466.00±1.73-642.00±1.73 IU and lower vitamin C ranging from 9.30±0.00-10.67±0.02 mg for their smoothie samples.

A sensory evaluation aims at measuring consumers' sensory perception of products as well as the affective, emotional, and behavioural responses that arise from this perception (Delarue, 2022). The smoothies in this study had moderate to high acceptability in all the attributes evaluated. There was no significant difference among the colour, texture, flavour and general acceptability of the smoothie samples. However, the control sample had better taste than the other samples which were rated as similar in taste level. This indicated that projecting the individual taste of one fruit above others did not seem to yield the best acceptable taste of the smoothie, compared to a uniform blend of all the tastes as contained in the control sample. The result of the present study on the sensory properties of smoothies contradicted the report of earlier research by Dürrschmid et al. (2009)

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where smoothies containing mango flavour were rated higher than other alternatives.

Conclusion

The study has provided baseline information on the nutrition composition and sensory properties of smoothies made from pineapple, watermelon and mango. The result demonstrated that the smoothie samples contained an appreciable amount of protein, crude fibre, carbohydrate, low fat, high content of pro-vitamin A, vitamin C, calcium, potassium and iron. In terms of the sensory evaluation, all the smoothies were equally accepted by the panellists, suggesting that people can use them as a way of diversifying their diet. Consumptions of the smoothie can contribute to the intake of healthier and nutritious beverages, thereby helping in ameliorating the alarming increase of micronutrient deficiencies with their concomitant economic burden among the populace.

Recommendation

1. Since the consumption of smoothies is still evolving, people should be sensitized to the importance of smoothies as a good replacement for commercial drinks and beverages.
2. Further studies are required to determine the self-life, microbial load, and anti-nutritional composition of these smoothies

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