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Nutritional Quality and Antioxidant Capacity of Selected Fruits in Lafia, Nasarawa State

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ABSTRACT

Fruits contain a lot of antioxidants which promote neutralization of free radicals, and their minerals and nutrients prevent micro and macroelements deficiencies and malnutrition. This paper assessed the total phenolic content (TPC), total flavonoid content (TFC), vitamin C, antioxidant capacity, mineral composition, and proximate profile of five different fruits sold in Lafia, Nasarawa State. TPC was calculated with Folin-Ciocalteu method, TFC by means of aluminium chloride colorimetric assay and vitamin C through colorimetric method. The antioxidant capacity was tested by DPPH and FRAP procedures, which was detected by UV spectrophotometry. Atomic Absorption Spectrophotometry was used to determine the concentration of minerals after acid digestion. Proximate composition was determined by standard procedures namely oven drying to eliminate moisture, Kjeldahl as a technique to determine protein, dry ashing to determine ash, Soxhlet extraction to determine fat and calculation of carbohydrate and fibre was carried out. It was found that orange had the highest TPC (76.0 ± 0.53 mg GAE/g), TFC (97.0 ± 0.09 mg QE/g), vitamin C (9.4 ± 0.04 mg AA/g) and DPPH value (72.1 ± 0.09), and FRAP 10.6 ± 0.01 Fe²⁺/g. Mango was highest in Mg, K, Ca, moisture, ash and fibre whereas banana was richest in Fe, Cu, Zn and carbohydrate. The highest protein, fat and Mn content was in pineapple. These results indicate higher intake of oranges to overcome oxidative stress and mango, banana, and pineapple to overcome mineral deficiencies and malnutrition.

Keywords: Antioxidants, phenolic, flavonoid, mineral, nutrients, free radicals, vitamin C.

1.0 INTRODUCTION

Fruits are key ingredients in the diet of human beings because they are rich in nutrients and have health promoting effects. They are sources of numerous vitamins, minerals, dietary fibre and bioactive compounds which help in the prevention of several chronic diseases such as cardiovascular diseases, diabetes and cancer [1]. The positive health impacts of fruits consumption have been explained mostly by the fact that they are rich in natural antioxidants like vitamin C, flavonoid and phenolic compounds.

Antioxidants are extremely relevant in defending biological systems against oxidative damage due to reactive oxygen species and other free radicals which are produced during metabolism [2]. Overproduction of free radicals has been associated with the emergence of a few degenerative illnesses such as cancer, atherosclerosis and neurodegenerative diseases [3]. Thus, it is extensively suggested to consume foods with a high content of natural antioxidants to promote the minimization of oxidative damage and preserve cellular integrity [4].

Among the most critical phytochemicals in fruits, one can note phenolic compounds and flavonoids. These substances are strong antioxidants because they can donate a hydrogen atom or electrons to free radicals to stabilize them and eliminate oxidative injury [5]. Several studies have proven that high phenolic and flavonoid provide high antioxidant actions [6].

Besides antioxidants, fruits have some mineral elements that are necessary in different physiological processes in the human body. Minerals are involved in significant functions such as in enzymatic

processes, creation of bones, transmission of nerves, and regulation of metabolism [7]. These minerals should be taken in sufficient amounts to ensure that the body has adequate physiological functions and to avoid diseases caused by deficiencies.

Also, fruits contain valuable macronutrients such as carbohydrates, proteins, fats and dietary fibre. Proximate analysis has been widely employed to establish the basic nutritional composition of foods and give useful data pertaining nutritional quality of food [8]. Orange, banana, apple, pineapple and mango are some of the commonly consumed fruits in Nigeria, which are easily found in local markets. These are very cheap fruits that provide nutrients to a number of households. Nevertheless, their nutritional value can change according to environmental factors, farming and food processing [9]. Although the consumption of these fruits is extensive in Nasarawa State, Lafia Local Government Area, little information is available on the antioxidant capacity and nutritional contents of the fruits. Consequently, this paper sought to determine the dietary antioxidants, mineral, and proximate composition of these fruits.

2.0 MATERIALS AND METHODS

2.1 Study Area

This research was carried out in Lafia Local Government Area, Nasarawa state, Nigeria. It is home to 330,712 inhabitants as per the findings of 2006 census. It is among the thirteen local government districts of Nasarawa State [10]. It is geographically located at 08° 33' N and 08° 32' E. It is in the north central geopolitical region of Nigeria. It is recorded to possess savannah scenery that has an average yearly temperature of between 24 and 33°C and a precipitation scope of 1000-1500 mm [11]. The 13 wards that constitute Lafia Local Government are called Agyaragu-Tofa, Adogi, Arikyia, Ashigye, Assakio, Akurba, Gayam, Chiroma, Shabu/Kwandare, Keffi-Wambai, Wakwa, Makama and Zanwa. Marketed fruits are imported to the town from neighbouring states such as Jos and Benue state.

