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COMPARATIVE NUTRITIONAL QUALITY OF SM 27, SM 50 and SM 51 AS IMPROVED VARIETIES OF MAIZE (*Zea mays* L.)

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Abstract
Three varieties of maize (SM 27, SM 50 and SM 51) were investigated for their proximate values and anti-nutritional contents. The results showed that moisture content was between 6.0±0.00 (SM 51) and 11.50±0.00 (SM 50 and SM 27). Variety SM 27 had the largest quantity of lipid (1.98±0.04) and protein (25.20±0.44) while SM 50 was the richest in carbohydrate content (62.41±0.39). Only protein content was significantly different depending on the varietal type (P<0.050. The concentration of the three anti-nutrients varied significantly depending on the variety type (P<0.05). Cyanide was within 0.16-0.41mg/100g; oxalate was within 1.02-14.21 mg/100g. SM 27 had the highest amount of oxalate and phytic acid while SM50 had the highest of cyanide. Results showed a high positive correlation between cyanide and moisture (0.993); oxalate and lipid (0.949); as well as between phytic acid and protein in a perfect manner (1.000). High negative relationship was established between carbohydrate and protein (-0.950); cyanide and fibre (-0.882) as well as phytic acid carbohydrate (-0.959). Among the three varieties, SM50 appeared to be best in nutritional values being the richest in carbohydrate and moisture which are the basic constituent of typical starchy food. This variety also contained the lowest amount of phytic acid. It is recommended to growers and breeders. This study suggests an improvement in the carbohydrate content of maize so as to reduce the phytic acid level based on the negative relationship established between them.

Key words: *Zea mays,* Improved varieties, Nutrients, Anti-nutrients, Correlation

Introduction
Maize (*Zea mays* Linneaus) is a widely consumed annual cereal crop cultivated globally. It is of the family Poaceae and considered to be a staple food in many parts of the world (Tajamu *et al*., 2016). Its domestication and diversification by indigenous farmers rank as one of the greatest accomplishments of plant breeding. Archeological records suggest that maize was first brought into cultivation in Mexico and Central America (Hossain *et al.,* 2016); it is a third leading crop of the world after rice and wheat, the world production of maize was 967 million metric tons and due to its highest yield potential among the cereals it is known globally as 'queen of cereals' (Tajamu *et al*., 2016). In Nigeria, it is the most important cereal crop next to sorghum (Ape *et al.,* 2016). Maize has a variety of uses, it provides food and fuel for humans, feeds for animals; and can be used as raw materials in manufacturing industries (Dei, 2017). Its grains have great nutritional values and can be processed into various types of products such as cornmeal, grits, starch, flour, tortillas, snacks, and breakfast cereals (Hossain *et al.,* 2016). It can be eaten boiled, roasted, fried or popped (Ape *et al.,* 2016). Several studies have been conducted on the nutritional composition of maize, it has been found to contain a lot of beneficial nutrients ranging from carbohydrate, protein, macro elements, minerals, vitamins to phytochemicals (Ndukwe *et al.,* 2015; Hossain *et al.,* 2016; Sheng *et al.,* 2018). Little work has been done on the comparison of the nutritional composition of different maize varieties in south-western Nigeria; hence, this study aims to investigate the

proximate composition of different varieties of maize grown in this region of Nigeria. Knowledge of the differences in proximate composition will help in selecting the best variety for human and animal consumption. Maize is a multipurpose crop, providing food and fuel for human beings, feed for animals, poultry and livestock. Its grains have great nutritional value and are used as raw material for manufacturing many industrial products (Afzal *et al*., 2009). Its grains are important for the production of oil, starch and glucose (Niaz and Dawar, 2009). Moreover, Food composition data is important in nutritional planning and provides data for epidemiological studies (Ali *et al*., 2008). Breeding efforts have produced different maize varieties for adoption by growers and consumers. However, there is limited information about the nutritional composition in emerging maize varieties. The aim of this study was to determine the proximate analysis and the anti-nutritional factors in three varieties of selected maize. Specifically, it was designed to determine the amount of carbohydrates, protein, lipids, fibre, ash and moisture contents present in SM 27, SM 50 and SM 51 varieties; to determine the concentrations of phytic acid, cyanide and oxalate present in the maize samples as anti-nutrients and to determine the relationship among the biochemical compounds investigated using Pearson's method

