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COMPARATIVE ANALYSIS OF THE PROXIMATE COMPOSITIONS AND SOME MINERAL CONTENTS IN RED AND GREEN APPLES

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Abstract
Apples are grown all over the world and are incredibly vitamin and mineral-rich. This study was carried out to compare the proximate compositions and the mineral contents of both red and green apples commonly consumed in our immediate environment. From the results obtained, the proximate compositions (%) of the red apples were - moisture content (81.34±3.73), carbohydrate (13.21±1.92), protein (0.49±0,02), fat (0.32±0.01), crude fibre (2.17±0.41), ash (2.48±0.25) while that of the green apples were moisture content (82.55±3.89), carbohydrate (12.31±1.45), protein (0.27±0.01), fat (0.22±0.01), crude fibre (2.37±0.23), ash (2.28±0.22). The red apples proximate compositions were generally better than those of the green apples, except for the crude fibre. The mineral compositions (mg/kg) of the red apples were: Na - 0.01±0.00, K - 0.12±0,04, Ca - 0.02±0.00, P - 0.04±0.01, Mg - 0.02±0.00, Fe - 1.96±0.07, Zn - 0.56±0.03, Cu - 0.39±0.04, Mn - 0.64±0.02 while that of the green apples were Na - 0.00±0.00, K - 0.12±0.01, Ca - 0.01±0.00, P - 0.03±0.00, Mg - 0.02±0.00, Fe - 1.85±0.04, Zn - 0.42±0.01, Cu - 0.27±0.02, Mn - 0.50±0.02. In general, red apples had higher levels of Na, Ca, P, Fe, Zn, Cu, and Mn, but both red and green apples had the same contents of K and Mg. This means that red apples will be a superior source of nutrients and minerals to the consumers than green apples.

***Keywords**: Apples, Nutrients, Minerals, Environment, Compositions*

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1.0 Introduction

An apple is described by Wikipedia as a sweet, edible fruit that is produced by the apple tree (*Malus domestica*). Apple trees are the most widely grown species in the genus *Malus*, and they are planted all over the world. Elzebroek and Wind (2008), Francini et al. (2021), and Petkova et al. (2023) have reported that there are about 7,500 apple cultivars. Despite sharing a rootstock, cultivars differ in terms of yield and tree size. There are various cultivars for both subtropical and temperate regions.

Nordqvist (2017) also reported the Welsh saying that, "An apple a day keeps the doctor away." Apples are high in antioxidants, flavonoids, and dietary fibre, which lowers the risk of cancer, hypertension, diabetes, and cardiovascular illnesses, according to recent studies (Oyenihi and Akomolafe, 2022; Sredojević et al., 2025). Furthermore, it has been reported by Dakuyo and Konaté (2022), Arnold et al. (2024), and Sümbül et al. (2025) that the proximate and mineral contents of red and green apple varieties vary greatly, impacting their health advantages.

Many disease processes are modulated by biologically active ingredients found in plant-based meals, including phytochemicals (Stan et al., 2025). The abundance of phytochemicals and minerals found in apple juices and extracts has been extensively researched (Hollman et al., 2010; Hyson, 2011; Krška et al., 2024; Madar et al., 2025). These advantages are mostly attributed to the nutrient-dense apple peel (Francini et al., 2021; Gotal Skoko et al., 2024).

According to Flood-Obbagy and Rolls (2009), eating apple slices before meals decreases calorie intake and increases fullness. By reducing triglycerides and LDL cholesterol, natural chemicals in apples also aid in weight control (de Oliveira et al., 2008; Cho Han & Lee, 2013). Because habitual apple eaters had lower levels of triglycerides, total cholesterol, and harmful LDL cholesterol, some of the natural substances in apples help people lose weight (de Oliveira et al., 2008; Cho Han and Lee, 2013; Jennings, 2018).

The nutritional superiority of some cultivars is further supported by recent discoveries by Neshovska (2024) and Kauser et al. (2024), which highlight variations in the vitamin and mineral content of apple types.

This study was undertaken to assess the proximate and mineral compositions of red and green apples, highlight their health implications, and determine which variety offers greater benefits to consumers.

2.0 Materials and Methods

2.1 Sample Collection

Mature ripe apples (red and green) used for this study were bought in June 2023 from twenty different sales points within the twenty Local Government Areas in Lagos State, Nigeria. The apples were thoroughly washed to remove any possible contaminants. A total of forty apples (twenty red and twenty green) were purchased. To form the sample used for the study, the red apples were carefully sliced and mixed, and the same procedure was carried out for the green apples.