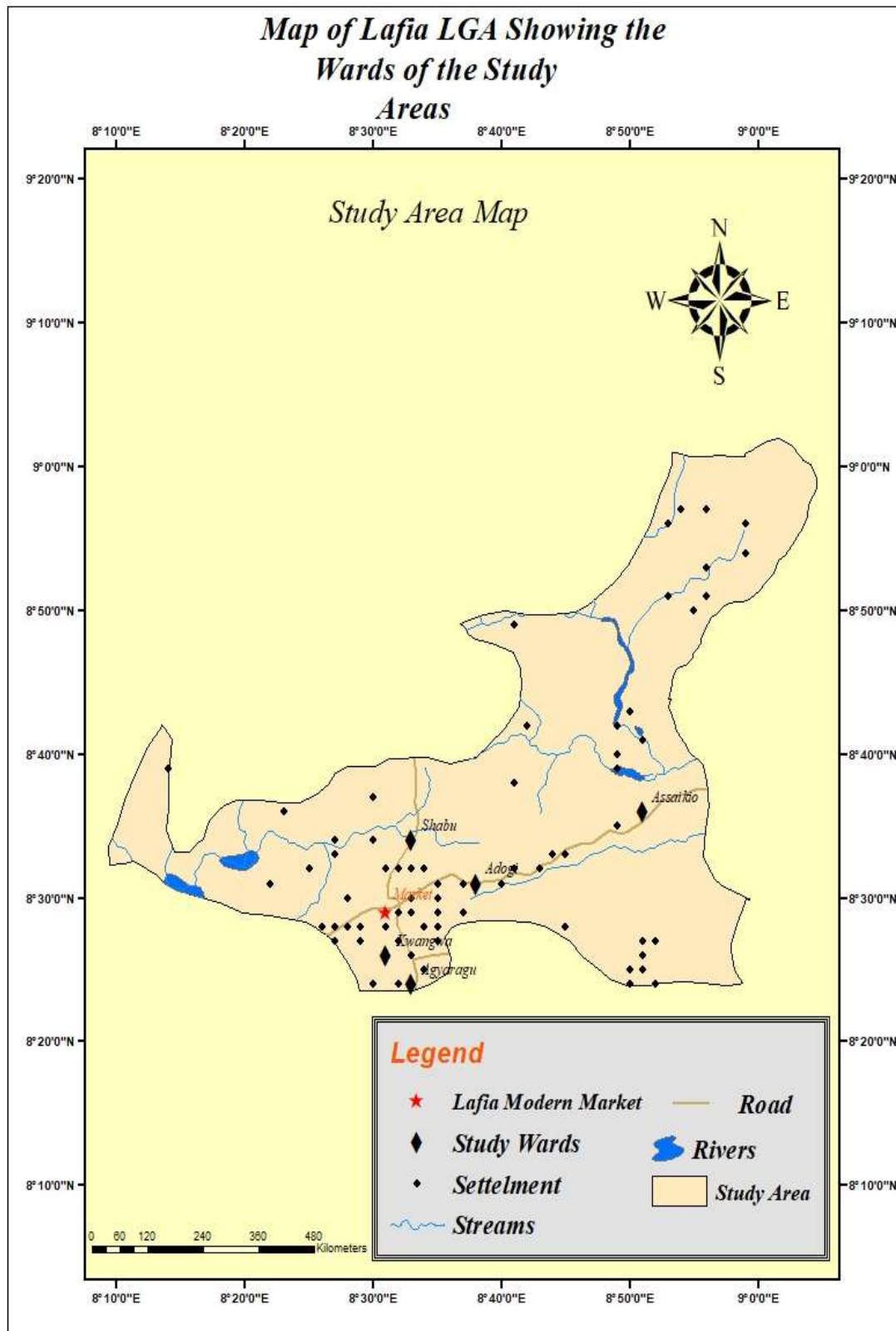


Figure 2.1 Map of the study area

2.2 Materials and Reagents

The equipment used were knife, blender, mortar and pestle, test tube, measuring cylinder, pipette, dropper, weighing balance, oven, crucibles, filter paper, Buchner funnel, conical flask, volumetric

flask, beaker, cuvette, tripod stand, thimble, hot plate, tong, spatula, tray, stirrer, desiccator, ultraviolet spectrophotometer and atomic absorption spectrophotometer. In this study, only analytical-grade chemicals and reagents were used. Each of the solution was made in deionized water. The glassware and sample bottles were thoroughly washed using distilled water before and after use.

2.3 Sample Collection

Mature, ripened bananas (*Musa acuminata*), pineapples (*Ananas cosmosus*), red apples (*Malus domestica*), sweet oranges (*Citrus sinensis*), and Alphonso mangoes (*Mangifera indica*) were purchased in the study area at fruit stand. The number of samples per fruit was 10 with 2 samples at each sampling point. The fruit samples were grouped using sample codes of O1 sweet oranges, B1 bananas, A1 red apples, P1 pineapples, and M1 mangoes. Samples of the fruits were taken to the Department of plant science, Federal University of Lafia to verify and identify them. The collected samples were kept in polyethylene bags that were perforated to allow circulation of air.