Materials and Methods

Sample Collection and Identification

The seeds were collected from seed Centre, College of Agronomy Joseph Saawuan Tarka University, Makurdi (JUSTUM)

Method for Proximate

Moisture content determination

Moisture content was determined using the conventional method as described by Kumar *et al*. (2021) and the Association of Official Analytical Chemists (AOAC, 1995). Three moisture cans were dried in the oven and put into desiccators to cool before weighing. Exactly 5g of each sample was put in each of the moisture cans, placed in the oven and dried at 105ºC for 2 hours. It was removed and placed in a desiccator to cool before weighing. The cycle of heating, cooling and weighing was repeated until constant weight was obtained. The moisture content was determined by weight difference and expressed as a percentage of sample weighed.

$$\% \text{ Moisture } \frac{w2-w3}{w2-w1} \text{ x } \frac{100}{1}$$

$$w1 = \text{weight of the empty moisture can}$$
$$w2 = \text{weight ofcan and sample before drying}$$
$$w3 = \text{weight of can and sample after drying}$$

Crude protein determination

The Micro-kjeldahl method as described by AOAC (1995) and Kumar *et al.* (2021) was used to determine the protein content of sample. Exactly 2g was mixed with 10ml of concentrated tetraoxosulphate (VI) acid in a Kjeldahl digestion flask. A tablet of selenium catalyst was added and the mixture was heated under a fume cupboard. The digest was transferred into a 100ml volumetric flask. Exactly 10ml of the digest was mixed with equal volume of 45% sodium hydroxide (NaOH) solution and poured into a kjeldahl distill apparatus. The mixture was distilled and the distillate was collected into a 4% boric acid solution containing 3 drops of Zuazaga indicator (mixture of methyl red and bromacresol green) to obtain a total of 50ml distillate. The distillate obtained was titrated againt 0.02N H_2S0_4 solution. Titration was done from the initial green color to a deep red or pink end point. The total nitrogen was calculated and multiplied with the factor 6.25 to obtain the crude protein content.

$$\% \text{ Crude protein} = \%N6.25$$

$$\% \text{ N2} = \frac{(100x)\text{Nx14xVfxT}}{\text{w x 100 x VA}}$$

$$\text{W} = \text{weight of the sample}$$

N = Normality of filtrate ((H_2S0_4) = 0.02N

V_F = Total volume of the digest = 100ml

V_A = Volume of the digest distilled

Determination of fat content

Fat content of the samples was determined by the solvent extraction method using a soxlet apparatus (AOAC, 1995; Mathias *et al.,* 2020). Five gram (5g) of each sample was wrapped Whatman number one filter paper. The wrapped sample was put in a soxlet flask of the reflux connected to a condenser by heating the solvent in a flask through electro thermal heater. It was vaporized and condensed into the reflux flask. The process lasted for 4hours before the defaulted samples were removed and reserved for crude fibre analysis. The solvent was recovered and extracting flask with its oil content was dried as residual solvent. After cooling in the desiccator, the flask was reweighed. The weight of the fat (oil) extracted was expressed as percentage of the sample weight using the formula given below

$$\% \text{ of fat} = \frac{w2 - w1}{w1} x \frac{100}{1}$$

W = weight of the sample

W_1 weight of empty extraction flask

W_2 = weight of flask and oil extract

Ash content determination

The furnace incineration gravimetric method was used in the determination of the ash content (AOAC, 1995; Mathias *et al.,* 2020). The crucibles were dried in an oven and cooled in the desiccators before weighing. Approximately 5g of the sample was weighed and put into the crucible, covered and placed in a muffle furnace at a temperature of 70^{o}C. The temperature was maintained for 2 hours until a whitish ash was obtained. After two hours, the muffle furnace was switched off and the crucibles were removed and placed in sample desiccators to cool. The crucibles containing the samples were weighed and the percentage ash content was determined.

