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# Nutritional profile of maize drinks produced from different maize varieties in Kumasi Metropolis Area, Ghana

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ABSTRACT

Food product development has seen a major shift in market value because of the increasing market for functional beverages as a result their long shelf life and convenience, as well as meet consumer demands in terms of appearance, size, and content. Customers enthusiastically embrace food items that claim health advantages beyond just providing essential nutrients.The study assessed the nutritional qualities non-alcoholic cereal beverages using different maize varieties. The study used experimental research design. Five varieties of maize (Honampa, Ahoofe, Mamaba, Abebe and Dzifo) were purchased from the Kumasi Metropolis CSIR-Crop Research Institute Fumesua. The raw materials were sorted washed properly to avoid contamination. Proximate composition, colour profile and chemical analysis of the maize drinks were evaluated using standard methods. The proximate composition showed moderate levels of carbohydrate (Mamaba-6.94%; Ahoofe-2.91%; Abebe-4.21%; Dzifoo-5.78% and Honampa-6.97%) and crude protein (Mamaba-1.25%; Ahoofe-1.55%; Abebe-0.97%; Dzifoo-0.94% and Honampa-1.26%). The chemical analysis of the maize drinks revealed a significant difference ($p<0.05$) in the beta carotene of the maize varieties, with Ahoofe having the highest beta carotene content (84.45ug/100g). The maize drinks's pH ranged from 3.30-4.62. The maize drinks also showed high lightness in colour (60.38-72.24), redness (1.94-4.54) and yellowness (18.54-24.91) which makes the products appealing to consumers.

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## 1. Introduction

The global demand for a wide variety of beverages, driven by their thirst-quenching and instant energy-releasing properties, has led to continuous growth in the beverage sector (1). Beverages are typically categorized into alcoholic, non-alcoholic, and dairy-based types (2).

Non-alcoholic beverages, which are not fermented during preparation, are particularly valued for their ability to deliver essential nutrients and bioactive substances to the body, thus enhancing their bioavailability (3). The availability of bioactive components, such as carotenoids, dietary fiber,

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flavonoids, and vitamins, offers potential in disease prevention (4,5). Functional beverages, which cater to the growing consumer demand for convenience, content variety, and longer shelf life, are the fastest-growing market segment globally (1).

Compared to other cereal-based beverages, functional beverages manufactured from maize have certain unique characteristics. Notably, the bioactive compounds found in maize, such as phenolic acids, flavonoids, carotenoids (especially in yellow and orange maize), and dietary fibre, significantly improve the grain's capacity to lower cholesterol, improve its antioxidant capabilities, and reduce inflammation (6). Unlike many cereal-based drinks manufactured from rice or oats, maize beverages, particularly those made from Quality Protein Maize (QPM), offer lysine and tryptophan in high quantities which are essential amino acids that are often low in conventional maize and many other cereals (7). Moreover, pro-vitamin A can be added to beverages made from maize, especially when biofortified varieties such as Ahoofe or Honampa are used, which gives them a practical advantage in treating micronutrient deficiencies such as vitamin A deficiency in vulnerable groups (8). Due to their nutritional and functional qualities, maize-based functional beverages are a promising option for health-focused product development, particularly in developing countries.

In many regions, including Africa, cereal-based beverages both fermented and non-fermented are a staple part of the diet. In Africa, cereals contribute up to 77% of total calorie intake and play a significant role in dietary protein consumption (9). In Ghana, maize-based drinks are particularly popular, and these beverages are often enjoyed as desserts or used in traditional medicine due to their purported therapeutic properties (10). Maize offers a unique advantage in functional foods due to its versatility and ability to be processed using both traditional and modern methods, which helps address food and nutrition deficiencies (11). Additionally, the health benefits of an excess of anthocyanins in coloured maize, carotenoids, and phenolic compounds, have spurred its increased use due to its antioxidant and bioactive properties (12).

Ghana's maize production is steadily rising, however, it only records 2 metric tonnes per hectare, which is less than what is practical from an economic standpoint. Despite the fact that the Ministry of Agricultural have contributed to the development and production of 55 enhanced maize varieties, including 29 hybrid varieties (13), none of these hybrids have been completely utilized, with the exception of those created for the international cooperation. This implies that the use of improved cultivars in Ghana is quite low. Ghana needs high-yielding maize hybrids including Honampa, Ahoofe, Mamaba, Abebe, and Dzifo to ensure food security, increase production and self-sufficiency, and alleviate nutritional deficiencies (14). The nutritional properties of the maize cultivars Honampa, Ahoofe, Mamaba, Abebe, and Dzifo vary, particularly with regard to the amount of pro-vitamin A and protein they contain. The Honampa kind of pro-vitamin A biofortification contributes to higher vitamin A intake. It can produce 5.2 tons per acre and requires 110 to 115 days to mature (15). In Ghana in 2015, the Ahoofe variety—a pro-vitamin A-rich maize hybrid that provides increased vitamin A levels was introduced (16). Developed as a Quality Protein Maize (QPM)