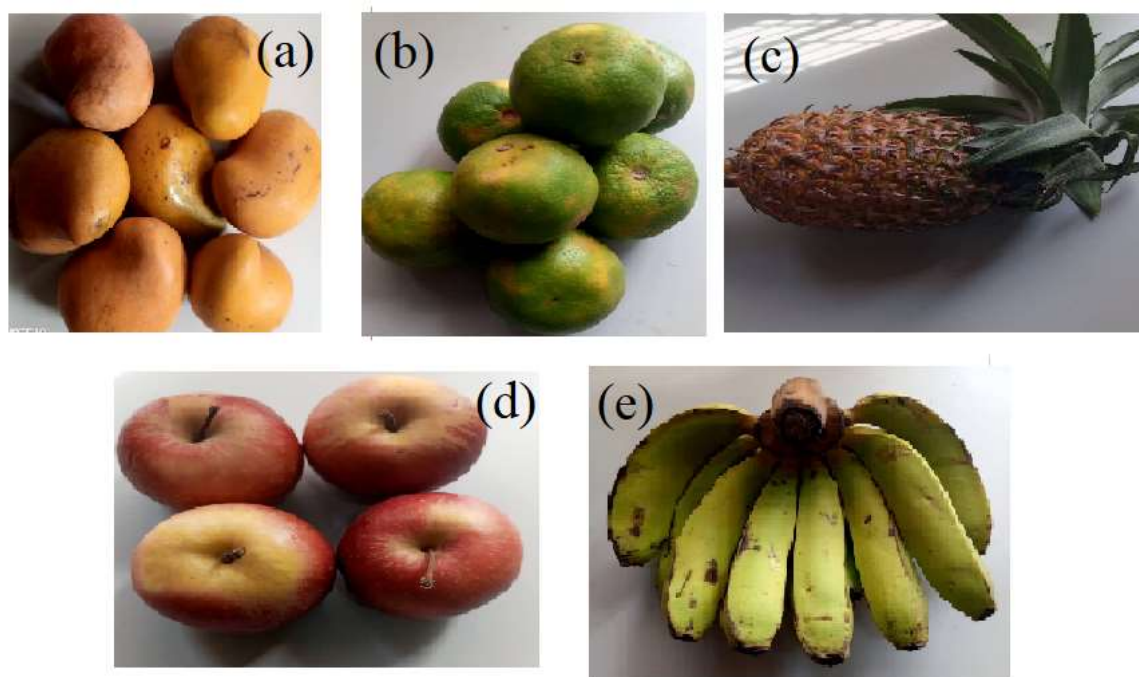


Figure 1: Images of the fruit samples (a) mango (b) orange (c) pineapple (d) apple (e) banana

2.4 Sample Preparation

The fruit samples were washed using distilled water to remove dirt and dust and other contaminants. Outer skins of mangoes, apples and sweet oranges were scraped away with a sharp knife with skin of bananas gently peeled off by hand. Sweet orange, mango, and apple seeds were carefully removed out of the pulp. The skin of pineapple samples was cut in a rotary motion after the removal of its leaf crown. The pulp of each sample of fruit was then cut into two. The first portion was freshly sliced into small pieces and was homogenized with the help of blender. The second part was dried and crushed with mortar and pestle to fine powder. The samples were stored in cool dry place. The first section was used to measure ferric ions (Fe^{3+}) reducing antioxidant power, 2, 2-diphenyl-1-picrylhydrazyl radical scavenging capacity, total phenolic, total flavonoid and vitamin C. The second part was used to determine proximate composition and mineral analysis.

2.5 Sample Extraction

A 100.0 g of each fruit sample was poured into five different 500 mL beaker, then, 100 mL of 98 percent pure ethanol was added. The samples were then placed to stand for 24 hours after shaking vigorously on a rotary vibrator, for 40 minutes. It was then filtered using a Whatman filter paper. To

extract further, glacial acid and acetone were used. Extracts were concentrated in a hot air oven at 50°C.

2.6 Determination of antioxidants and antioxidant capacity

2.6.1 Total phenolic content (TPC)

Total phenolic content was determined using Folin-Ciocalteu method. 2.0 mL sodium carbonate (7.5 percent (v/v)) was added to the fruit extracts then 2.5 mL of Folin-Ciocalteu (10 percent (v/v)) was added. The absorbance at 765 nm was measured with the help of an ultraviolet spectrophotometer after 40 minutes of incubation of the reaction mixture at 45°C. The standard of the calibration curve was gallic acid. Gallic acid (10 mg) was dissolved in 98 percent ethanol, and then diluted to different concentrations at 25, 50, 75, 100 and 125 µg/mL. The total phenolic content was expressed in milligram of gallic acid equivalent per gram of fruit extract [12].

2.6.2 Total flavonoid content

The amount of flavonoid was established through aluminium chloride colorimetric method. Each fruit extract was combined with 0.1 mL of 10 percent of aluminium chloride and 0.1 mL of 1 M of potassium acetate. The reaction was then left to rest at room temperature, after adding 2.8 mL of distilled water to bring the total volume to 5 mL. The absorbance of the solution at 415 nm was determined by UV Spectrophotometer. To establish the calibration curve, 10 mg of quercetin was dissolved in 98 percent ethanol and subsequently diluted in 25, 50, 75, 100, and 125 µg/mL. The total flavonoid content was determined using the calibration curve and expressed as milligram quercetin equivalents (QE) per gram of fruit extract [13].

2.6.3 Total Vitamin C content

Vitamin C was quantified using 2, 6 dichlorophenolindophenol (DCPIP) reagent. Ascorbic acid solutions at various concentration of 25, 50, 75, 100, and 125 µg/mL in 3 percent (w/v) metaphosphoric acid were prepared to make a calibration curve and 1 mL of sample extract was added and mixed vigorously with 3 mL of 0.2 mM 2, 6 dichlorophenolindophenol, then, an ultraviolet spectrophotometer reading was obtained at 515 nm. These results were described in milligrams ascorbic acid per gram of fruit extract [14].

2.6.4 [2, 2-diphenyl-1-picrylhydrazyl radical scavenging capacity (DPPH)]

The DPPH radical scavenging assay was conducted using this procedure: After weighting by mass, the samples were transferred to flasks containing 2 mL each of 0.2 M NaOH and 1.0 M HNO₃ solutions respectively. The samples were then mixed thoroughly with DPPH solution before the flasks were capped with sealed caps. The flasks were then incubated at 37°C for one hour. The calibration curve was plotted by dissolving 10 mg of ascorbic acid in 98 percent ethanol at concentration of 25, 50, 75, 100 and 125 µg/mL. The radical scavenging activity was calculated through equation 2.2 [15].

$$\text{Radical scavenging activity \%} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100 \dots \dots \dots (2.2)$$

Where: A_{control} = Absorbance of control, A_{sample} = Absorbance of sample.