$$\% \, Ash = \frac{w2 - w3}{w2 - w1} x \, \frac{100}{1}$$

W_1 = weight of the crucible

W_2 = weight of sample crucible

W_3 = weight of crucible + ash

Determination of crude fibre

This was determined according to the method described by AOAC (1995). Approximately 5g of each sample was defatted (during fat analysis). The defatted sample was treated with 200ml of 1.2% H_2SO_4 and boiled under reflux for 30 minutes. The resultant mixture was filtered by washing with several portions of hot water using a two-fold muslin cloth to trap the particles. The washed samples were carefully transferred to a beaker and boiled for 30minutes with 200ml of 1.25M NaOH solution. The digestion sample was washed

severally with hot water. The washed sample was carefully scrapped into a weight porcelain crucible and dried in the oven at 150°C for 3hours, cooled in desiccator and weighed. The cooled sample was ashed in a muffle at 550°C for 2hours, cooled in a desiccator and reweighed. The crude fibre content was calculated as:

$$\% \text{ Crude fibre} = \frac{\text{loss in weight incinertion}}{\text{weight of sample}} \text{x} \frac{100}{1} = \frac{w2 - w3}{\text{weight of sample}}$$

W_2 = weight of crucible sample after washing and drying in oven
W_3 = weight of crucible + sample ash

Determination of Carbohydrates
Carbohydrates determination was carried out as Nitrogen free extraction (NFE) as given by Chauldry and Malik (2000). The NFE was calculated in % as: NFE = 100 - % (a+b+c+d+e) where: a= protein, b= fat, c= fibre, d= ash, e= moisture

Methods for Determination of Anti-Nutritional Factor
Oxalate determination
This was determined according to the method described by AOAC (1995). Exactly 0.5g of sample was weighed into 100ml conical flask, and 15ml 3M H_2S0_4 was added and stirred for 1hour with magnetic stirrer. This was filtered using No 1 Whatman paper. Exactly 5ml of filtrate was titrated with 0.05M of KMnO4 solution until faint pink colour persisted for 30 seconds. The oxalate content was calculated by taking 1ML 0.05M KMnO4 as equivalent to 2.2mg oxalate.

Phytic acid determination
Titrimetric method as described by AOAC (1995) was used. Exactly 2g of sample was soaked in 100mls 2% HCl for 3hours and then filtered. 25ml of filtrate was places in a 100ML conical flask + 5MK of NH4SCN solution was added as indicator + 50ml of distill water added to give it proper acidity (PH= 4.5) this was titrated with $FeCl_3$ solution containing 0.005ml of Fe^{3+} per ml of solution until a brownish yellow colour persist for 5minutes. Phytin Phosphorus (PP) was determined and the phytic acid content was calculated by multiplying the value of PP by 3.55. Each mg of iron equal 1.19mg of PP.

Fe equivalent=1.15x titer value
PP= titer valuex1.19x1.95
Therefore, phytic acid =1.95x1.19x3.55x titer value.

Cyanide determination
Exactly 2.5g of sample was grinded into a paste and was dissolved in 50ml of distilled water in a conical flask; this was left over night for cyanide extraction. The extract was filtered. Four millimeter of alkaline picrate was added to 1ml of sample filtrate and incubates in a water bath for 5minutes. After colour development (reddish brown colour), the absorbance was read at 450nm against blank (AOAC, 1995).

Data analysis
Data analysis was done on the Minitab 17.0 application package. The mean and standard error of the mean were computed. Chi Square test was applied as a non-parametric test of dependence. The One Way ANOVA (Analaysis of Variance) tool was used to test the differences in means of varietal nutrients. Mean separation was done using the Fisher's method at $P \leq 0.05$ level of significance. Pearson's correlation showed the relationships among the proximate and anti-nutritional components of maize.