2.2. Proximate Compositions and Mineral Contents

The samples were analysed according to the official methods of analysis described by (Greenfield and Southgate, 2003) and the Association of Official Analytical Chemists (AOAC, 2005, and AOAC, 2019). All analyses were carried out in replicate.

2.2.1. Moisture Content Determination: Using the Oven Drying Method

a) Crucible was weighed after drying in an oven and cooling in a desiccator = W_1.
b) The sample (2 g) was weighed into the crucible. Sample weight + crucible weight = W_2.
c) Until the weight remained constant, the crucible and the weighed sample material were heated at 105 °C in an oven.
d) Using a pair of tongs, the crucible containing the dried sample material was moved into a desiccator, allowed to cool, and then weighed again, W_3.

$$\text{The \% Moisture Content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100\,\%$$

2.2.2. Ash Content Determination

Apparatus: Porcelain Crucibles, a desiccator, Analytical Balances and a Furnace.

Determination: A porcelain crucible was filled with 2.0 g of the sample. After being moved into the muffle furnace, which was set to 550 °C, it was left for roughly four hours. It had turned to white ash at this point. After cooling to around 100 °C in air, then at room temperature in a desiccator before being weighed. This was done in duplicate. The percentage ash was calculated from the formula below.

$$\text{The \% of Total Ash Content} = \frac{\text{Weight of Ash}}{\text{Weight of sample}} \times 100\%$$

2.2.3. Crude Fibre Determination

a) After weighing 2.0 g of the sample (W_1) into the fibre flask, 100 mL of 0.25 M H_2SO_4 was added, and the mixture was heated with a heating mantle under reflux for an hour.
b) A fibre sieve cloth was used to filter the heated mixture. After discarding the filtrate and returning the residue to the fibre flask, 100 mL of 0.31 M NaOH was added, and the mixture was heated under reflux for another 1 hour.
c) A fibre sieve cloth was used to filter the mixture, and 10 mL of acetone was added to dissolve any organic material.
d) Before being put into the crucible, the residue was washed on the sieve cloth with about 50 mL of hot water. After, the crucible and the residue were oven-dried overnight at 105°C in order to remove moisture.
e) After cooling in a desiccator, the oven-dried crucible with the residue was weighed to determine its weight = W_2
f) For 4 hours, the crucible containing weight W_2 was placed in the muffle furnace and heated at 550 °C.
g) The sample was cooled in desiccators and weighed after cooling to obtain W_3. The weight of the fibre is determined by the difference between W_2 and W_3.

$$\text{The \% Crude Fibre} = \frac{W_2 - W_3}{W_1} \times 100\%$$

2.2.4. Protein Determination

a) A digestion flask was filled with 2 g of the sample after it had been weighed.
b) Concentrated H_2SO_4 (10 mL) was added.
c) The acid and the sample were gradually heated until the digesting process was completed.
d) This was ascertained once the solution became clear.
e) Hydrogen peroxide (H_2O_2), another strong oxidising agent, was added to the digest to clarify it.
f) Complete digestion was indicated by the solution becoming extremely clear.
g) To create the stock solution, the digest was then poured into a 100 mL volumetric flask and filled with water devoid of ammonia.
h) Nessler's reagent (2 mL) was added to another 25 mL volumetric flask containing 5 mL of the aliquot.
i) Ammonia-free water was used to bring the mixture up to volume.
j) The colour changed from yellow to brown, indicating the presence of nitrogen.
k) The intensity of the colour is directly proportional to the amount of nitrogen in the sample, which is also related to the quality of the protein in the sample.
l) The amount of protein was determined by measuring the colour generated at 460–462 nm using a spectrophotometer.

$$\text{The \% Protein Content} = \%\,N \times 6.25$$

2.2.5. Calculating the Fat Content

a) Conical flasks that had been cleaned and dried were filled with 1.0 g of each sample.
b) The samples were heated at 62°C for 10 minutes using 10 mL of alcohol in a water bath.
c) Samples were allowed to cool using a desiccator.
d) Each flask's sample was mixed with 12 mL of diethyl ether, and the mixture was vigorously shaken.
e) The samples in each flask were mixed with 0.5 mL of dilute ammonia.
f) Water (4.5 mL) and light petroleum ether (12.5 mL) were added, and they were gently stirred.
g) Each sample's top layer was siphoned off into a beaker that had been cleaned and weighed.
h) After heating the extracts to evaporate the solvent, they were weighed, and the values were recorded.

$$\text{The \% Fat Content} = \frac{\text{Weight of extract}}{\text{Weight of sample}} \times 100\ \%$$

2.2.6. Carbohydrate Determination

Each sample's total carbohydrate content was calculated using the differential. This was accomplished by deducting from 100% the proportion of moisture, ash, protein, fibre, and fat that was obtained.