hybrid, the Mamaba variety contains almost teice the quenity of lysine and tryptophan compared to conventional maize types, addressing deficiencies in these essential amino acids (17). Abebe, also known as CRI-Abebe, is a vitamin A biofortified supplement that provides higher quantities of this essential nutrient (18). The year 2015 also saw the introduction of Dzifo, a pro-vitamin A-rich maize variety with a higher vitamin A content in Ghana. While Honampa, Ahoofe, Abebe, and Dzifo are notable for their higher pro-vitamin A content, which resolves vitamin A inadequacies, Mamaba stands out for its better protein quality, particularly in terms of lysine and tryptophan content. Malnutrition remains a significant global challenge, with approximately 250 million children worldwide suffering from its effects. According to estimates, between 250,000 and 500,000 youngsters lose their sight each year as a result of inadequate nutrition (19). Functional foods, such as maize drinks, offers a viable way to address these problems by offering nutrient-rich maize drinks that give customers sources of pro-vitamin A, which can help prevent vitamin A deficiency and blindness. Numerous studies have been done on maize beverages; the majority of these studies have concentrated on fermented drinks, but some have examined non-fermented ones. Kitabatake et al. (20) investigated the process of making Togwa, a non-alcoholic beverage, using germinated finger millet and maize flour. Ade-Omowaye et al. (21) focused on non-alcoholic drinks made from maize. Masehlele et al. (22), using kefir grains, created a drink made from maize meal. Mahewu, a non-alcoholic maize beverage, was developed by Kudita et al. (23), who used sorghum and millets in place of maize. Nevertheless, these studies have concentrated on non-alcoholic maize beverages made from biofortified pro-vitamin A maize varieties such Dzifo, Mamaba, Ahoofe, Honampa, and Abebe.This study aims to analyze the nutritional profile of maize-based drinks derived from different maize varieties, providing insight into their potential role in improving nutrition and health outcomes.

## 2. Materials and Methods

### 2.1. Sources of materials

The Orange Maize (Ahoofe), Mamaba Maize, Abebe Maize, Dzifoo Maize and Honampa Maize were bought from the CSIR-Crop Research Institute Fomesua in the Kumasi Metropolis. Also, ginger, dates, cloves, and Grains of Selim, were bought from the open market at Kwadaso, a suburb Kumasi in Ghana.

### 2.2. Formulation of maize drink from different varieties of maize

A preliminary study was conducted to establish the water to corn ratio to determine the best proportion for the different varieties of the maize drink samples. Samples of five (5) test treatments with labels, PRDT 1 (Mamaba maize), PRDT 2 (Ahoofe maize), PRDT 3 (Abebe maize), PRDT 4 (*Dzifo* maize), and PRDT 5 (Honampa maize) were used for the study. The PRDT 1 served as the control as it is the most consumed variety in Ghana. The formulation used for this study is presented in Table 1.

**Table 1**. Maize drink formulations from different maize varieties

| Variety | Maize (g) | Dates (g) | Water (L) | Cloves (g) | Pepper Corn (g) | Fresh Grated Ginger (g) |
|---|---|---|---|---|---|---|
| **Mamaba** | 200 | 50 | 1 | 20 | 10 | 12 |
| **Ahoofe** | 200 | 50 | 1 | 20 | 10 | 12 |
| **Abebe** | 200 | 50 | 1 | 20 | 10 | 12 |
| **Dzifoo** | 200 | 50 | 1 | 20 | 10 | 12 |
| **Honampa** | 200 | 50 | 1 | 20 | 10 | 12 |