Results and Discussion

The outcome of proximate analysis (as expressed in percentages) is presented in table 1. Moisture content was between 6.0±0.00 (SM 51) and 11.50±0.00 (SM 50). Varity SM 27 had the largest quantity of lipid (1.98±0.04) and protein (25.20±0.44) while SM 50 was richest in carbohydrate content (62.41±0.39) only protein content was significantly different depending on the varietal type (x^2=7.21, P<0.05) as shown in figure 1. Grand mean contents for the proximate arrangement among the three varieties of maize are given as: 9.33±1.69 (moisture), 11.00±0.29 (ash), 4.42±0.10 (fibre), 1.55±0.24 (lipid), 19.29±4.82 (protein) and 54.41±4.45 (carbohydrates), the latter being the most abundant in maize seed (figure 1). Carbohydrate was found to be the largest nutritional component of maize where SM 50 (62.41%) recorded the highest amount. This amount was lower than the 73.3% reported in maize by Mlay *et al*. (2005). The present outcome was consistent with the report given by Kasote *et al*. (2020) who analyzed the lipid and protein content in selected maize varieties and found almost the same values in lipids and proteins as reported in this work. In another study, the ash content in maize as reported by Kasote *et al*. (2016) was in tandem with the present report. The lowest moisture content (6.0%) was recorded in SM 51 variety, a property that may add to the stability and quality of product because grains that contain high moisture are subject to rapid deterioration from mold growth, and insect damage (Suleiman *et al*., 2013; Sweets, 2018).

Chi square analysis (figure 2) shows that the concentration of the three anti-nutrients varied significantly depending on the variety type (P<0.05). This may be due to genetic factors. Cyanide was within 0.16-0.41mg/100g; oxalate was within 1.02-14.21 while phytic acid was between 9.23-36.08mg/100g. Boxplots revealed that SM50 had the highest of cyanide (figure 3) while SM27 had the highest amount of oxalate (figure 4) and phytic acid (figure 5). Mean comparative analysis of anti-nutritional factors showed that SM27 was richer in all anti-nutrients than other two varieties (figure 6). The quality nutritional components reported in this study conflict with the anti-nutrients especially in SM50 that was the riches in both carbohydrate nutrient and cyanide anti-nutrient. This finding is in agreement with the work of Chaven and Kadam (2019) who found a significant amount of toxic or anti-nutritional substances in some cereals. This is also in tandem with the observations given by Udenigwe and Lin (2021). According to the authors, phytate is widely distributed in high amount in mature legumes, cereal grains and oil seeds. Many of the anti-nutrients have either a direct or indirect effect on the immune function and nutritional status of the body (Pariza, 2016; Daud *et al.,* 2021; Haldar and Chatterjee, 2021). Some of these substances reduce the anti-nutritional value of foods by interfering with mineral bioavailability and digestibility of proteins and carbohydrates (Chaven and Kadam, 2019).

Due to the high amount of anti-nutrients reported in this work, sustainable approaches must be adopted to reduce them. This may include processing of grains before consumption. Some authors earlier found that soaking of grains before cooking reduced some anti-nutrients as cooking alone failed to record any success (Ganesan *et al.,* 2017). This is because processing may affect the physical, chemical and/or biological characteristics of foodstuffs since structural alterations and degradation of components may occur (Ratti, 2018). Table 3 gives the correlation coefficients among the nutrients and anti-nutrients. Results showed a high positive correlation between cyanide and moisture (0.993); oxalate and lipid (0.949); phytic acid and ash (0.770) as well as between phytic acid and protein in a perfect manner (1.000). High negative relationship was established between carbohydrate and protein (-0.950); cyanide and fibre (-0.882) as well as phytic acid carbohydrate (-0.959). Tanaka, *et al.* (2014) reported that phytic acid rapidly

accumulates in the aleurone layer of seeds during the ripening period accompanied by storage substance such as starch lipids.

Correlation analysis shows that reduction in the lipid and ash components may also reduce the oxalate and phytic acid components respectively, while improvement on the carbohydrate may reduce the phytic acid in these grains. It also suggests the need to reduce the moisture content of the maize grain as this may reduce the cyanide content based on the nature of relationship between the two variables. Purposeful breeding may be employed to produce quality maize that incorporates balanced mixes of basic nutrients with reduced anti-nutritional factors in the overall interest of the consumer and food security.

