



Comparative study on the nutritional value of local maize variety (Hakorin Hajiya) and improved varieties of maize (sammaz14 and golden strawberry)

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Abstract

Zea mays, commonly known as maize or corn, are a widely consumed staple crop with significant nutritional value. The proximate compositions of the seeds of the local maize variety (Hakorin Hajiya), the improved varieties of white maize (Sammaz14) and golden strawberry maize were analyzed in this study. The seed samples were dried on a clean tray and ground into powder for nutritional and mineral analysis using standard methods. The improved variety of white maize (Sammaz 14) was found to have higher percentage values of crude fat (0.22%), crude moisture (8%), crude protein (7.5%), sodium (42.5 mg/kg), potassium (140mg/kg), calcium (0.9 mg/kg), and magnesium (0.35 mg/kg). However, the local variety (Hakorin Hajiya) had higher crude ash (4%), fiber (0.07%). Golden strawberry maize had the highest carbohydrate (94.67%). This indicates that the seeds of the improved variety (Sammaz14) of white maize have higher nutritional value and can be used to supplement staple foods in both rural and urban areas. Additionally, individuals with hypoglycemia are advised to consume strawberry maize due to its high carbohydrate content. Overall, this study highlights the nutritional variations among different maize varieties and suggests the potential benefits of incorporating the improved variety of white maize (Sammaz 14) into diets to enhance nutritional intake.

Keywords: proximate analysis, nutritional value, improved maize variety, local variety

Introduction

Zea mays, commonly known as maize or corn, is an annual cereal crop belonging to the *Poaceae* family. It is cultivated worldwide for its grains, which are used as a staple food, animal feed, and in various industrial applications (Ranum *et al.*, 2014) [13]. Maize was domesticated by ancient indigenous communities in Mesoamerica during prehistoric times. Its domestication involved the cultivation of a wild grass called teosinte (Chaudhary *et al.*, 2013) [4]. Proximate composition analysis determines the major components of plant, including carbohydrates, proteins, fats, and moisture. Proximate composition analysis also aids in quality control and food safety assessments by determining the levels of moisture, protein, fats, and carbohydrates in plant samples. This analysis is particularly important in the food industry to ensure consistent product quality and safety for consumers. By quantifying the macronutrient content, researchers can assess the energy content, amino acid profile, and fiber content, providing insights into the nutritional value of plant-based foods (Rizzo *et al.*, 2013) [18]. Mineral composition analysis determines the presence and concentration of essential minerals such as calcium, iron, zinc, and magnesium in plant. This information is crucial for assessing the micronutrient content and bioavailability of plant-based foods, as these minerals are vital for various physiological functions and overall health (Gibson *et al.*, 2010) [5]. It helps identify potential deficiencies or excesses, guiding interventions and strategies to address nutritional imbalances (Gomes *et al.*, 2021).

The composition of macronutrients in maize can vary depending on the variety and processing methods (Suri & Tanumihardjo, 2016) [15]. Maize has been found to consist of approximately 72% starch, 10% protein, and 4% lipid as per reported by (Inglett, 1970) [6]. These macronutrients contribute to the energy density of maize, providing around 365 kcal per 100 grams, as reported by the USDA National Nutrient Database.

The protein quality of maize is relatively low because it lacks sufficient amounts of two essential amino acids; lysine and tryptophan. Additionally, the endosperm protein of maize kernels contains an excess of leucine. These deficiencies and imbalances in amino acid composition were identified by (Osborne and Mendel in 1914) [16]. Proteins stored in seed vegetative tissues and of plant account for much of the protein consumed directly as food by humans and livestock (Eliot, 1999). The protein content in maize kernels varies between the endosperm and germplasm, with the endosperm containing a lower concentration (8%) compared to the germplasm (18.4%). However, the endosperm provides the highest quantity of protein (78% versus 18%, respectively), as indicated by (Wilson, 1987) [19]. The crude protein in maize is typically estimated based on nitrogen content and consists of various protein fractions, including prolamins, glutelins, albumins, and globulins, which differ in their solubility properties according to studies by (Osborne, 1924 [16]; Nagy *et al.* 1941 [11]; Landry, 1980) [7].

After starch and protein, the third major nutritional component of maize kernels is fat, which is present in the form of oil. The fat content in maize kernels typically ranges from 3.5% to 6% of the total kernel weight, with an average of around 4.5%. The oil content can be influenced by the size of the kernel germ, larger germs generally associated with higher oil content (Nuss & Tanumihardjo, 2010) [10].

Maize contains various micronutrients that are essential for optimal health. Well-known human vitamin-related disorders like, beriberi, pellagra, anemia etc. could be addressed by maize consumption as it's a good source of vitamin B-complex, including thiamin (B1), niacin (B3), pantothenic acid (B5), pyridoxine (B6), and folate (B9). Vitamins in plant-derived foods can also be increased either through optimization of growth conditions, conventional plant breeding or through the use of transgenic techniques, a process known as biofortification (Muhammad *et al.*, 2021) [8]. Maize also provides minerals such as magnesium, phosphorus, potassium, and manganese, which are important for maintaining bone health, nerve function, and electrolyte balance (Soetan *et al.*, 2010) [14].

The present investigation aims to identify maize varieties with higher nutritional value for the benefit of consumers. Additionally, the study aims to compare the composition of three maize varieties to determine which one has a better nutritional profile. In this research we establish proximate level of protein, fibre, moisture, lipid and carbohydrate in local white maize (*Hakorin Hajiya*), improved varieties of white maize (Sammaz 14) and also golden straw berry maize. We also determine the mineral content of the three varieties (Focusing on calcium, potassium, sodium, magnesium and phosphorus). And lastly we compared the nutritional value of the seeds between the local white maize (*Hakorin Hajiya*), improved varieties of white maize (Sammaz 14) and golden maize.