The % Carbohydrate = 100% - (% moisture + % ash + % protein + % crude fibre + % fat)

2.2.7. Mineral Elements Determination

Using a flame photometer (Model: Corning 410), the concentrations of calcium, sodium, and potassium were measured. The formula for calculating each element's concentration was as follows: %Ca, %K, or %Na.

$$= \frac{\text{Meter Reading (MR) x slope x Dilution factor}}{1000}$$

NOTE: MR x slope x dilution factor will give the concentration in part per million (ppm or mg/kg). The concentration in % can be calculated by dividing it by 10000.

(i). Phosphorus Determination (Spectrophotometric Method) - Phosphorus was determined routinely by the vanado-molybdate colorimetry. The percentage phosphorus was calculated from using the formula:

$$\text{\%Phosphorus} = \frac{\text{Absorbance x Slope x Dilution factor}}{10000}$$

(ii). Determination of Mg, Cu, Mn, Fe, Zn Using Buck 210vgp AAS - Magnesium, Copper, Zinc, Manganese and Iron were determined using an atomic absorption spectrophotometer (Model: Buck VGP 210).

2.2.8. Statistical Analysis - All determinations were carried out in triplicate per variety (red and green apples). Data were entered into a spreadsheet and independently verified for accuracy before analysis. Results were presented as mean ± standard deviation (SD).

3.0. Results and Discussion

The results of the proximate analysis and the mineral contents of red and green apples bought from twenty different sales points within the 20 Local Government Areas in Lagos State, Nigeria, are summarised in the Tables below.

Table 1. Proximate Contents of red and green apples from Lagos State

Parameters	Red apples	Green apples
% Moisture	81.34±3.73	82.55±3.89
% Dry Matter	18.66±1.78	17.45±2.11
% Crude Protein	0.49±0,02	0.27±0.01
% Crude Fat	0.32±0.01	0.22±0.01
% Crude Fibre	2.17±0.41	2.37±0.23
% Ash	2.48±0.25	2.28±0.22
% Carbohydrate	13.21±1.92	12.31±1.45

Values are expressed as mean ± standard deviation (n = 3)

Table 2. Mineral Contents of red and green apples from Lagos State

Parameters	Red apples	Green apples
Na (mg/kg)	0.01±0.00	0.00±0.00
K (mg/kg)	0.12±0,04	0.12±0.01
Ca (mg/kg)	0.02±0.00	0.01±0.00
P (mg/kg)	0.04±0.01	0.03±0.00
Mg (mg/kg)	0.02±0.00	0.02±0.00
Fe (mg/kg)	1.96±0.07	1.85±0.04
Zn (mg/kg)	0.56±0.03	0.42±0.01
Cu (mg/kg)	0.39±0.04	0.27±0.02
Mn (mg/kg)	0.64±0.02	0.50±0.02

Values are expressed as mean ± standard deviation (n = 3)

Table 1 above shows the proximate compositions of both red and green apples. The moisture content of the red apples was 81.34±3.73% while that of the green apples was 82.55±3.89%. The moisture contents of the samples were high, agreeing with ranges reported by Dakuyo and Konaté (2022) and Petkova et al. (2023). This result also agrees with the range reported by

Mohammed (2015) for local apple fruit, 82.75±0.01% and 83.50±0.02% for imported apple fruit, but lower than the value of 87.73% reported by Okokon and Okokon (2019). The moisture content of this study falls within the limit of 80 – 90% specified for fruits by FAO (1995). These results revealed that apples are perishable and will have a short shelf life due to their high moisture content (Adeleke and Abiodun, 2010; Lim and Rabeta, 2013). The moisture content of the red apples was a little lower than that of green apples, and this implies that red apples will have a longer shelf life than green apples. High moisture implies perishability, a trait confirmed by Francini et al. (2021).

The crude protein content of the red apples was 0.49±0,02% while that of the green apples was 0.27±0.01%. The results of this study agree with the range of 0.12% – 1.21% reported by Lim and Rabeta (2013) but are higher than the values of 0.23% for local apples and 0.25% for imported apples reported by Mohammed (2015) but much higher than 0.03% reported by Okokon and Okokon (2019). From this study, Protein levels were higher in red apples, consistent with the findings of Arnold et al. (2024) and Sümbül et al. (2025). This indicates that red apples will be a better source of protein for the consumers than the green apples.