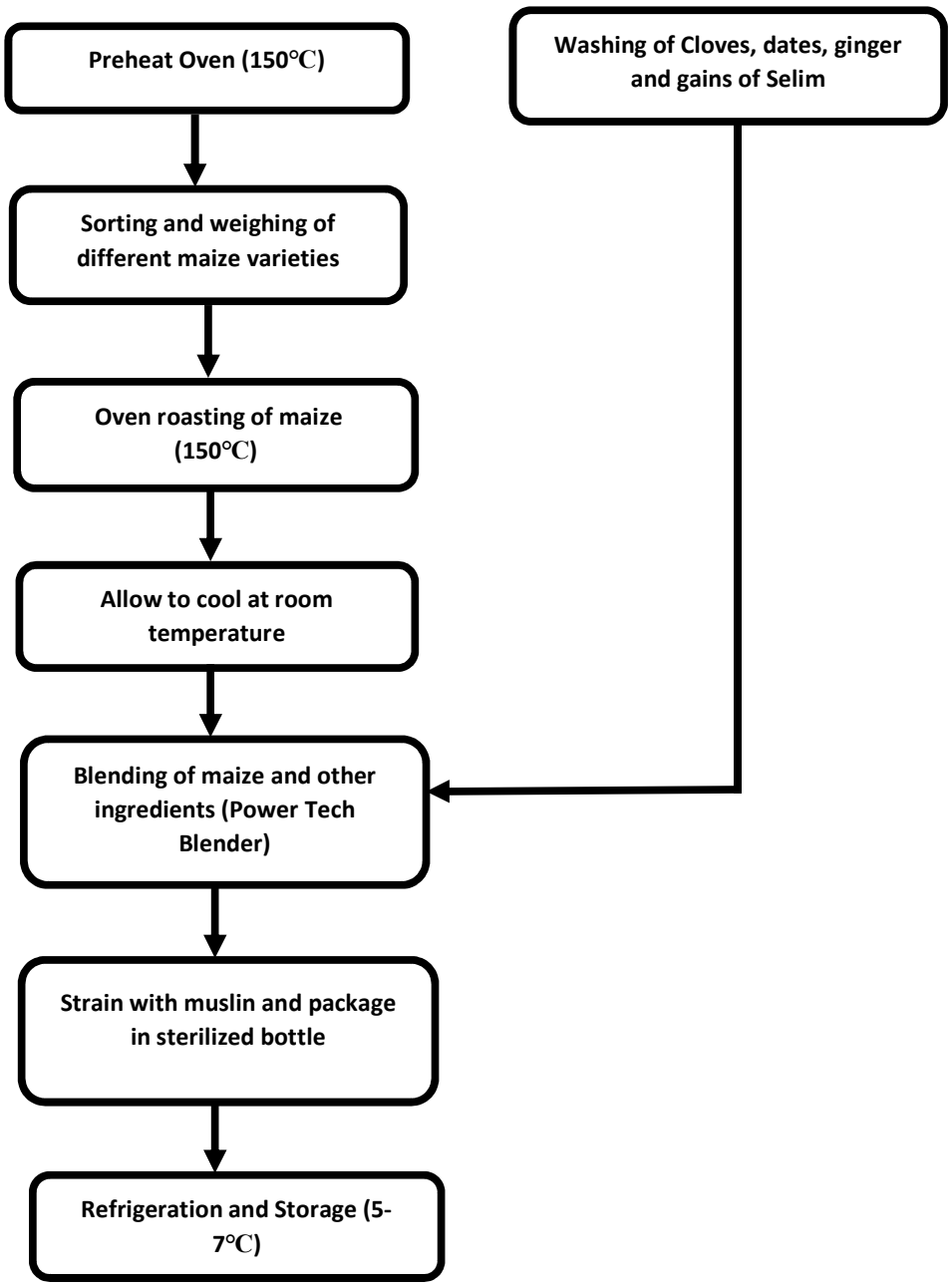


**Figure 1.** Preparation flow of different varieties of maize drinks.

2.3. Preparation of maize drinks

Weighed amounts of washed ingredients, which included 50 g of dates, 20 g of cloves, 10 g of grains of Selim, and 12 g of freshly grated ginger were used for the preparation of each drink sample. The maize was roasted at 150°C for 30 min in a supermatic oven, with intermittent stirring using a wooden spoon to ensure uniform roasting and prevent burning. After roasting, the maize commodity was cooled to room temperature, then poured into a high-tech food blender, along with the ginger, cloves, dates, and grains of Selim, and blended until smooth. A liter of water was added, and the mixture was strain using a fine muslin cloth to remove any solid residues. The final product was packaged and refrigerated at 5°C. Fig. 1 presents the process flow diagram for the preparation of the maize drinks.

2.4. Proximate evaluation of maize drink samples

2.4.1. Moisture

The samples' moisture content was evaluated following the AOAC (24). A pre-dried, coded pan was weighed, and a 5 g portion of the sample was evenly spread over its surface. For 4 h sample was put in the oven (105°C) to guarantee complete drying. After finishing, the sample and pan were placed in a desiccator to prevent the reabsorption of moisture. The dried sample and pan's ultimate weight was recorded, and the moisture content calculated.

Percentage moisture=

$$\frac{Weight\ of\ dish+Sampl\ \ (Before)-Weight\ of\ dish+sampl\ \ (after)}{Weigh\ \ of\ sample}\ x\ 100$$

2.4.2. Crude fat

Using the Soxhlet extraction method, the amount of fat in the samples was examined in accordance with the AOAC (24) procedure. The sample (5 g) was precisely weighed into a thimble lined with a non-absorbent substance to stop sample loss. The thimble was then positioned in the Soxhlet apparatus, which was connected to a pre-weighed, clean, and dry Soxhlet flask containing approximately 200 mL of petroleum ether was used as the extraction solvent.

The apparatus was assembled, and a condenser was set up with a continuous flow of cold water to condense the solvent vapors. The system was allowed to operate for 6 h, during which the solvent continuously extracted the fat from the sample. Once the extraction was complete, the petroleum ether was evaporated, and the Soxhlet flask containing the extracted fat was dried in an oven at 105°C for 1 h. After drying, the flask was transferred to a desiccator, cooled to room temperature before being weighed again. The fat content was then calculated.

$$\%FC = \frac{ht\ of\ flask + oil - weight\ of\ empty\ flask\ X\ 100}{weight\ of\ sample}$$

2.4.3. Total ash content

The ash content of the test samples was ascertained using the gravimetric technique in accordance with AOAC (24) standard .An already weighed crucible was labeled at it base for identification. At 550 degrees, about 2 g of the sample were measured into the crucible and placed inside a muffle furnace. Using a tong for safe handling, the sample was incinerated for 2 h to ensure complete combustion of all organic matter.

The crucible was taken out of the furnace following ashing, cooled to room temperature in a desiccator, and reweighed.