Materials and methods

Sample collection

Seeds of the three varieties local maize (*hakorin hajiya*) and improved (Sammaz 14) of white maize and golden maize were used. While the golden maize and (*hakorin hajiya*) were procured from college of Agriculture zuru, The improved variety of (sammaz 14) were also procured from (IFAD) Sokoto.

Proximates analysis

Determination of crude protein

The crude protein content of all the seed were determined using the Kjeldahl method as follow:

- 1. Sample Preparation:** All the seeds were ground into a fine powder to ensure uniformity and increase the surface area for analysis.
- 2. Digestion:** A portion of the ground seeds sample was digested in concentrated sulfuric acid (H_2SO_4) with the addition of a catalyst, such as copper sulfate ($CuSO_4$). This step breaks down the organic matter and converts the nitrogen present in the protein into ammonium sulfate ($(NH_4)_2SO_4$).
- 3. Distillation:** After digestion, the ammonium sulfate solution were diluted with water and alkalinized using sodium hydroxide (NaOH). This raises the pH and converts ammonium ions (NH_4^+) into ammonia (NH_3).

- 4. Titration:** The liberated ammonia (NH_3) were distilled and collected in a known volume of acid solution, typically boric acid (H_3BO_3), with an indicator, such as methyl red or bromocresol green. The excess acid is then titrated with a standardized solution of hydrochloric acid (HCl).

- 5. Calculation:** The amount of nitrogen present in the sample, determined by the titration, was used to calculate the crude protein content. Nitrogen was multiplied by a conversion factor.

Determination of crude ash

The crude ash content of the samples was determined as follows:

- 1. Sample preparation:** Foreign materials or contaminants were removed from the samples of the plant material and dried at a low temperature to remove moisture.
- 2. Weighing:** The empty and clean crucible (ashing dish) was initially weighed.
- 3. Sample addition:** 2.0 grams of each sample were added to the crucible or ashing dish.
- 4. Ashing:** The crucible with the samples was placed in a muffle furnace or a furnace capable of reaching temperatures of $500^\circ C$. The temperature was slowly increased and maintained for about 4-6 hours to ensure complete combustion of organic matter. This process burns off the organic components, leaving behind the inorganic ash.
- 5. Cooling and desiccation:** the crucible from the furnace was removed and allowed to cool inside a desiccator to prevent moisture absorption from the surrounding air.
- 6. Weighing of ash:** The crucible with the ashed sample was allowed to cool to room temperature and weighed again.
- 7. Calculation:** The crude ash content was calculated using the formula:

$$\text{Crude Ash (\%)} = [(W_2 - W_0) / W_1 - W_0] \times 100$$

Where

W_0 = weight of empty crucible

W_1 = weight of sample fresh

W_2 = weight of sample dry

Determination of moisture

The 2.0 grams of each sample were added to empty moisture dish and placed into an air oven. The two samples were dried in the hot air drying oven at $110^\circ C$ at constant weight. The samples were then kept in a desiccators and allowed to cool after which the crucible with the dry sample was then weight and returned to the oven to ensure that the drying is complete. The weight was taken again. For each remaining samples, the moisture was determined using the following formula;

$$\text{Moisture (\%)} = [(W_2 - W_0) / W_1 - W_0] \times 100$$

Where

W_0 = weight of empty crucible

W_1 = weight of sample fresh

W_2 = weight of sample dry.

Determination of crude fat (Lipid)

Crude fat (lipid) was determined from the sample using n-hexane as the solvent as per standard protocol of (Bello *et al.*, 2020) [3].

Finally, the Lipid Content (%) was calculated using the formula below:

$$\text{Lipid Content (\%)} = [(B - A) / \text{Sample weight}] \times 100$$

Where

A = Weight of empty container

B = Weight of container with lipid extract

Determination of fiber (%)

2.0 g of the ground sample were weighed and put into a 1 liter control flask. Then 200ml of H_2SO_4 (1.25%) was added and then boiled gently for 30 minutes using cooling fingers to maintain a constant volume. It was then filtered through a poplin cloth and stretched over 9cm Buschner funnel and rinsed well with hot distilled water. The two samples were taken back into the flask with spatula and to it was added 100ml of boiling 1.25% NaOH. It was boiled gently to maintain a constant volume. Thereafter, it was filtered through a poplin cloth. The residue was washed thoroughly with distilled water and rinsed once with 10% HCl and twice with industrial methylated Spirit. It was then rinsed finally three times with petroleum ether (BP40- 60°C) and allowed to dry. The residue was then kept overnight at 105°C in the oven and was cooled in a desiccators. The two samples were weighted again and ashed at 55°C for 90 minutes in a muffle furnace, cooled weighted and again. Then the % fibre was calculated using the following.

$$\text{Fiber (\%)} = [\text{Dry weight} - \text{Ash weight} / \text{Weight of sample}] \times 100$$

Determination of carbohydrate

The nitrogen free extraction (NFE) referred to a soluble carbohydrate; it is not determined directly but obtained as a difference between the sum of crude ash, crude fibre, crude lipid and crude protein. The carbohydrate content from each sample was determined using the relation below:

$$\text{Carbohydrate content (\%)} = 100 - (\% \text{ Ash} + \% \text{ Crude fibre} + \% \text{ crude lipid} + \% \text{ crude Protein}).$$

Determination of sodium and potassium

Potassium and Sodium is obtained by flame photometer. The flame photometer was set by inserting appropriate filter usually by 768m μ for K and 589m μ wave length for Na respectively. The instrument was set to 100 transmittance by taken 2-10ppm of K and Na solution. The standard curve was prepared by plotting transmittance reading against concentration of standard K and Na solution.