The crude fat present in the red and green apples was 0.32±0.01% and 0.22±0.01% respectively. These results agreed with the range of 0.24% to 0.37% reported by Lim and Rabeta (2013) but were lower than 0.41% for local apples and 0.35% for imported apples reported by Mohammed (2015) and 0.40% reported by FAO (1995). Low-fat content was observed, a trait common to fruits (Lim and Rabeta, 2013; Kauser et al., 2024; Madar et al., 2025). This study revealed that red apples contain a higher percentage of crude fat than green apples.

The crude fibre contents were 2.17±0.41% and 2.37±0.23% for red and green apples, respectively. Fibre levels were slightly higher in green apples, in line with results by Neshovska (2024) and Stan et al. (2025). The results of this study for crude fibre were higher than the range (0.86 – 1.81%) reported by Lim and Rabeta (2013) and 1.64 – 1.83% reported by Mohammed (2015).

The ash compositions of both red and green apples were 2.48±0.25% and 2.28±0.22% respectively. Ash contents were high, indicating rich mineral presence, supporting observations by Kauser et al. (2024) and Gracey (2025). The values obtained here were higher than 0.30% reported by both FAO (1995) and Okokon and Okokon (2018) for apple fruit juice. Also, higher than 0.30% for local apple and 0.27% for imported apple as reported by Mohammed (2015), but agreed with the range of 1.63 – 2.77% reported by Campeanu et al. (2009). The quantity of minerals present in a sample corresponds to the amount of ash (Coimbra and Jorge, 2011).

The carbohydrate content of the red apples was 13.21±1.92% while that of green apples was 12.31±1.45%. This implies that the red apple will be a better source of carbohydrates for the body than the green apple. The values obtained for carbohydrate in this study revealed that the carbohydrate in the red apples was higher than 8.49 – 12.68% reported by Lim and Rabeta (2013), while the value for the green apples agreed with the range. The values of this study for both the red and green apples were lower than 13.80 – 14.67% by Mohammed (2015).

From Table 2, the mineral compositions of the red apples were as follows in (mg/kg): Na - 0.01±0.00, K - 0.12±0,04, Ca - 0.02±0.00, P - 0.04±0.01, Mg - 0.02±0.00, Fe - 1.96±0.07, Zn - 0.56±0.03, Cu - 0.39±0.04, Mn - 0.64±0.02 while that of the green apples were Na - 0.00±0.00, K - 0.12±0.01, Ca - 0.01±0.00, P - 0.03±0.00, Mg - 0.02±0.00, Fe - 1.85±0.04, Zn - 0.42±0.01, Cu - 0.27±0.02, Mn - 0.50±0.02. The mineral composition of red and green apples shows both similarities and differences.

Sodium levels were negligible in both varieties, confirming their heart-healthy nature (Petkova et al., 2023). Potassium was equal (0.12 mg/kg) in both apples, highlighting apples as good sources for electrolyte balance (Kauser et al., 2024). Calcium was slightly higher in red apples, suggesting better skeletal benefits.

Phosphorus was also higher in red apples, supporting energy metabolism (Francini et al., 2021).

Magnesium levels were identical, showing no varietal difference in both apples.

Iron content was higher in red apples, aiding oxygen transport and anaemia prevention (Petkova et al., 2023). Likewise, zinc was greater in red apples, strengthening immune and metabolic functions.

Copper was more in red apples, supporting enzymatic and antioxidant roles (Gotal Skoko et al., 2024).

Manganese was also more abundant in red apples, beneficial for bone health and metabolism.

Generally, this study revealed higher iron, zinc, copper, and manganese in red apples, consistent with previous studies by Arnold et al. (2024), and Krška et al. (2024).

Overall, red apples consistently contained higher mineral levels than green apples. Green apples, though lower in most minerals, still provide essential nutrients. Both varieties are low in sodium and beneficial for cardiovascular health. The differences may be due to genetic factors, soil conditions, and maturity stages (Kumar et al., 2022). These mineral differences suggest cultivar-specific health benefits, as noted by Gotal Skoko et al. (2024) and Sredojević et al. (2025). Nutritionally, red apples appear superior in mineral density, but both complement each other in the diet.

4.0 Conclusion

This study has shown that both red and green apples are rich in nutrients, with slight variations in their proximate and mineral compositions. Red apples generally contain higher protein, fat, carbohydrate, and mineral levels, especially iron, zinc, copper, and manganese, making them more nutrient-dense. Green apples, however, had slightly higher fibre content, which is beneficial for digestion and satiety.

Both varieties were found to be low in fat and sodium, aligning with their cardioprotective roles. The observed differences may be attributed to varietal genetics, soil composition, and environmental factors during cultivation. These findings highlight that both red and green apples are valuable dietary fruits with complementary health benefits. Overall, red apples may offer superior nutritional advantages, but incorporating both varieties enhances dietary diversity and health outcomes.

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