2.6.5 Ferric reducing antioxidant power (FRAP)

The fruit extracts were supplemented with 2.7 mL of ferric 2, 4, 6- tripyridyl-s -triazine (Fe³⁺) TPTZ complex and 2.7 mL of distilled water. The solutions were incubated for 30 minutes at 37°C in a dark setting. Then a spectrophotometric reading at 595 nm was noted. The ferrous sulphate calibration curve was used to determine ferric reducing antioxidant power and expressed as µmol Fe²⁺/g per fruit extract [16].

2.7 Sample digestion and elemental analysis

A full digestion of samples of fruits was done by crushing 50 grams with mortar and pestle. Each powdered dried sample was placed in a digestion flask containing 23 mL of 6 M hydrogen trioxonitrate (V) (HNO₃) over a period of about 6 hours. The digested samples were put in 25 mL volumetric flask and left to cool at room temperature then filtered using Whatman filter paper and diluted to the required level with deionised water.

The digested samples of fruits were analyzed with an atomic absorption spectrophotometer for manganese, calcium, magnesium, potassium, iron, copper and zinc. An electrode lamp was used for

each element. To ensure that all was correct the atomic absorption spectrophotometre was operated on each of the standard solutions of the elements before determination. To determine magnesium, potassium, calcium, iron, copper, zinc and manganese, 2, 4, 6, 8 and 10 mL equivalent per litre standard solutions were used to plot the calibration curve. The concentration in milligram for the elements was derived by multiplying the absorbance by the dilution factor and dividing by 1000 [17].

$$\text{Molecular weight} = \frac{\text{Absorbance (ppm)} \times \text{Dry weight} \times \text{dilution factor}}{\text{Weight of sample} \times 1000} \dots\dots\dots (2.3)$$

2.8 Proximate Analysis

2.8.1 Moisture content

The content of moisture was determined using the oven drying technique. Well-mixed dried samples of fruits were weighed exactly to 1.5 g in clean and dried crucibles (W1). The crucibles were placed in an oven at a temperature of 105°C and left over a period of six hours, until the weight did not change anymore. The crucibles were then left to cool in desiccator half an hour. The weight of the samples (W2) was calculated [18]. The calculation of the percent moisture content was performed with the help of the following formula:

$$\text{Percent moisture} = \frac{W_1 - W_2}{\text{weight of sample}} \times 100 \dots\dots\dots (2.4)$$

Where W₁= Initial weight of crucible + sample, W₂=Final weight of crucible + sample.

2.8.2 Protein content

Protein content of the samples was determined by Kjeldahl method. 0.5 g of each dried fruit sample was added to the digestion flask. A 20 mL hydrogen tetraoxosulphate (VI) was added after adding a mixture of catalysts. To make the contents thoroughly mixed, the flask was swirled. The mixture was heated to trigger the process of digestion. The digest was then allowed to cool and transferred to a 100 mL volumetric flask and distilled water added to it to achieve the intended volume. During distillation, the presence of ammonium hydroxide leads to the development of a yellowish colour. A 0.1 M solution of hydrochloric acid was used as a titrant to make the distillate pink. Each step was done with a blank solution. The percent of crude protein of fruit samples was calculated using equation 2.5 [19].

$$\text{Percent Nitrogen} = \frac{S - B \times N \times 0.014 \times D}{\text{weight of sample} \times V} \times 100 \dots\dots\dots (2.5)$$

Where S= Sample titration reading, B= Blank titration reading, N=Normality of HCl, D=Dilution of sample after distillation, V= Volume taken for distillation 0.014 Milli equivalent of nitrogen.

$$\text{Percent Protein} = 6.25 \times \% \text{ N} \dots\dots\dots (2.6)$$

2.8.3 Crude fat content

Crude fat was determined by using Soxhlet apparatus with the help of petroleum ether. The moisture-free sample was weighed and wrapped in a weighed filter paper and placed in a fat free thimble and placed in the extraction tube. N-hexane was measured, placed in a clean and dried conical flask and the flask was attached to the device. Before the end of the siphoning, the conical flask was unplugged, and n-hexane was left to evaporate at six siphoning. The extract was washed using n-hexane, and then it was placed in a sterile glass dish and left to evaporate in a water bath. The dish made of glass was then cooled using a desiccator after two hours of baking at 105 °C [20]. The percent (%) of crude fat was calculated using the formula in equation 2.7.

$$\text{Percent Crude fat} = \frac{\text{Weight of ether extract}}{\text{Weight of sample}} \times 100 \dots\dots\dots (2.7)$$

2.8.4 Ash content

The crucibles were dried in an oven at 100°C in two hours and transferred into a desiccator, cooled, and weighed. Each sample of dried fruit was weighed and placed in the crucibles. The fruit samples and crucibles were then heated at a temperature of 550°C in a muffle furnace and the process lasted

five hours. The burnt samples were removed and left to cool in a desiccator with a closed lid after which they were weighed within an hour. The ash percent was calculated in relation to the formula below [21].

$$\text{Percent Ash} = \frac{(\text{Mass of ash+crucible}) - (\text{mass of crucible})}{(\text{Mass of ash + crucible}) - (\text{mass of crucible})} \times 100 \dots\dots\dots (2.8)$$