Determination of calcium (Ca) and magnesium (Mg)

Calcium and magnesium were determined by Ethylenediaminetetra-acetic acid (EDTA) method. Calcium was obtained by pipetting 2ml of the aliquots of the samples

solution into filtration flask. Three drops each of Potassium Cyanide (KCN), Hydroxylamine hydrochloride ($NH_2OH.HCl$) and triethanolamine were added together with 0.3g of Murexide and it was then filtrated with EDTA solution to the end point from pink to Purple. The % Ca was determined as follows;

$$\text{Calcium (\%)} = [TV \times NA / 20 \text{ (ml of aliquots)}] \times 100$$

Where

TV= Titer value.

NA = Normality of acid.

For magnesium, after pipetting 2ml of aliquots sample solution into the titration flask, 5ml of buffer solution were added to get the 3 drops each of KCN, $NH_2OH.HCl$, triethanolamine and Eriochrome Black T (EBT) indicator were added and then filtrated with EDTA. The solutions turn from purple to blue (end point). Then the % Mg was calculated using the following formula;

$$\text{Magnesium (\%)} = (TV \times NA / (0.01 \text{ ml of aliquots EDTA})) \times 100$$

Where

TV= Titer value.

NA = Normality of acid.

Phosphorus estimation

Phosphorous (P) value was obtained using spectrophotometer. 2ml of the sample was pipetted into a 50ml volumetrically flask. After that 45ml of distilled and 2ml of ammonium molybdate solution were then added and mixed properly. Then 1ml of $SnCl_2 \cdot 2H_2O$ dilute solution was added and mixed again. After 5minutes, the reading was taken on the spectrophotometer at 660nm wave length and was calculated using the following formula

$$P = (\text{Abs} \times 0.61 \times DF \times DF) / \text{Atomic weight of phosphorous}$$

Where

P = phosphorous

Abs = Absorbance

0.61 = co-factor

DF = Dilution Factor (100)

30.97 = Atomic weight of P.

Results and discussion

Proximate and mineral composition analysis of plant plays a significant role in assessing their nutritional value, quality, and potential health benefits. These analyses provide valuable information about the macronutrient and micronutrient content of plants, helping researchers, nutritionists, and food scientists in various aspects of food research, product development, and dietary planning. It assists in developing balanced and nutritious diets by determining the availability of macronutrients in plant sources. This information is crucial for formulating specialized diets, such as those for athletes, individuals with specific dietary requirements, or those aiming to achieve certain health goals. It also helps in selecting appropriate food combinations and designing functional food products with optimized nutrient profiles.

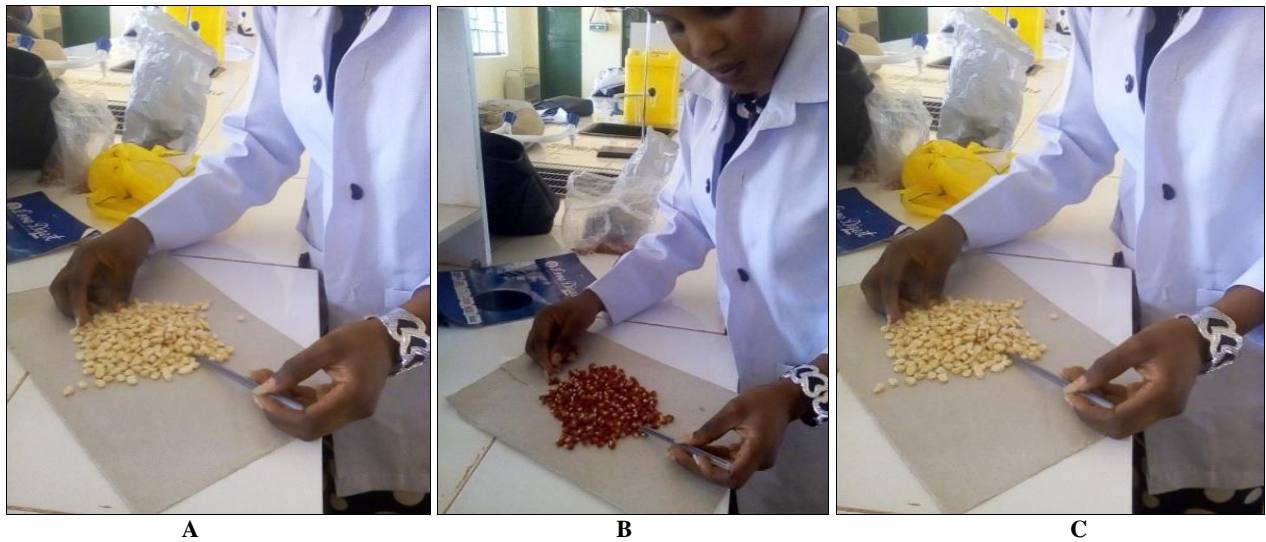


Fig 1: Maize varieties used; (A) Hakorin hajiya, (B) Straw berry, (C) = Sammaz (14)

Table 1: Nutritional compositions (%) of the three maize varieties

Parameters	Local variety (Hakorin Hajiya)	Golden Straw berry	Improved variety Sammaz14
Carbohydrate ate	93.64%	94.67%	93.37%
Ash	4%	3%	3%
Lipid	0.03%	0.04%	0.22%
Fiber	0.07%	0.02%	0.05%
Moisture	7.5%	6.5%	8.0%
Nitrogen	6.3%	6.8%	7.5%

Table 2: Mineral compositions (mg/kg) analysis of the three maize varieties

Parameters	Local variety (Hakorin Hajiya)	Golden Straw berry	Improved variety (Sammaz14)
Calcium (Ca)	0.1 mg/kg	0.14 mg/kg	0.9 mg/kg
Phosphorus (P)	3 mg/kg	4mg/kg	4 mg/kg
Sodium (Na)	37.5 mg/kg	40 mg/kg	42.5 mg/kg
Potassium (K)	100 mg/kg	100 mg/kg	140 mg/kg
Magnesium(Mg)	0.02 mg/kg	0.32 mg/kg	0.35 mg/kg