Table 1: Proximate composition in three varieties of maize

Varieties	Moisture (%)	Ash (%)	Fiber (%)	Lipid (%)	Protein (%)	Carbohydrate (%)
SM 27	10.50±0.00	11.00±0.00	4.29±0.01	1.98±0.04	25.20±0.44	47.03±0.40
SM 50	11.50±0.00	10.5±0.00	4.36±0.01	1.50±0.03	9.75±0.42	62.41±0.39
SM 51	6.0±0.00	11.5±0.00	4.62±0.01	1.17±0.04	22.93±0.10	53.79±0.06
Grand mean	9.33±1.69	11.00±0.29	4.42±0.10	1.55±0.24	19.29±4.82	54.41±4.45

Moisture: χ^2 (Variety Vs Moisture content) = 1.84, P=0.399 (P>0.05)
Ash: χ^2 (Variety Vs Ash content) = 0.045, P=0.978 (P>0.05)
Fiber: χ^2 (Variety Vs Fiber content) = 0.01, P=0.993 (P>0.05)
Lipid: χ^2 (Variety Vs Lipid content) = 0.214, P=0.898 (P>0.05)
Protein: χ^2 (Variety Vs Protein content) = 7.21, P=0.027 (P<0.05)
Carbohydrate: χ^2 (Variety Vs Carbohydrate content) = 2.184, P=0.335 (P>0.05)