2.8.5 Crude fibre content

The mixture was filtered with a Buchner funnel after 30 minutes heating of 200 mL of 1.25 percent H₂SO₄ acid and 5 g of each dried fruit sample. The residue was washed using distilled water until it became acid-free. Boiling of the residue was done in 200 mL of 1.25 percent NaOH. To prepare it alkaline-free, it was filtered and washed with distilled water severally. Thereafter, it was washed twice using ethanol and a single time using 10 percent hydrochloric acid. Finally, petroleum ether rinsing was done. The residue was dried in an oven at 105°C overnight after being put in a crucible. The quantity of material left as percent of the original weight of the sample was used to measure the crude fibre content using the formula below [22].

$$\text{Percent crude fibre} = \frac{(\text{Weight of dried ether extract}) - (\text{weight of dried washed extract})}{(\text{Weight of dried sample})} \times 100 \dots\dots\dots (2.9)$$

2.8.6 Carbohydrates content

The carbohydrate content was determined using the equation 2.10 [23].

$$\text{Percent Carbohydrate} = [100 - (\text{Protein} + \text{Fat} + \text{Moisture} + \text{Ash} + \text{Crude Fibre})] \dots\dots\dots (2.10)$$

2.9 Statistical Analysis

All tests were done thrice, and the results were represented as mean ± standard deviation. The statistical analysis was done using analysis of variance (ANOVA) at p < 0.05 level of significance.

3.0 RESULTS AND DISCUSSION

3.1 Dietary Antioxidants

Table 1 shows the dietary antioxidant composition of the fruit pulps (orange, banana, apple, pineapple and mango). The TPC was found to be 31.6±0.12 to 76.00±0.53 mg GAE/g, with orange containing highest level of TPC and apple the least and the level of difference was found to be statistically significant (p < 0.05). The obtained value of orange was lower than 154±10.2 mg GAE/g reported by [24] but differences could be explained by the variations in the environmental factors like soil composition, rainfall, season, and agronomic practices [25]. One of the key metabolites in plants is phenolic compounds which are potent antioxidants with capacity to chelate metal ions, free radical, and oxidizing enzymes and have been found to help in cell protection [26].

The total flavonoid content was between 27.2±0.10 to 97.0±0.09 mg QE/g, although the highest was found in orange and the lowest was found in mango (p < 0.05). It is well known that flavonoids have a wide range of biological activity, such as anticancer, neuroprotective, antimicrobial, anti-inflammatory and cardio protective [27].

On the same note, vitamin C was in a range of 2.0±0.01 to 9.4±0.04 mg AA/g with orange recording the highest. Vitamin C is essential in protecting tissues, absorption of iron and oxidative stress prevention, and adults are advised to take vitamin C 45 mg per day [28].

The DPPH radical scavenging activity was used to measure the antioxidant activity, and the values were found between 41.2±0.35 and 72.1±0.09, with the highest activity found in orange. This observation has indicated that an increased concentration of antioxidant compounds increases the potential to scavenge free radicals.

In addition, the values of FRAP was between 2.9±0.01 and 10.6±0.01 μmol Fe²⁺/g. Highest value was found in orange. FRAP test is a test which determines the capacity of antioxidants to reduce the Fe³⁺-TPTZ complex to give an idea about the electron-donating ability [29]. The availability of phenolic compounds may explain to a significant extent the high antioxidant activity of the examined fruits because they are the key participants in the DPPH and FRAP antioxidant systems [30].

Table 1 Dietary antioxidant and antioxidant capacity

Fruit Samples	Total Phenolic (mg GAE/g Extract)	Total Flavonoids (mg QE/g Extract)	Vitamin C (mg AA/g Extract)	DPPH scavenging activity %	FRAP $\mu\text{mol Fe}^{2+}/\text{g}$
Orange	76.0±0.53	97.0±0.09	9.4±0.04	72.1±0.09	10.6±0.01
Banana	44.3±0.21	51.1±0.17	2.0±0.01	60.4±0.14	2.9±0.01
Apple	31.6±0.12	52.2±0.07	3.9±0.03	51.7±0.02	3.3±0.01
Pineapple	67.2±0.03	66.2±0.03	6.3±0.01	68.4±0.06	7.7±0.05
Mango	52.4±0.09	27.0±0.10	4.7±0.02	41.2±0.35	5.2±0.01

Values are mean ± standard deviation of triplicate analysis

Table 2 Mineral content in milligram (mg)

Fruit samples	Mg	K	Ca	Fe	Cu	Zn	Mn
Orange	0.111±0.002	2.754±0.783	0.196±0.035	0.038±0.025	0.448±0.008	0.198±0.025	0.212±0.025
Banana	7.288±0.050	3.516±0.530	0.063±0.018	0.877±0.530	0.085±0.003	0.514±0.053	0.236±0.053
Apple	3.278±0.015	5.050±0.658	0.265±0.040	0.522±0.124	0.758±0.004	0.050±0.124	0.325±0.124
Pineapple	9.741±0.099	3.301±0.894	0.480±0.076	0.346±0.045	0.173±0.006	0.301±0.045	0.461±0.045
Mango	12.79±0.543	6.323±0.366	0.704±0.018	0.496±0.073	0.296±0.023	0.323±0.073	0.438±0.073

Values are mean ± standard deviation of triplicate analysis

3.2 Mineral Composition

Table 2 has shown the mineral composition of the selected fruit pulps. The magnesium level was between 0.111 ± 0.002 and 12.79 ± 0.543 mg with the highest concentration being in mango and lowest being in orange respectively. Potassium level was between 2.754 ± 0.783 to 6.323 ± 0.366 mg with the highest and the lowest in mango and orange respectively. The statistical difference between the mean values was significant ($p < 0.05$). Magnesium is found to be a key factor in the regulation of blood vessels, metabolism, and bone formation, and lack of it has been associated with neuromuscular and heart diseases [31]. While insufficiency of potassium has been linked to hypertension and muscle impairment [32].