Proximate analysis

Carbohydrate content of the three maize varieties

The Result for proximate analysis of the three varieties of maize shown in table 1 and figure 2 shows that, golden straw berry was found to have higher percentage of carbohydrate of about 94.67% followed by local variety (hakorin hajiya) and improved variety with about 93.64%and 93.37% respectively. Carbohydrates provide

readily accessible fuel for physical performance and regulate nerver tissue (Whitney and Rolfes, 2005) [20]. The occurrence of carbohydrate as the highest parameter in this study is superior to that of (Nweke, 2010) [19]who reported that, Yellow corn gave the highest total carbohydrate of 76.57%, White corn had 76.00%, sweet corn and popcorn gave 69.25 and 74.12% carbohydrate content respectively.

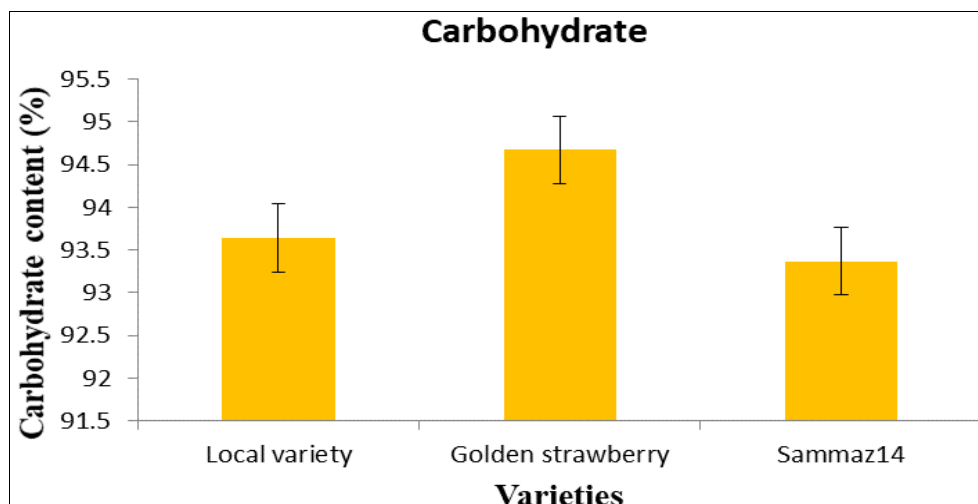


Fig 2: Determination of Carbohydrate Content in three varieties of maize

Crude Protein content of the three maize varieties

The Result for proximate analysis of the three varieties of maize shown in table 1 and figure 3 shows that, the improved varieties of white maize (Sammaz 14) and straw berry shows higher protein content of about 7.5.% and 6.8

% respectively compared to local maize variety (hakorin hajiya) with 6.3% which is in agreement with that of (Abba & Echezona, 2015) [1] who reported that, The percentage protein of (7.10 %) was recorded in Sammaz-14.

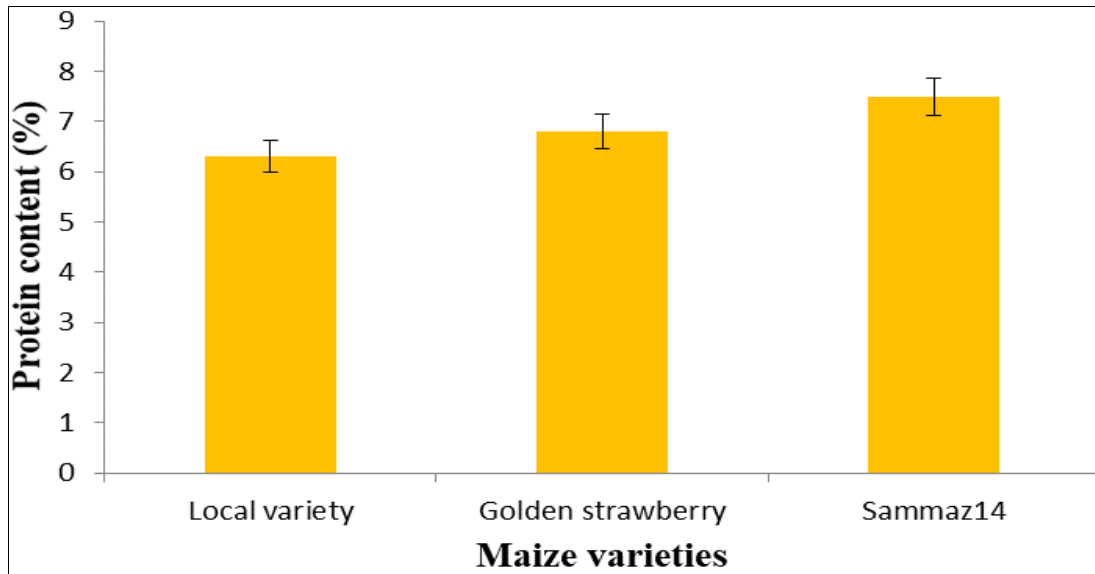


Fig 3: Determination of Protein Content in three varieties of maize

Crude fat content of the three maize varieties

The Result for proximate analysis of the three varieties of maize shown in table 1 and figure 4 shows that, Improved variety (Sammaz 14) was found to have higher percentage of crude fat of about 0.22% followed by golden straw berry and local variety (hakorin hajiya) with about 0.04% and 0.03% respectively which is not in agreement with that of (Abba & Echezona, 2015) [1] who reported that, The

percentage crude fat of (3.68%) was recorded in Sammaz-14. However, (Nweke, 2010) [9] reported 0.5%, 1% and 1.5% of crude fat in sweet corn, popcorn and white corn respectively. Crude fat is a universally stored form of energy in living organisms. They are major structural elements of biological membranes as phospholipids and sterols (Nelson and Cox, 2008) [12].