The content of ash was computed as follows:

$$\%AC = \frac{weight\ of\ crucible + (before) - weight\ of\ crucible + (after) \times 100}{weight\ of\ \text{test}\ sample}$$

2.4.4. Crude protein

Kjeldahl method was used to determine the protein content of the samples, following standard protocols. A digestion tube was filled with one gram of the test sample and 15 mL of sulfuric acid that was 98% concentrated. Two Kjeltabs (catalyst tablets containing potassium sulfate and copper sulfate) were included to accelerate the digestion process. The sample was then digested at 420°C for about 2 h until a clear solution was obtained.

After digestion, A 100 mL volumetric flask was filled with 10 mL of the digest, then topped up with distilled water the mark. A 20 mL aliquot of the diluted digest was mixed with 50 mL of 40% sodium hydroxide (NaOH) and 200 mL of water (distilled). The mixture was introduced into a Kjeldahl distillation apparatus, ensuring that the condenser's water circulation pump was functioning and maintained at 120–150°C.

In a cornical flask with 30 mL of a 4% boric acid solution, the ammonia that was emitted during distillation was gathered. Until about 100–150 mL of distillate was obtained, the distillation process was carried out.

The resulting solution was titrated with a standardized 0.1 N hydrochloric acid (HCl) solution to determine the nitrogen content. A blank sample was also run to account for any background interference using a suitable conversion factor, the amount of protein was calculated based on the nitrogen content. The amount of crude protein was calculated as crude protein (%) = (Vol. of HCl used for sample titration – Vol. of HCl used for blank titration) × Normality of HCl × 14.007 × 6.25 / sample weight (in grams).

2.4.5. Total carbohydrate

Nitrogen-free extract (NFE) was obtained by subtracting the sum of the other proximate parameters from 100, and this was used to calculate the total carbohydrate by difference (AOAC, 2010): % Carbohydrate (NFE) = 100 − (M + P + F + A)

Where M = Moisture content; P = Protein; F = Fat; A = Ash.

2.4.6. Determination of total solids

The freshly prepared test samples' total solid content was determined using conventional procedures (AOAC) (25). Five grams of sample was dried to a constant weight in a hot forced-air oven (Binder) at 105°C and total solid was calculated;

$$\%\ Total\ solids = \frac{\text{weight of Dried Solid}}{\text{weight of test sample}}\ x\ 100$$

2.4.7. Determination of total energy

Using the Atwater factor, the samples' energy value was calculated by multiplying their protein and carbohydrate content by 4, and the amount of fat by 9.

Energy (Kcal/100g)= (Crude protein × 4) + (Total carbohydrate × 4) + (Crude fat × 9).

2.4.8. Determination of Beta carotene

Determination of Beta carotent was done using the method of Munkhuwa et al., (26) with slight modification. About 50 mL of cold acetone was added to each sample at 5 g and shaken vigorously for 1 min and filtered (Whatman No.4 filter paper). After 40 mL of petroleum ether was added, acetone extract (filtrate)

was transferred into a 500 mL separating funnel with a Teflon stop-cock. After that, 300 mL of distilled water were cautiously added along the funnel's walls. To get rid of any remaining acetone, the funnel was then cleaned using 200 mL of distilled water. After that, 15 g of anhydrous sodium sulphate was added to a 50 mL volumetric flask containing the petroleum ether phase to remove any leftover water. To evaluating beta-carotene concentration, The filtrate was put in a glass cuvette (1x1 cm) and absorbance recorded varying ranges using a UV/Vis Spectrophotometer (CECIL CE7400)( 453, 505, 645, and 663 nm). The β-carotene was computes as;

β-carotene (mg/100m) = 0.216A663 - 0.304A505 + 0.452A453.

The results are showed as µg/100g of each sample.

2.4.9 Determination of pH

Hydrogen ion concentration, pH was measured according to AOAC (24) method. A Metler Toledo (seven compact, S210 pH meter) was used to measure the samples' (10% (w/v)) pH at 25°C. Standard buffer solutions with pH values of 4 and 7 were used to calibrate the pH meter. Approximately of each of the samples was used.

2.4.10. Colour analysis

Colour was determined following Suriano et al., (27). The chroma meter (CR-410, Konica Minolta) measured the colour properties of the samples and was recorded in values of CIELAB colour scales. The values L*(0 black to 100 white), a*( redness 0 to 60) and b *( yellowness (0 to 60) or blueness (0 to 60) defined the three-dimensional colour space. Before analyzing the samples, the chroma meter was calibrated using a white reference tile. Duplicate measurements were made, and the average results were noted.

2.4.11. Determination of total phenolic

The Folin-Ciocalteu test was used to determined total phenolic content, with gallic acid (GA) serving as the standard. One gram of each sample was mixed with 20 mL of water (deionized) and vortexed (50 mg/mL). The extract was then pipetted into a test tube along with 1 mL of 20% sodium carbonate and 20 µL of Folin-Ciocalteu reagent.This was kept in the dark at 40°C for 30 min at room temperature. The absorbance at 760 nm was measured using UV-Vis spectrophotometer (model: Mettler-Toledo GmbH Im Langacher 8606). A calibration curve was constructed using the standard solution (GA) (0.0001, 0.0002, 0.0003, 0.0004, 0.0008,0.001 mg/mL). The total phenol content was computed from calibration curve (GAE) in milligrams (mg) per gram of the extract.