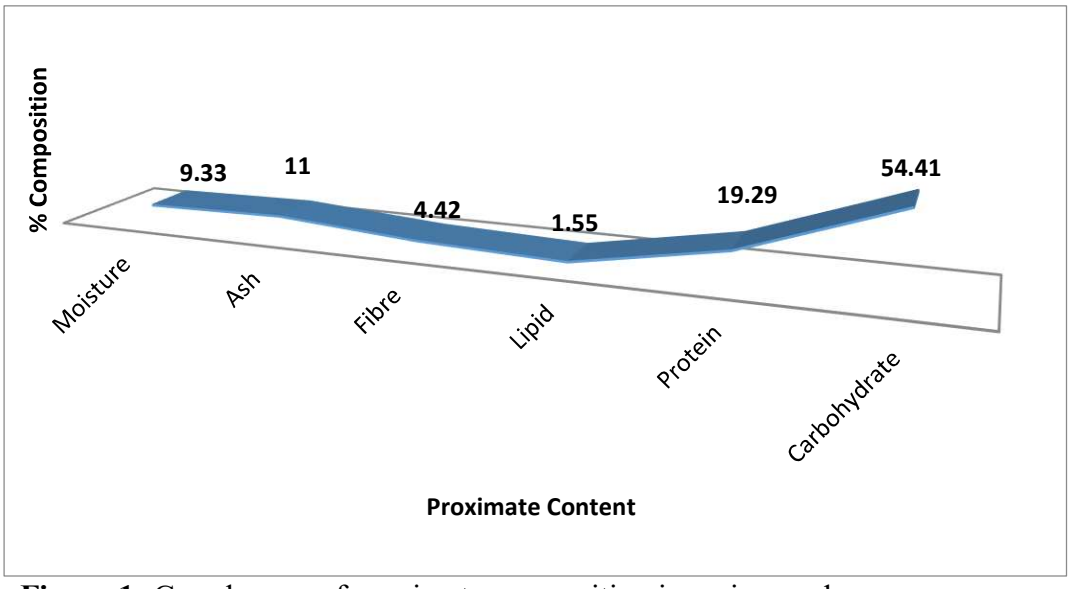

Figure 1: Grand mean of proximate composition in maize seeds

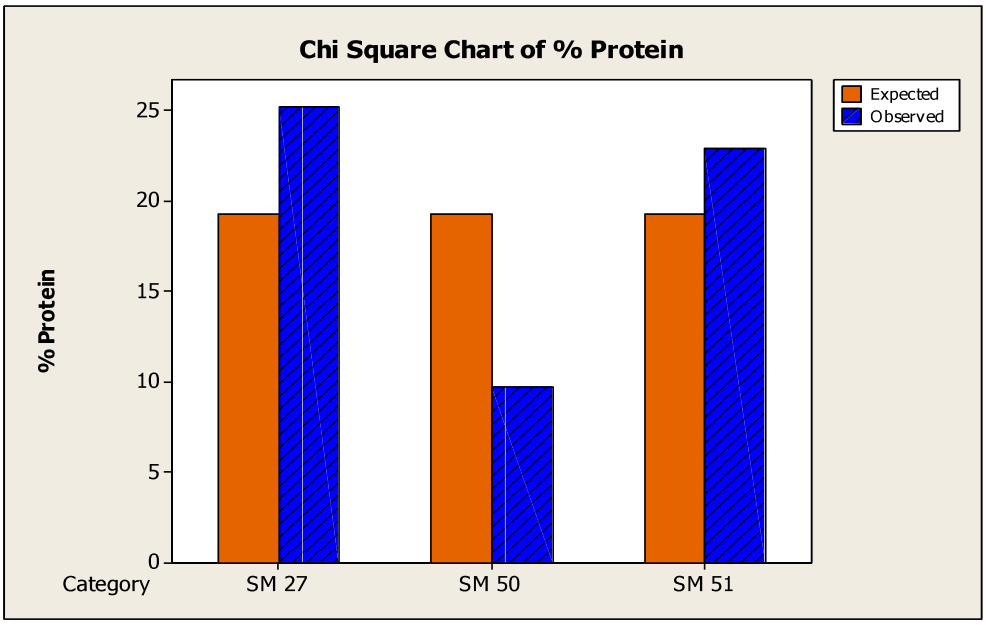

Figure 2: Chi Square distribution of protein contents in three varieties of maize