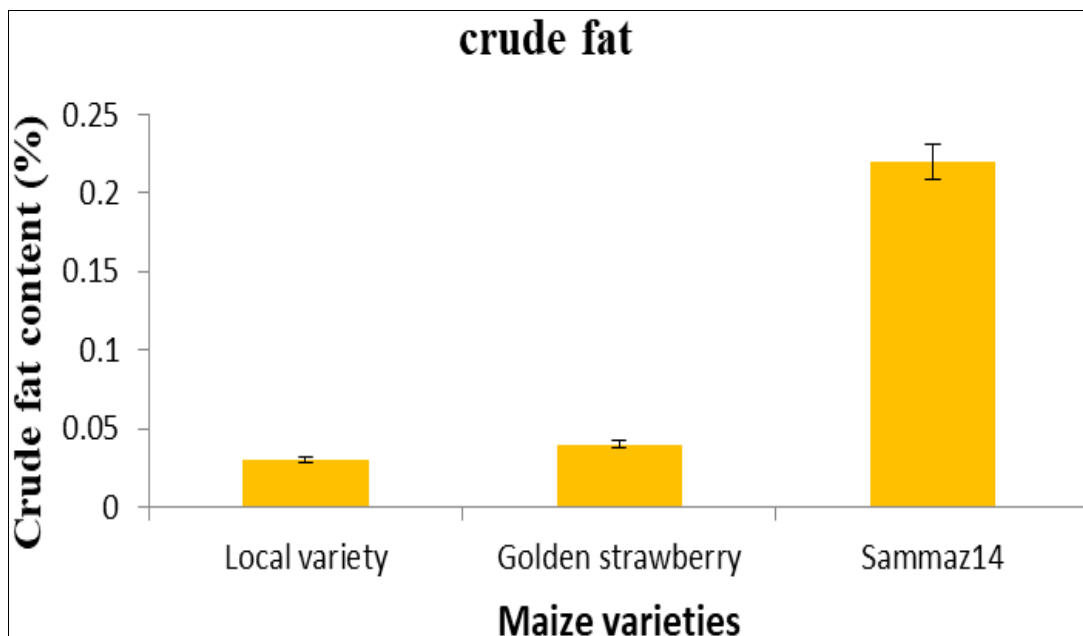


Fig 4: Determination of crude fat content in three varieties of maize

Crude Ash content of the three maize varieties

The percentage ash content of local and improve variety reported in this study fall within the range of 3% to 4% as shown in (Table 1 and figure 5) which is in agreement with the article published by (Anyaegbu *et al.*, 2020) [2] with a

range of 1.25% to 1.52%. The local variety (hakorin hajiya) were shown to contained higher crude ash content of about 4% compared with the two improved varieties (Sammaz14 and Golden strawberry) with crude ash content of 3%.

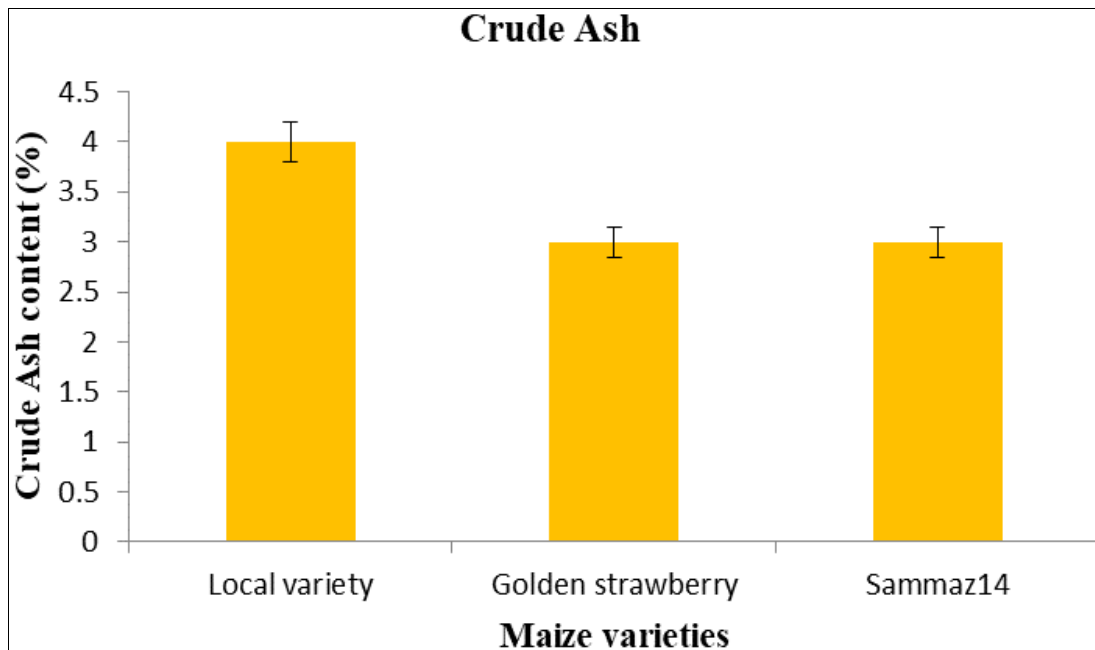


Fig 5: Determination of crude ash content in three varieties of maize

Moisture content of the three maize varieties

As shown in table 1 and figure 6. The moisture content of the Improved variety (Sammaz 14) was found to be higher with about (8%) followed by local variety and golden strawberry with 7.5 and 6.5 respectively. This result is not in

agreement with the findings of (Abba & Echezona, 2015)^[1] who reported in their published research article that sammaz 14 has moisture content of 3.12%. However, (Nweke, 2010)^[9] reported 13.0%, 11.0%, 8.0% and 12.5% of moisture content in sweet corn, popcorn, white corn and yellow corn respectively.