2.4.12. Antioxidant activity

The antioxidant capacity was analyzed following Ansari et al.,(28) method with slight modifications. Test tubes containing 1 mL each of the extract in duplicate (0.4mg/mL) and 1 mL of DPPH (1, 1-diphenyl-2-picrylhydrazyl) solution (0.1mM) in ethanol were incubated (30 min) in the dark at room temperature. After, the absorbances were measured at 517 nm with UV/VIS Spectrophotometer (model: Mettler-Toledo GmbH Im Langacher 8606).

The DDPH scavenge ability was computed as:

DPPH radical scavenging activity (% inhibition) = [1-(As/Ao)] x 100

As - absorbance of sample.

Ao - absorbance of DPPH solution

2.5. Data analysis

Data was analyzed using SPSS version 27. Significant differences in the physicochemical, colour profile and antioxidant activities of the different varieties of maize drinks was determined using analysis of variance (ANOVA), mean, and standard deviation at 95% confidence level.

**3. Results**

3.1. Proximate composition of maize drinks

The results showed significant difference ($p<0.05$) in the moisture of the maize drinks which varied from 91.69 to 94.73% with Ahoofe having the highest moisture content (94.73%) and Honampa (91.69%) having the least moisture content.

The results showed a significant difference in the content of ash in the maize drinks which ranged from 0.03 to 0.89%. Ahoofe maize drink had the highest ash (0.89%) content followed by Honanmpa (0.26%). However, there were statistically significant differences between the ash content of Mamaba, Abebe, and Dzifoo (Table 1).

The crude fat content of the maize drinks revealed significant difference ($p<0.05$), with Ahoofe recording the highest fat content (0.34%) followed by Mamaba (0.06%) with Honampa having the least (0.03%).

The proximate composition of the maize drinks also showed no statistically significant differences between the crude protein of Mamaba (1.25%) and Honampa (1.26%), and that between Dzifoo (0.94%) and Abebe (0.97%). However, there were statistically significant differences between Ahoofe (1.55), Honampa (1.26%) and Abebe (0.97%) ($p<0.05$).

The results revealed that, the total carbohydrate content of the maize drinks varied from 2.91 to 6.97% with Honampa having the highest carbohydrate content (6.97%) followed by Mamaba (6.94%) and the least being Ahoofe (2.91%) with significant differences ($p<0.05$).

The total solids ranged between 5.27 to 8.30%. A statistically significant difference existed between Ahoofe, Dzifoo, Honampa, and Mamaba ($p<0.05$). However, there was no statistically significant difference Ahoofe (5.61) and Abebe (5.27).

The maize drink with the highest energy was Mamaba (33.25 Kcal/100g) followed by Honampa (33.20 Kcal/100g) and the least being Ahoofe (20.80 Kcal/100g) ($p<0.05$).

3.2. Colour evaluation of maize drinks

Table 2. shows the colour profile of the maize drinks. The results revealed that Ahoofe maize drink recorded the maximum lightness (72.24) indicating that it was lighter than Mamaba (60.38), Abebe (64.44), Dzifoo (66.60) and Honampa (61.22). There was a statistically significant difference in the lightness of the maize drinks. Dzifoo was lighter than Mamaba but not statistically significantly different from Abebe.

The red/green coordinates revealed that all samples were statistically significantly different in the redness from each other with Mamaba having the maximum redness (4.54), followed by Honampa (3.88) and Ahoofe having the minimum redness (1.94).

The results (Table 3) also showed that all the maize drinks were yellow with Ahoofe having the maximum yellowness (24.91) and Dzifoo having the minimum yellowness.

**Table 1.** Proximate composition of samples from different maize drink varieties

| Attributes | Samples | | | | | p-value |
|---|---|---|---|---|---|---|
| | Mamaba | Ahoofe | Abebe | Dzifoo | Honampa | |
| **Moisture (%)** | 91.72±0.00$^{a}$ | 94.33±0.13$^{b}$ | 94.73±0.16$^{b}$ | 93.71±0.59$^{b}$ | 91.69±0.20$^{a}$ | 0.00 |
| **Ash (%)** | 0.03±0.03$^{a}$ | 0.89±0.01$^{b}$ | 0.03±0.00$^{a}$ | 0.03±0.00$^{a}$ | 0.26±0.31$^{a}$ | 0.00 |
| **Crude fat (%)** | 0.06±0.00$^{c}$ | 0.34±0.00$^{d}$ | 0.05±0.00$^{c}$ | 0.04±0.00$^{b}$ | 0.03±0.00$^{a}$ | 0.00 |
| **Crude protein (%)** | 1.25±0.06$^{b}$ | 1.55±0.03$^{c}$ | 0.97±0.04$^{a}$ | 0.94±0.01$^{a}$ | 1.26±0.13$^{b}$ | 0.00 |
| **Carbohydrate (%)** | 6.94±0.09$^{d}$ | 2.91±0.05$^{a}$ | 4.21±0.12$^{b}$ | 5.78±0.13$^{c}$ | 6.97±0.07$^{d}$ | 0.00 |
| **Total solids (%)** | 8.28±0.01$^{c}$ | 5.61±0.06$^{a}$ | 5.27±0.16$^{a}$ | 6.79±0.12$^{b}$ | 8.30±0.19$^{c}$ | 0.00 |
| **Energy (Kcal/100g)** | 33.25±0.11$^{c}$ | 20.80±0.46$^{a}$ | 21.21±0.59$^{a}$ | 27.20±0.46$^{b}$ | 33.20±0.81$^{c}$ | 0.00 |