The contents of calcium were observed to be between 0.063 ± 0.018 and 0.704 ± 0.018 mg with the highest content of 0.063 ± 0.018 mg in mango, and lowest value of 0.704 ± 0.018 mg in banana. The zinc levels were between 0.050 ± 0.124 and 0.514 ± 0.030 mg, with the highest level in banana and lowest value in orange. The statistically significant differences in mean values were found ($p < 0.05$). Calcium also controls nerve and muscle functioning. It is an important structural element of bones and teeth. Calcium deficiency may cause diseases like rickets and osteoporosis. Zinc is also a vital trace element that is used in the production of proteins, immune activities, and cell growth and lack of it can lead to immune malfunction, growth retardation, and other health issues [33].

Iron, copper and manganese concentrations in the fruit pulps were 0.038 ± 0.025 to 0.877 ± 0.003 mg, 0.085 ± 0.003 to 0.758 ± 0.004 mg, and 0.212 ± 0.025 to 0.461 ± 0.045 mg respectfully with statistically significant differences ($p < 0.05$). The sample with highest iron concentration was orange, copper level was highest in apple and manganese was highest in pineapple. Haemoglobin contains iron that is essential in the normal formation and conducting metabolic functions and insufficient iron may result in anaemia and immune suppression. Copper acts as a biocatalyst essential for central nervous system function and prevention of anaemia, while manganese functions as an antioxidant element that supports immune function and metabolic processes [33].

3.3 Proximate Composition

Proximate composition of the fruit pulps chosen is presented in Table 3. The moisture content was between 1.73 ± 0.04 and 6.40 ± 0.03 yielding mango and apple the highest and lowest value respectively. The mean of variation between samples of fruit was found to be statistically significant ($p < 0.05$). The moisture content is the amount of free water and volatile substances lost during controlled drying [34]. The fruits with greater moisture content are more prone to microbial spoilage and deterioration, and the ones with lower moisture content are less prone to microbial attack [35]. The contents of crude proteins were found to be 1.75 ± 0.05 to 7.88 ± 0.06 with the highest protein content found in pineapple and the lowest protein content found in orange. The variations between the means were found to be statistically significant ($p < 0.05$). Even though fruits are not considered to be primary sources of protein, they contain protein which provides body with essential amino acids needed in metabolism process, muscular growth and sustenance of physiological functions. The minimum dietary allowance of protein varies between 28 and 65 g and is dependent on age and physiology [36].

The sample fat levels of the fruit samples were between 3.95 ± 0.12 to 8.35 ± 0.02 with the maximum fat level of 8.35 ± 0.02 being in pineapple followed by mango with 3.95 ± 0.12 . The range of minerals was 4.25 ± 0.02 to 24.05 ± 0.11 the highest ash was observed in mango. The variances of the means were statistically significant ($p < 0.05$). Even though dietary fat improves palatability of food and increases the absorption of fat-soluble nutrients, excessive amounts of the dietary fats have been linked to various health disorders such as cardiovascular diseases. The mineral availability and nutritional quality of food materials can also be estimated by the proportion of ash [37]. The level of crude fibre was 29.03 ± 0.04 to 77.56 ± 0.06 with mango containing the largest amount and banana the smallest amount implying that the fruits are rich sources of dietary fibre. The carbohydrate levels were 0.31 ± 0.05 to 44.14 ± 0.21 percent, with banana registering the highest percentage (44.14 ± 0.21 percent) and orange having the lowest percentage of carbohydrates among the fruit samples. The values between the means were statistically significant ($p < 0.05$). Dietary fibre helps in maintaining gastrointestinal health, proper bowel movement, and in the prevention of cardiovascular diseases, diabetes, and hypertension. A daily intake of 25 g of dietary fibre is advised [38].

Table 3 Proximate Composition (%)

Fruit Samples	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
Orange	4.63±0.06	1.75±0.05	6.65±0.05	4.25±0.02	65.51±0.06	0.31±0.05
Banana	2.23±0.05	4.38±0.13	5.45±0.03	14.75±0.16	29.03±0.04	44.14±0.21
Apple	1.73±0.04	5.25±0.04	4.55±0.02	8.65±0.03	60.55±0.35	9.30±0.02
Pineapple	1.85±0.03	7.88±0.06	8.35±0.02	18.50±0.57	65.25±0.01	5.25±0.08
Mango	6.40±0.03	3.94±0.01	3.95±0.12	24.05±0.11	77.56±0.06	3.90±0.12

Values are mean ± standard deviation of triplicate analysis

4.0 CONCLUSION

The research compared the antioxidant, mineral composition, and proximate content of five fruit pulps (orange, banana, apple, pineapple and mango) that were chosen. The findings revealed that the fruits all had significant levels of vitamin C and phenolics, flavonoids, essential minerals, and nutrients that are healthy to the human body. Orange had the highest antioxidant constituents in the samples, which shows high potential in free radical scavenging and against oxidative stress. The mineral content analysis showed that mango was relatively rich in macro-elements whereas pineapple and banana were a significant source of trace elements that are significant in metabolic processes. The proximate analysis also revealed that the fruit pulps have high amounts of protein, crude fibre, carbohydrates, ash and moisture content which underlines their nutritional content. In general, the results show that these are useful foods that contain antioxidants and other important nutrients; hence they should be used on a regular basis to enhance nutrition and good health.