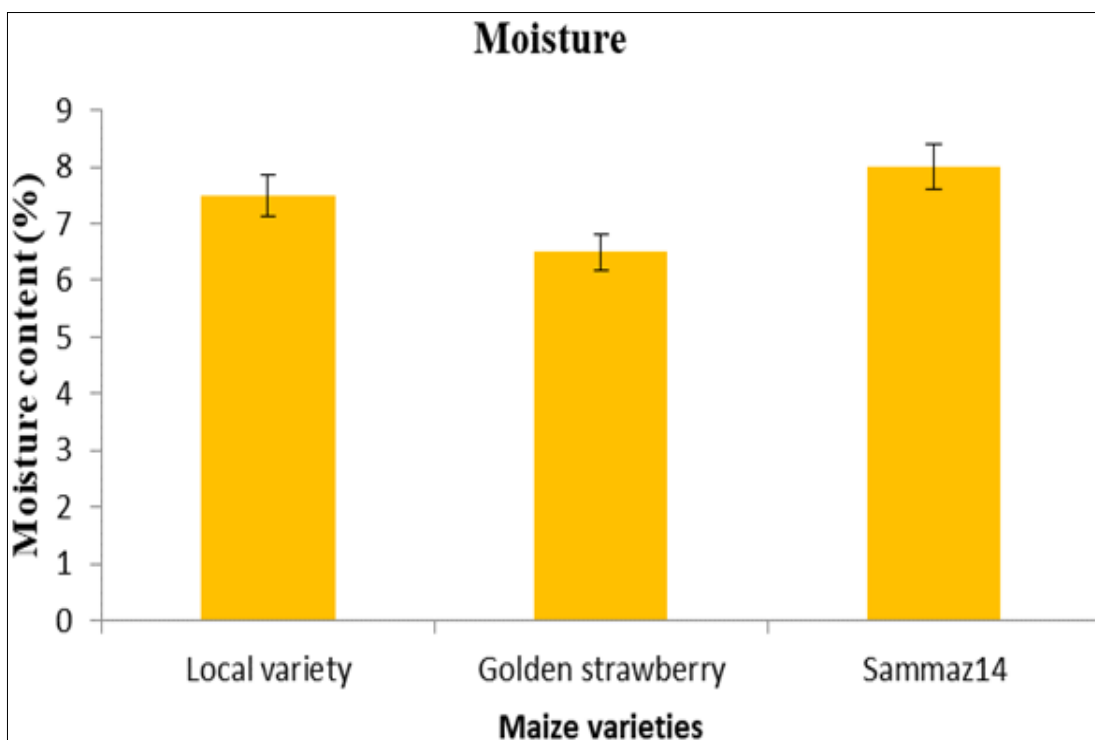


Fig 6: Determination of Moisture content in three varieties of maize

Fiber content of the three maize varieties

Crude fiber was found to be the fourth largest chemical present in maize grain after carbohydrate, protein, fat and moisture content. The percentage fibre was found at a range of 0.09% in local variety, 0.02% in golden straw berry and

0.05% in the improved variety (Sammaz14) which are in disagreement with the findings of (Ajabadenyi and Adebolu, 2005) who reported a fiber content in d range of 2.07% to 2.97% for maize varieties grain in Nigeria. The results were presented in Table 1 and figure 7.

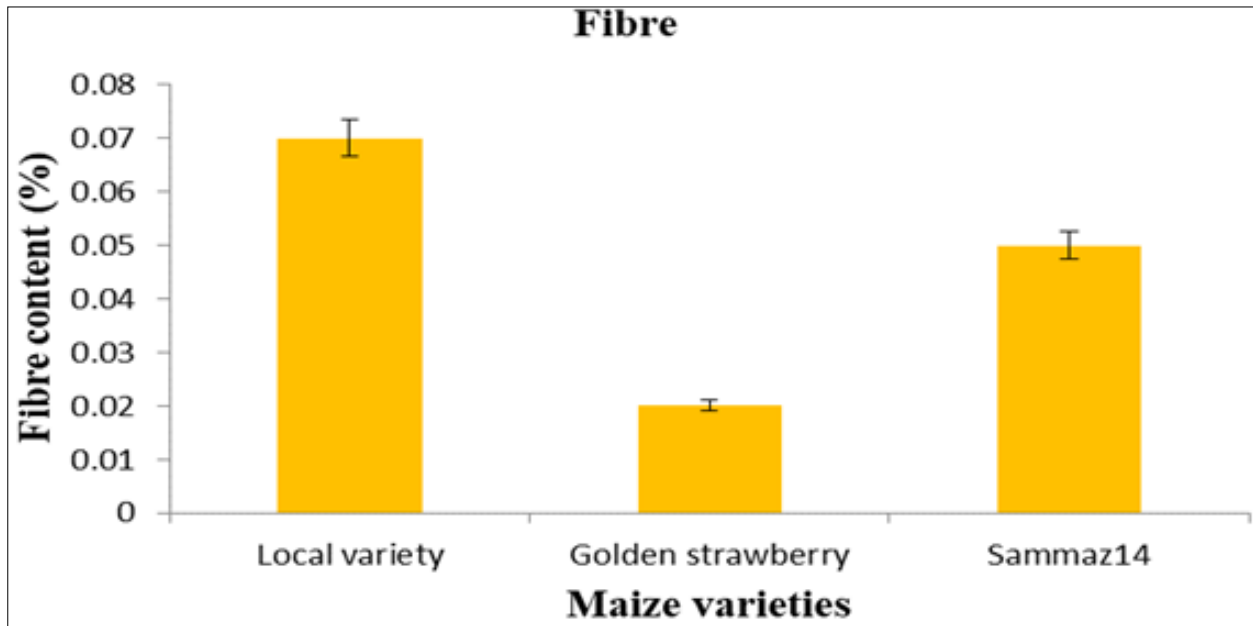


Fig 7: Determination of Fibre content in three varieties of maize

Mineral analysis

Calcium and Magnesium contents (mg/kg)

The study showed that, the improved variety maize has higher calcium of about 0.9 mg/kg followed by golden strawberry and local variety with 0.14 mg/kg and 0.1 mg/kg respectively. While the Magnesium content was found to be

higher in the improved variety maize with about 0.35 mg/kg followed by golden strawberry and local variety with 0.32 mg/kg and 0.02 mg/kg respectively as shown in Table 2 and figure 8. The high sodium content (42.5 mg/kg) in Sammaz14 variety and calcium (0.90 mg/kg) also indicates its importance in the formation of bones and teeth as well as muscle contraction aided by calcium.