Means of different superscripts are significantly different at $p<0.05$

**Table 2.** Colour profile of maize drinks

| Attributes | Samples | | | | | P-value |
|---|---|---|---|---|---|---|
| | Mamaba | Ahoofe | Abebe | Dzifoo | Honampa | |
| **L*** | 60.38±1.63$^{a}$ | 72.24±0.14$^{d}$ | 64.44±1.63$^{bc}$ | 66.60±0.11$^{c}$ | 61.22±0.83$^{ab}$ | 0.00 |
| **a*** | 4.54±0.55$^{c}$ | 1.94±0.02$^{a}$ | 2.91±0.46$^{ab}$ | 2.21±0.06$^{a}$ | 3.88±0.21$^{bc}$ | 0.00 |
| **b*** | 19.34±0.10$^{ab}$ | 24.91±0.06$^{c}$ | 19.76±0.70$^{b}$ | 18.54±0.11$^{a}$ | 20.29±0.06$^{b}$ | 0.00 |

Means of bearing different superscripts in the same row are significantly different at $p<0.05$

**Table 3.** Chemical analysis of different varieties of maize drink

| Attributes | Samples | | | | | P-value |
|---|---|---|---|---|---|---|
| | Mamaba | Ahoofe | Abebe | Dzifoo | Honampa | |
| **Beta-carotene (µg/100g)** | 7.35±0.19$^{a}$ | 84.45±0.81$^{d}$ | 9.28±0.80$^{ab}$ | 11.54±1.60$^{b}$ | 16.14±1.76$^{c}$ | 0.00 |
| **Phenolics (mg GAE/g)** | 0.17±0.00$^{d}$ | 0.53±0.00$^{e}$ | 0.13±0.00$^{b}$ | 0.11±0.00$^{c}$ | 0.13±0.00$^{a}$ | 0.00 |
| **Antioxidant (%)** | 55.10±0.10$^{c}$ | 59.73±1.41$^{d}$ | 44.41±0.03$^{a}$ | 48.54±0.23$^{b}$ | 49.61±0.05$^{b}$ | 0.00 |
| **pH** | 3.86±0.15$^{b}$ | 3.30±0.00$^{a}$ | 4.10±0.11$^{b}$ | 3.81±0.14$^{b}$ | 4.62±0.21$^{c}$ | 0.00 |

Means of bearing different superscripts in the samw row are significantly different at $p<0.05$

**Table 4.** Chemical analysis of different maize drink varieties

| Attributes | Samples | | | | | P-value |
|---|---|---|---|---|---|---|
| | Mamaba | Ahoofe | Abebe | Dzifoo | Honampa | |
| **Beta-carotene (µg/100g)** | 7.35±0.19$^{a}$ | 84.45±0.81$^{d}$ | 9.28±0.80$^{ab}$ | 11.54±1.60$^{b}$ | 16.14±1.76$^{c}$ | 0.00 |
| **Phenolics (mg GAE/g)** | 0.17±0.00$^{d}$ | 0.53±0.00$^{e}$ | 0.13±0.00$^{b}$ | 0.11±0.00$^{c}$ | 0.13±0.00$^{a}$ | 0.00 |
| **Antioxidant (%)** | 55.10±0.10$^{c}$ | 59.73±1.41$^{d}$ | 44.41±0.03$^{a}$ | 48.54±0.23$^{b}$ | 49.61±0.05$^{b}$ | 0.00 |
| **pH** | 3.86±0.15$^{b}$ | 3.30±0.00$^{a}$ | 4.10±0.11$^{b}$ | 3.81±0.14$^{b}$ | 4.62±0.21$^{c}$ | 0.00 |

Means of different superscripts are significantly different at $p<0.05$

3.3. Chemical analysis of maize drink

The results from the chemical analysis of the maize drink showed a significant difference ($p<0.05$) in the beta-carotene of the samples. Ahoofe had the maximum beta-carotene (84.45 µg/100g) and was evident in the colour profile of the maize drinks (Table 3). This was followed by Honampa (16.14 µg/100g) with Mamaba having the minimum (7.35 µg/100g) beta-carotene (Table 4).

There was a significant difference ($p<0.05$) phenolic content of the samples. Ahoofe had high amount (0.53) of phenolics than Mamaba (0.17), Abebe (0.13) and Dzifoo (0.11).

The antioxidant activities of the samples showed that, Ahoofe had the maximum antioxidant (59.73) followed by Mamaba (55.10) with Abebe (44.41) having the minimum antioxidant. There was a significant difference ($p<0.05$) in the antioxidant content of the samples.