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REFERENCES

- [1]. Tufail, T., Fatima, S., Ain, H. B. U., Ikram, A., Noreen, S., Rebezov, M., Al-Farga, A., Saleh, R., and Shariati, M. A. (2025). Role of phytonutrients in the prevention and treatment of chronic diseases: A comprehensive review. *ACS Omega*, 10(13), 12724–12755.
- [2]. Kiran, T. R., Otlu, Ö., and Karabulut, A. B. (2023). Oxidative stress and antioxidants in health and disease. *Journal of Laboratory Medicine*, 47(1), 1–11.
- [3]. Sadiq, I. Z. (2023). Free radicals and oxidative stress: Signalling mechanisms, redox basis for human diseases, and cell cycle regulation. *Current Molecular Medicine*, 23(1), 13–35.
- [4]. Chandimali, N., Bak, S. G., Park, E. H., Lim, H.-J., Won, Y.-S., Kim, E.-K., Park, S.-I., and Lee, S. J. (2025). Free radicals and their impact on health and antioxidant defences: A review. *Cell Death Discovery*, 11(1), 19.
- [5]. Maheshwari, S., Kumar, V., Bhadauria, G., and Mishra, A. (2022). Immunomodulatory potential of phytochemicals and other bioactive compounds of fruits: A review. *Food Frontiers*, 3(2), 221–238.
- [6]. Martínez, S., Fuentes, C., and Carballo, J. (2022). Antioxidant activity, total phenolic content and total flavonoid content in sweet chestnut (*Castanea sativa* Mill.) cultivars grown in Northwest Spain under different environmental conditions. *Foods*, 11(21), 3519.
- [7]. Yadav, S., Yadav, J., Kumar, S., and Singh, P. (2024). Metabolism of macro-elements (calcium, magnesium, sodium, potassium, chloride and phosphorus) and associated disorders. In *Clinical applications of biomolecules in disease diagnosis* (pp. 177–203). Springer.
- [8]. Kari, N. M., Ahmad, F., and Ayub, M. N. A. (2022). Proximate composition, amino acid composition and food product application of anchovy: A review. *Food Research*, 6(4), 16–29.
- [9]. Osei-Kwarteng, M., Ogwu, M. C., Mahunu, G. K., and Afoakwa, N. A. (2024). Post-harvest food quality and safety in the global South: Sustainable management perspectives. In *Food safety and quality in the global South* (pp. 151–195). Springer.
- [10]. Ekhuemelo, D. (2017). Assessment of domestic energy preference in Lafia Local Government Area of Nasarawa State, Nigeria.
- [11]. Abdullahi, I. N. (2020). *The impact of climate change on the management and regeneration of parkland trees in the savannah zones of Northern Nigeria* (Doctoral dissertation, Bangor University, United Kingdom).
- [12]. Walimunia, S. W. S., Molagodab, I. M. N., Jayasooriyac, R. G. P. T., and Sanjeevad, K. K. A. (2025). Evaluation of extraction yield, total phenolic content, and total flavonoid content of thirteen underutilized fruits in North Central Province of Sri Lanka. *Advances in Technology*, 5(2).
- [13]. Ayoubi, R., Foladi, M. M., Lutfi, S., and Zhakfar, A. M. (2024). Determination of phenolic and flavonoid content in *Ziziphus jujuba* Mill. fruit collected from Farah Province, Afghanistan. *Journal of Natural Science Review*, 2(1), 21–33.