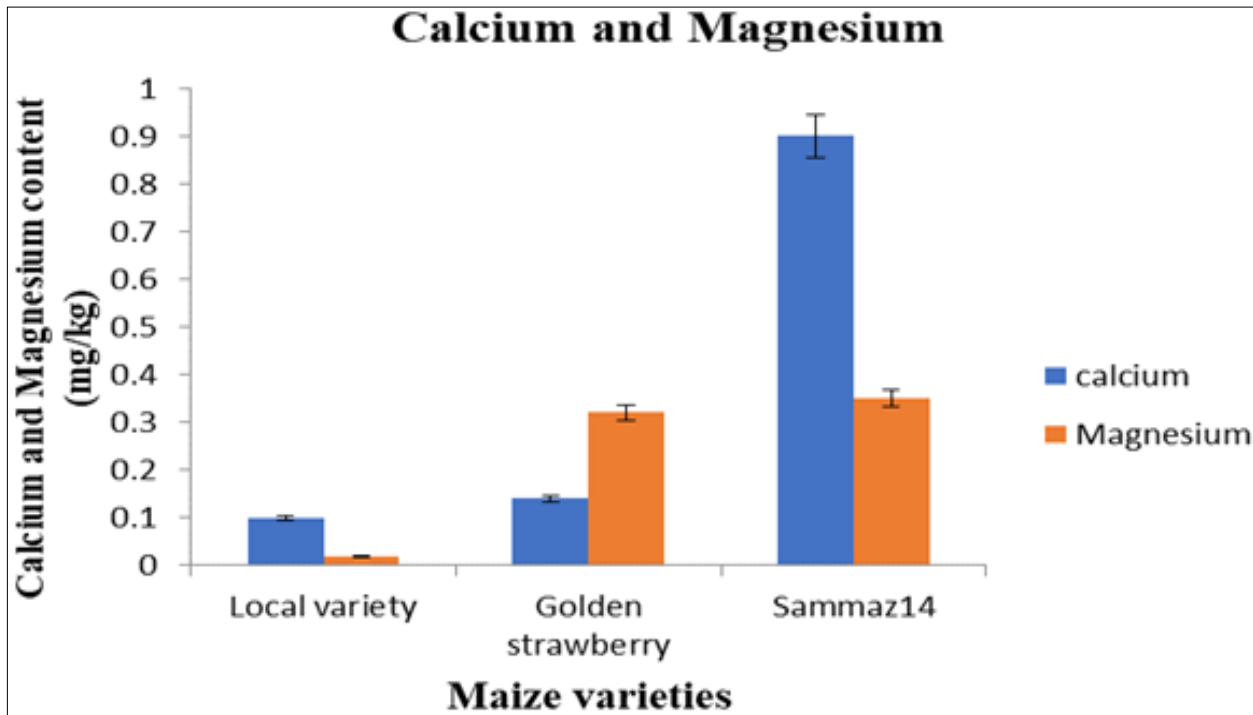


Fig 8: Determination of Calcium and Magnesium Content in three varieties of maize

Sodium and Potassium content of the three maize varieties

The study showed that the improved variety maize has higher sodium of about 42.5 mg/kg followed by golden strawberry and local variety with 40 mg/kg and 37.5 mg/kg respectively. However, potassium was also found to be

higher in improved variety of about 140 followed by golden strawberry and local variety with 100 mg/kg as shown in Table 2 and figure 9. The high potassium (140 mg/kg) and magnesium (0.35mg/kg) detected in this study indicates the ability of Sammaz14 variety to help lower blood pressure as reported by (Otsuki *et al.*, 2010) [17].