The pH of the maize drink was significantly different ($p<0.05$). Ahoofe had lowest pH (3.30) and Honampa having a pH of 4.62. The pH of Mamaba, Abebe, and Dzifoo did not show significant difference ($p>0.05$) (Table 4).

**4. Discussion**

4.1. Proximate composition of maize drinks

The proximate composition of the maize drinks revealed that, the moisture content of the maize drinks were similar to work done by Ofudje et al. (29) who reported the moisture content of Kunu Zaki products made from millet, maize and guinea corn to be in a range from 82.0 to 90.7. Another similar report by Madilo et al. (9), showed the moisture content of Aliha (a maize fermented beverage) to be from 93.71 to 96.31. However, work done by Ramos et al. (30), indicated a slightly lower moisture content of corn milk-cow milk blended products (85.16-86.23), this may be as a result of the composition of the product, Ogori et al. (31), also reported the moisture content of malted yellow maize to be 70.41-76.81. Variations in the amount of moisture in a beverage can impact the development of microorganisms that ferment it and the flavor characteristic that results (32). Viscosity contributes to the mouthfeel of a drink, which is a key aspect of its sensory profile (33). The thickness or thinness of a drink can affect how satisfying it feels, and this can influence

consumer preference hence the moisture content of Ahoofe, Abebe and Dzifoo should be controlled to maintain the quality drinks. This can be achieved by ensuring that the maize is properly dried before processing and also storing it in a cool dry place before using it in making the drinks.

In terms of the mineral content (ash) of the maize drinks, Ramos et al. (30) and Ogori et al. (31) reported a similar ash content of malted yellow maize (0.21-0.31%) which is in line with this study's findings. However, Ofudje et al. (29) recorded 1.30-2.0% as ash content of Kunu Zaki products produced from millet, maize and guinea corn. The ash level is a crucial quality characteristic that can affect the drink's taste, texture, and stability (34). The ash contains minerals which are essential for nutrition. Certain minerals (magnesium, phosphorus, sulphur, manganese) are essential to the construction of proteins and enzymes. They are essential for healthy development, upkeep, an efficient immune system, and the defence against cell damage (35). From the results, Ahoofe possesses high minerals and hence it will provide good nutrition to consumers.

The crude fat in this study was less than workdone by Oladapo et al, (36), Ogori et al. (31), and Ramos et al. (30). Due to genetic differences, different maize cultivars naturally have different oil contents (37). Oil content may be inadvertently influenced by cultivating some varieties (Ahoofe) for increased nutritional density or biofortification (38). Generally speaking, yellow or orange maize differs from white maize in its lipid and carotenoid makeup (27). As demonstrated in this study, roasting at 150°C for 30 min may affect lipid stability. Roasting at high temperatures or for extended periods of time might cause fat components to volatilize or partially breakdown (39). The body uses crude fat for producing energy. Fat can generate more than twice as much energy per gram than proteins and carbohydrates (40). When it comes to controlling weight and general health, foods with low crude fat content usually contain fewer calories than foods with high fat content. By decreasing blood triglyceride and cholesterol levels, low-fat diets can help lower the risk of heart disease (40). The maize drinks from this study will be a good choice for consumers for weight management.

The crude protein in this study was less than the findings of Ofudje et al. (2016), Oladapo et al. (36), and Ogori et al. (31). Nutritionally, proteins are vital to human health. They can be used as fuel and are one of the components of body tissue (41). Furthermore, the crude protein in maize drinks were lower than that of barley (11.74-13.7%), and buckwheat hulls (5.57-16.67%) (42,43). The low amount of crude protein means that the maize drinks must be fortified with proteins to provide consumers with the necessary protein for energy and bodybuilding.

The total carbohydrate of the maize drinks is similar with the findings of Ogori et al. (31) who reported the carbohydrate content of malted yellow maize to be 2.21-13.58%. Carbohydrates are beneficial to general health especially in improving digestive health (44).

The total solids were inversely proportional to the moisture content of the drinks. The findings of the total solids agrees with work done by Ofudje et al. (29). Abebe having the highest moisture content (94.73%) recorded the lowest total solids (5.27%), and Honampa having the lowest moisture content (91.69%) recorded the highest total solids (8.30%). Considering to its

nutritional and functional qualities of total solids, it plays a major role in the formulation of food. The quality of a food product can be impacted by its total solids content (45). A drink's total solids content can have an impact on its flavor. A drink with a very low total solids may taste bland, and one with a high total solids may taste salty or bitter. The viscosity and consistency of maize beverages can be influenced by the total solids content. Because of their increased viscosity and slimy consistency, high total solids can lead to filtration issues in brewing industry (46). The optimal total solids of the maize drinks will enhance its acceptability by consumers.