- [14]. Kalompatsios, D., Ionescu, A.-I., Athanasiadis, V., Chatzimitakos, T., Mantiniotou, M., Kotsou, K., Bozinou, E., and Lalas, S. I. (2024). Maximizing bioactive compound extraction from mandarin (*Citrus reticulata*) peels through green pretreatment techniques. *Oxygen*, 4(3), 307–324.
- [15]. Rikhabchand, S. A., & Dayaram, W. R. (2017). Estimation of total phenolic, total flavonoid content and evaluation of anti-inflammatory and antioxidant activity of *Ixora coccinea* Linn. stems. *Indonesian Journal of Pharmacy/Majalah Farmasi Indonesia*, 28(2).
- [16]. Alam, R., Ahsan, H., and Khan, S. (2023). The role of malondialdehyde (MDA) and ferric reducing antioxidant power (FRAP) in patients with hypertension. *Molecular and Cellular Biomedical Sciences*, 7(2), 58–64.
- [17]. Tamirat, F., Adane, W. D., Tessema, M., Tesfaye, E., and Tesfaye, G. (2024). Determination of major and trace metals in date palm fruit (*Phoenix dactylifera*) samples using flame atomic absorption spectrometry and assessment of the associated public health risks. *International Journal of Analytical Chemistry*, 2024, 9914300.
- [18]. Mathew, T. J., Ndamitso, M. M., Otori, A. A., Inobeme, A., and Adamu, A. (2024). Proximate and mineral compositions of seeds of some conventional and non-conventional fruits in Niger State, Nigeria.
- [19]. Boyle, F., Lynch, G., Reynolds, C. M., Green, A., Parr, G., Howard, C., Knerr, I., and Rice, J. (2024). Determination of the protein and amino acid content of fruit, vegetables and starchy roots for use in inherited metabolic disorders. *Nutrients*, 16(17), 2812.
- [20]. Das, U., Hasan, M. A. B., Hussain, T., Rahman, A., Mahmood, A., Marma, S., Tasnia, J., et al. (2025). Physicochemical, nutritional, and sensory attributes of high fiber fruit leather of red dragon fruit peel and mango. *Journal of Food Quality and Hazards Control*.
- [21]. Nur, S., Aisyah, A. N., Nursamsiar, N., Sami, F. J., Fadri, A., Khairi, N., and Sapra, A. (2023). Standardization and GC-MS analysis of kersen (*Muntingiacalabura* L.) fruit ethanol extract as an herbal raw material. *Bulletin of Pharmaceutical Sciences, Assiut University*, 46(1), 173–187.
- [22]. Yasmin, A., Sumi, M. J., Akter, K., Rabbi, R. H. M., Almoallim, H. S., Ansari, M. J., Hossain, A., and Imran, S. (2024). Comparative analysis of nutrient composition and antioxidant activity in three dragon fruit cultivars. *PeerJ*, 12, e17719.
- [23]. Enin, G. N., Antia, B. S., Shaibu, S. E., and Nyakno, I. (2023). Comparison of the chemical composition, nutritional values, total phenolics and flavonoids content of the ripe and unripe *Solanum nigrum* Linn. fruits from Nigeria. *World Journal of Pharmacy and Pharmaceutical Sciences*, 12(8), 1–18.
- [24]. Kaseke, T., Pfkwa, T. M., Nxumalo, K. A., Shinga, M. H., Opara, U. L., and Fawole, O. A. (2025). *Parinaricuratellifolia*: A treasure trove of phytochemicals, nutritional benefits, and biological activities. *Heliyon*, 11(1).
- [25]. Labbassi, S., Chabbi, N., Afi, C., Telmoudi, M., Karkour, C., Mimouni, A., Bendiab, K., et al. (2025). Phytochemical and leaf morphological characterization of cultivated *Moringa oleifera* Lam. under the semi-arid climate of Morocco. *International Journal of Vegetable Science*, 1–33.
- [26]. Jaddu, S., and Pradhan, R. C. (2025). *Innovative millet processing: Harnessing novel technologies for nutritional excellence*. Springer Nature.
- [27]. Stachelska, M. A., Karpiński, P., and Kruszewski, B. (2025). A comprehensive review of biological properties of flavonoids and their role in the prevention of metabolic, cancer and neurodegenerative diseases. *Applied Sciences*, 15(19), 10840.
- [28]. Alberts, A., Moldoveanu, E.-T., Niculescu, A.-G., and Grumezescu, A. M. (2025). Vitamin C: A comprehensive review of its role in health, disease prevention, and therapeutic potential. *Molecules*, 30(3), 748.
- [29]. Maliar, T., Blažková, M., Maliarová, M., Uváčková, E., Hlebová, M., Micháliková, S., and Viskupičová, J. (2026). The balance of plant extracts potency to scavenge model radical and to reduce ferric ion in model complex. *Journal of Microbiology, Biotechnology and Food Sciences*, 15(4), e13211.
- [30]. Kiss, A., Papp, V. A., Pál, A., Prokisch, J., Mirani, S., Toth, B. E., and Alshaal, T. (2025). Comparative study on antioxidant capacity of diverse food matrices: Applicability, suitability and inter-correlation of multiple assays to assess polyphenol and antioxidant status. *Antioxidants*, 14(3), 317.

- [31]. Stanojević, M., Djuricic, N., Parezanovic, M., Biorac, M., Pathak, D., Spasic, S., Lopacic, S., Kovacevic, S., and NesovicOstojic, J. (2025). The impact of chronic magnesium deficiency on excitable tissues—Translational aspects. *Biological Trace Element Research*, 203(2), 707–728.
- [32]. Binesh, A., Venkatachalam, K., Ranjan, A., Joy, S., and Prasanna, A. (2026). Major minerals (Na, K, Ca, Mg, P) in physiological function and disease. In *Functional biochemistry of metallic elements* (pp. 355–382). Springer.
- [33]. Razzaque, M. S., and Wimalawansa, S. J. (2025). Minerals and human health: From deficiency to toxicity. *Nutrients*, 17(3), 454.
- [34]. Aniegboka, C. O., Okunola, A. A., and Adekanye, T. A. (2024). Effect of temperature and moisture content on the nutritional properties of African breadfruit (*Treculiaafricana*) seed. *Food Research*, 8(4), 90–98.
- [35]. Almoumen, A., Mohamed, H., Sobti, B., Ayyash, M., Kamleh, R., Al-Marzouqi, A. H., and Kamal-Eldin, A. (2025). Quality of bread rolls fortified with date fruit pomace: Structure, proximate composition, staling, and sensory evaluation. *NFS Journal*, 38, 100214.
- [36]. Richter, M., Baerlocher, K., Bauer, J. M., Elmadfa, I., Heseker, H., Leschik-Bonnet, E., and Stangl, G. (2019). Revised reference values for the intake of protein. *Annals of Nutrition and Metabolism*, 74(3), 242–250.
- [37]. Adamczyk, J., Smółka-Danielowska, D., Krzątała, A., and Krzykowski, T. (2024). Chemical and mineral composition of bottom ash from agri-food biomass produced under low combustion conditions. *International Journal of Environmental Science and Technology*, 21(4), 4025–4036.
- [38]. Deehan, E. C., Mocanu, V., and Madsen, K. L. (2024). Effects of dietary fibre on metabolic health and obesity. *Nature Reviews Gastroenterology and Hepatology*, 21(5), 301–318.