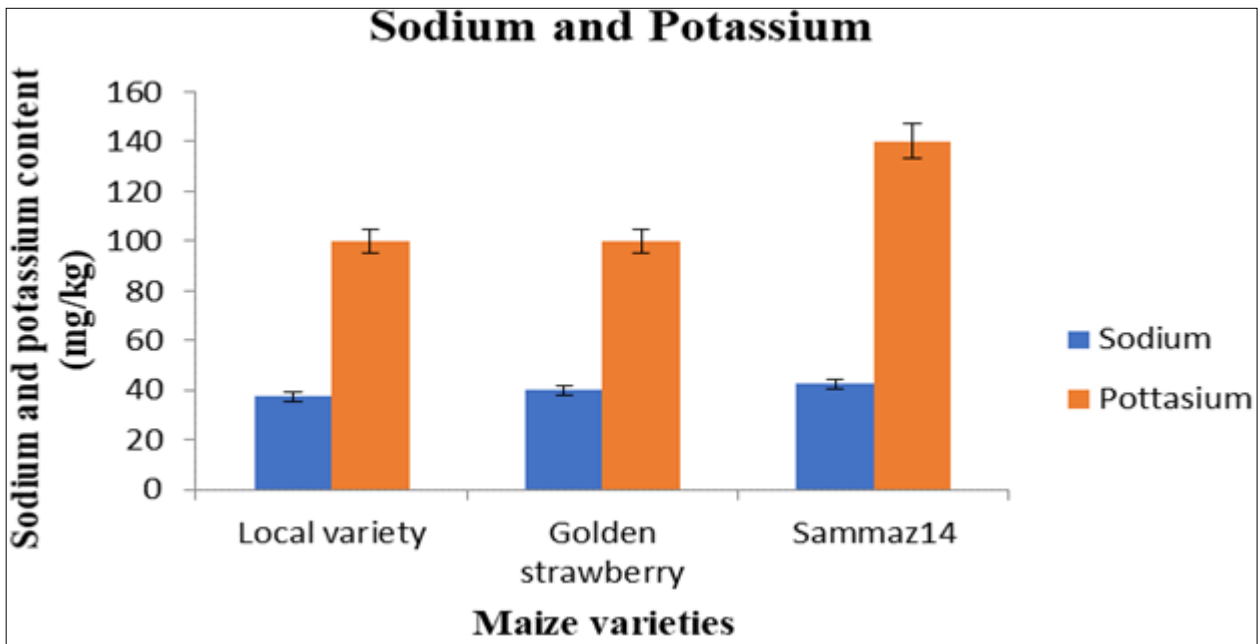


Figure 9: Determination of Sodium and Potassium Content in three varieties of maize

Phosphorus content of the three maize varieties

The study showed that the improved variety maize (Sammaz 14) and golden strawberry was to contained higher phosphorus content of about 4.0 mg/kg followed by local

variety with 3.0 mg/kg as shown in Table 2 and figure 10. The high value of phosphorus content (4.0 mg/kg) in (Sammaz 14) shown in this study which is very vital in bone formation indicates its importance in our body system.

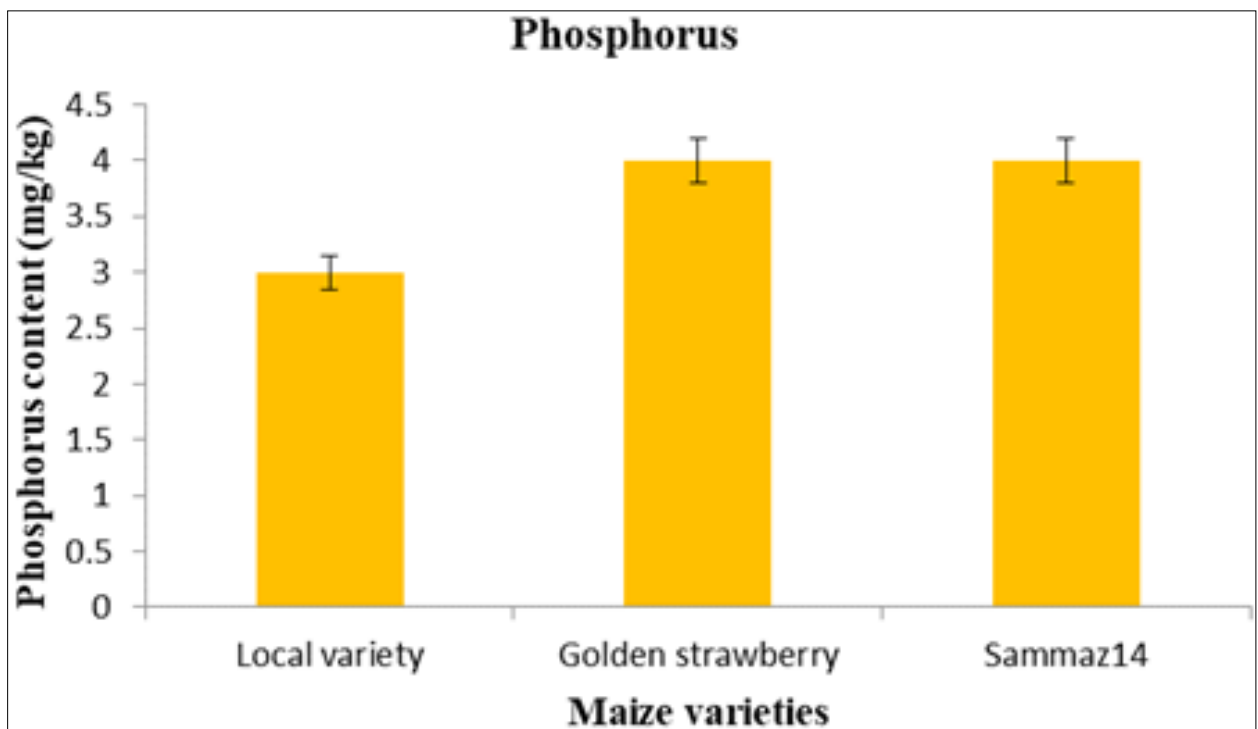


Fig 10: Determination of Phosphorus Content in three varieties of maize

Conclusion

The analysis carried out on three different varieties of maize indicates their Nutritional (Proximate) compositions. The study showed the varying level of moisture, ash, crude fibre, crude protein, lipid and carbohydrate content among the three different varieties of white and golden strawberry maize, Improved variety (SAMMIZ14) was found to have higher percentage value of lipids crude protein, moisture, crude ash, sodium, potassium, calcium, magnesium, while strawberry maize was observed to have a higher amount of

carbohydrate as shown in table 1 and 2 respectively. This shows that the improved variety (Sammaz14) variety of white maize is rich in nutrient and can be used to supplement the staple food in both local and urban area. The nutritional constituents of Sammaz14 could therefore, be used as a reason for use of it as an important dietary source of nutrients in a food based approach for combating micronutrient deficiency. The mineral analysis indicates that (Sammaz14) contain macro/major elements which are needed in high quantity in meals with potassium being the

highest; Sodium and Magnesium were also found to be abundant in this plant. These are all good indications of high nutritive value

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