The energy content of the maize drinks were in line with the findings of Madilo et al. (9) who reported the energy of Aliha (a maize-based traditional fermented beverage) to be from 21.65 to 57.7 Kcal/100g. However, this differs from the study by Oluwole et al., (47) who reported the energy levels of beverages produced from maize and sorghum to be between 135.40-172.75 Kcal. The primary sources of energy content were proteins and carbohydrates because the crude fat level was very low in all of the samples. The major source of total energy in all samples was carbohydrates. The highest energy values (33.20 and 33.25 Kcal/100g, respectively) were directly connected with the highest carbohydrate content, which was seen in samples such as Honampa (6.97%) and Mamaba (6.94%). Conversely, Ahoofe has the lowest energy value (20.80 Kcal/100g) and the lowest carbohydrate content (2.91%). Due to their lower levels in the samples, proteins also contributed to energy, but less so than carbohydrates. Ahoofe had the lowest energy value despite having the highest protein content (1.55%) due to its low fat and carbohydrate content. The moderate protein content (~1.25%) of Honampa and Mamaba contributed slightly to their high energy values, but the carbohydrate content was far more important. The body uses glucose from food to produce energy for both physical activity and internal processes. Mamaba and Honampa will be a good source of energy for consumers especially those who are always on the go as in contains 66.5 Kcal energy.

4.2. Colour profile of maize drinks

The lightness of the maize drinks differed from the findings of Sobowale et al. (48), and Masehlele et al. (22), on alcoholic drink produced from maize and fermented maize meal drinks respectively. Lightness of colour can boost customers' enjoyment of consumption and elicit positive feelings about the product (49) hence the product's lightness indicates that it will be selected by consumers when it’s on the market (Table 3).

The redness of the maize drinks may have been brought on by the maize's extended exposure to heat treatment (oven roating), which may have given it a darker hue (50). This report differed from the work done by Sobowale et al.(48), and Masehlele et al. (22), on alcoholic drinks produced from maize and fermented maize meal drinks respectively who reported the greenness of their sample. The maize drinks’ more enticing colours are indicated by the higher redness values; hence it will be appealing to consumers (Table 3).

Conversely, the natural pigment carotenoids are probably the cause of the yellowness values (50) in the maize drinks. This was confirmed in the chemical analysis of maize drink which showed Ahoofe to have

the highest beta carotene (Table 4). There was a statistically significant difference in the yellowness of the maize drink samples ($p<0.05$). This report differed from the results of Sobowale et al. (48), and Masehlele et al. (22), on alcoholic drinks produced from maize and fermented maize meal drinks respectively who reported the blueness of their sample. The maize drinks' more enticing colors are indicated by the higher yellowness values; hence it will be appealing to consumers.

4.3. Chemical composition of maize drink

The maize drinks contained beta carotene, but it contents differed from that reported by Awobusuyi et al., (51) on amahewu, (a maize cereal- beverage) who reported the beta carotene to be 3300 µg/100g.The may be due to the typed of maize used which was a pro-vitamin A biofortified. Carotenoids are the pigments that give maize its yellow hue. The body converts beta-carotene into vitamin A, which is necessary for immune system function, cell division, healthy vision, and other processes (52). Thus, ingesting these maize drinks may offer a substantial source of pro-VA carotenoids to consumers.

The phenolic content of the maize drinks also differed from that reported Zang et al. (53), who reported the phenolic content of maize drink to be 69.1 to 225.1 mg GAE/g. Cuevas-Montilla et al. (54), revealed that the phenolic content of nine Bolivian purple maize varieties was within 3.1-8.2 mg 337 GAE/g maize. Six coloured maize genotypes with phenolic content levels ranging from 4.5 to 10.5 mg GAE/g of maize was reported by Zilic et al., (55). A drink made from maize with a low phenolic content may have less antioxidant activity, which could lessen some of its health benefits. The maize drinks had elevated levels of antioxidant activity than those reported by Flores-Calderón et al., (56) 3.52 to 4.82 mmol TE/L. Antioxidants are beneficial to human health because they reduce the risk of age-related diseases such as cancer and cardiovascular disease (57).

The pH of the maize drinks were in line with the findings of Ofudje et al. (29) who reported the pH of Kunu Zaki products made from millet, maize, and guinea corn to be in a range from 3.8 to 5.0. However, Oladapo et al, (36) and Ogori et al. (31), reported slightly higher values of pH. The development of fermenting microorganisms and the drink's subsequent flavour profile can both be impacted by pH. Low pH levels can also provide some defence against the growth of microorganisms. pH levels that are too high or too low will stop microbiological growth (58). The low pH values of Ahoofe and Mamaba can prolong its shelf life by inhibiting microbial growth.

**5. Conclusion**

This study showed that maize drinks produced from different varieties of maize had adequate minerals, beta carotene and antioxidant activity suggesting it benefits for digestive health, weight management and a significant source of pro-vitamin A carotenoids. The maize drinks were acidic suggesting its ability to inhibit microbial growth and potentially extending shelf life. The color profile of the maize drinks differed significantly with Ahoofe having maximum yellowness due to the presence of carotenoids.

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**Authorship contribution**

Ophelia Tang: Conceptualization of idea, Resources, Visualization, Data curation, writing of original draft, writing of review and references.

Doreen Dedo Adi**:** Conceptualization**,** Supervision, Data curation, Formal analysis, Validation, Reviewing, and Editing.

John Acquah-Mensah: Methodology, Software, Validation, Data curation, review and editing.

**Conflict of interest**

The authors declare that they have no conflicts of interest.

**Data availability**

All necessary data has been duly supplied in this study.

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