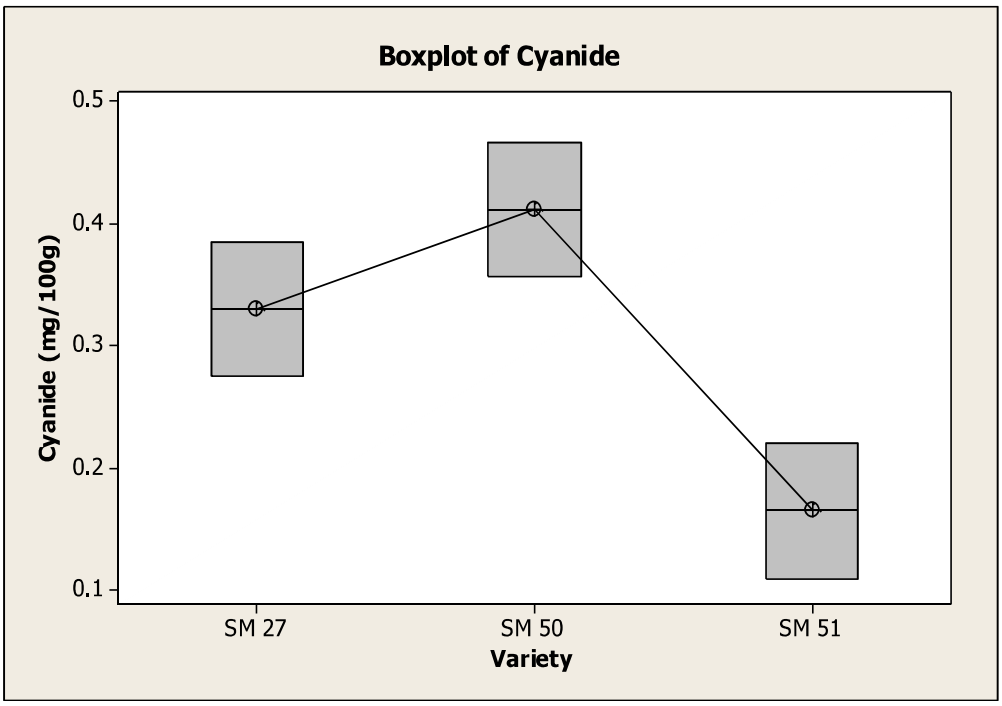

Figure 3: Boxplot of cyanide content in three varieties of maize

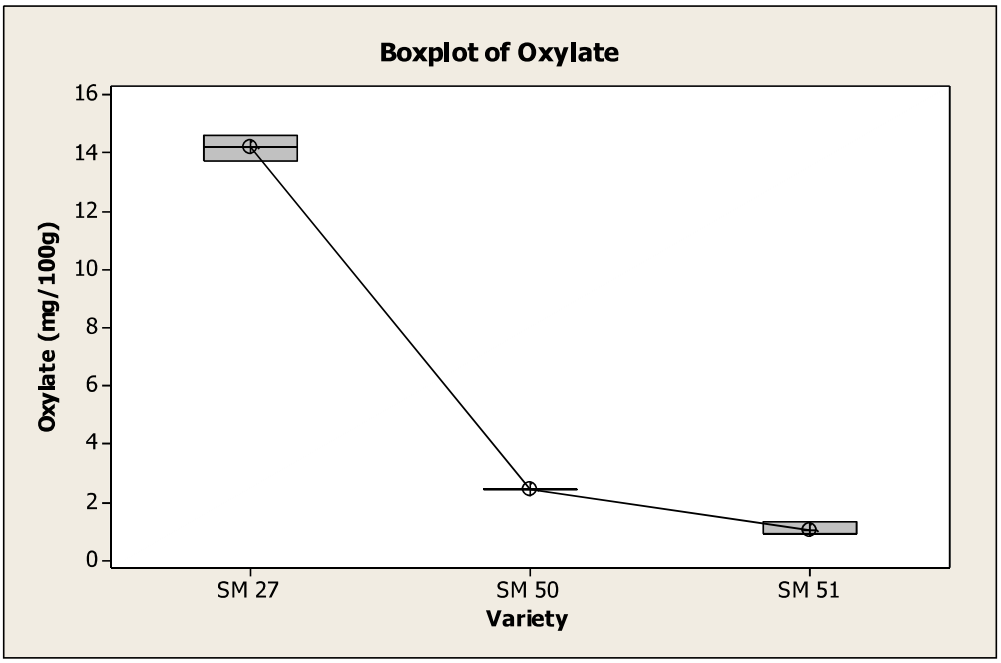

Figure 4: Boxplot of oxalate content in three varieties of maize

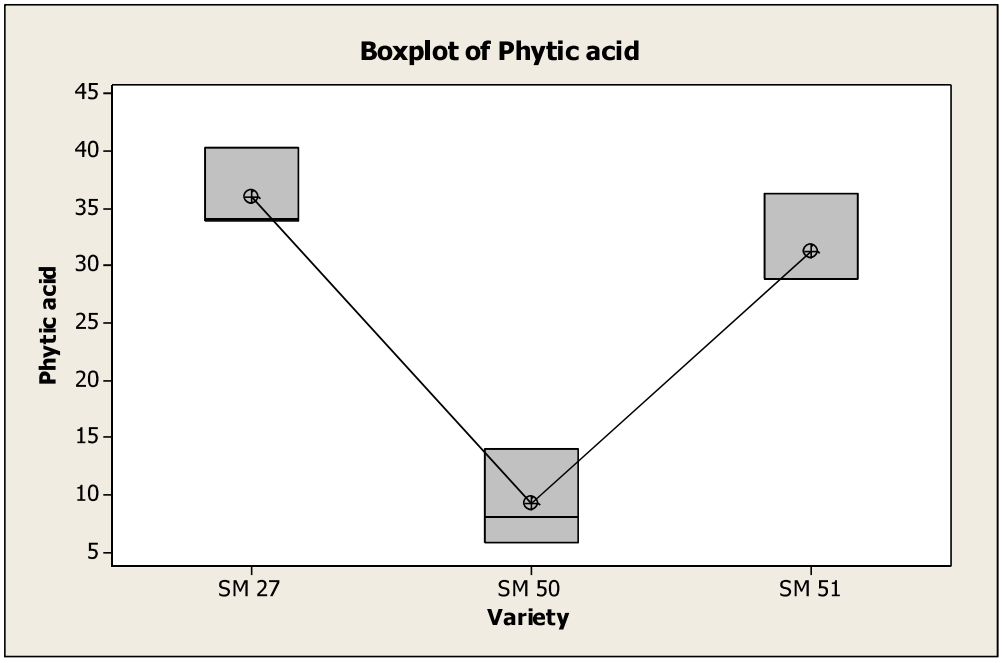

Figure 5: Boxplot of phytic acid content in three varieties of maize

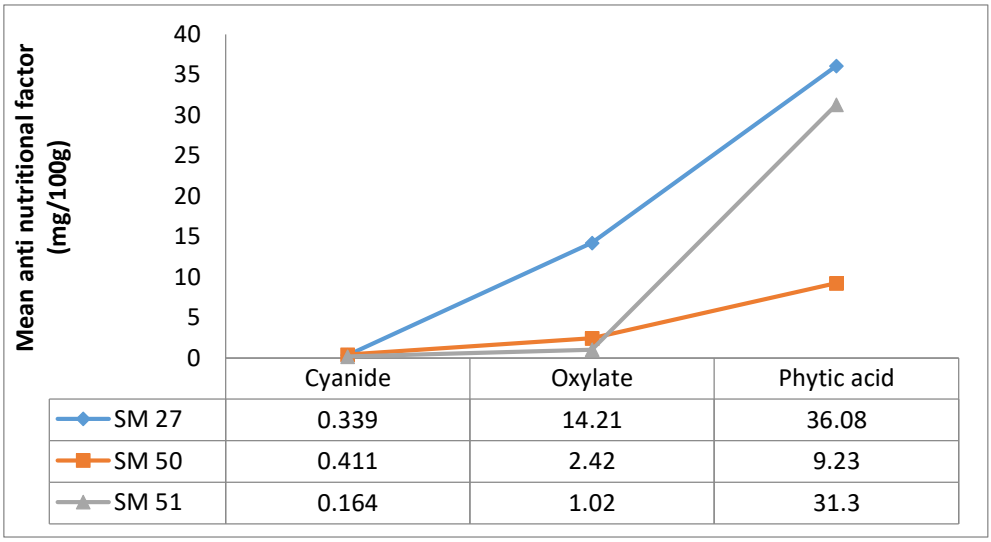

Figure 6: Comparative analysis of anti-nutritional factors in three varieties of maize

Table 3: Pearson's Correlation Matrix

	Ash	Moisture	Fibre	Lipid	Protein	Carbo-hydrate	Cyanide	Oxylate	Phytic acid
Ash	1								
Moisture	-0.939	1							
Fibre	0.748	-0.931	1						
Lipid	-0.405	0.696	-0.910	1					
Protein	0.790	-0.530	0.183	0.241	1				
Carbohydrate	-0.559	0.239	0.133	-0.532	-0.950	1			
Cyanide	-0.972	0.993	-0.882	0.608	-0.624	0.350	1		
Oxylate	-0.097	0.434	-0.733	0.949	0.534	-0.771	0.327	1	
Phytic acid	0.770	-0.503	0.153	0.271	1.000	-0.959	-0.600	0.560	1

Strength of correlation
0.00-0.39= Weak correlation; 0.40-0.69= moderate correlation; 0.7-0.9=High correlation; >0.90 = Very high correlation

Conclusion

The present study has shown the nutritional qualities of the three varieties of maize investigated. This is because it contained sufficient amount of proximate contents needed for daily dietary intake and also acceptable limit of anti-nutrients. Among the three varieties, SM50 appeared to be best in nutritional values being the richest in carbohydrate and moisture which are the basic constituent of typical starchy food. This variety also contained the lowest amount of phytic acid. It is recommended to growers and breeders. This study suggests an improvement in the carbohydrate content of maize so as to reduce the phytic acid level based on the negative relationship established between them.

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