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EVALUATION OF PROXIMATE COMPOSITION AND ANTI-NUTRITIONAL FACTORS IN SUPER 6, OBA SUPPER 6 AND OBA 98 VARIETIES OF MAIZE (*Zea mays* L.)

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Abstract
Maize is an important food crop in Nigeria. In a quest to achieve sustainable production, some varieties have emerged as products of breeding programme. There is limited information on the nutritional qualities of the emerging varieties. Three improved maize varieties (Super 6, Oba Supper 6 and Oba 98) were evaluated for their proximate and anti-nutritional factors. Grand composition of nutritional values showed high presence of carbohydrate (61%) followed by protein (21%). Moisture content was 8% while lipid, fiber and ash were 3.8%, 3.7% and 2.1% respectively. Oba 98 had the highest amount of moisture (8.3%) while Oba-6 had the highest amount of carbohydrate (63.2%). Oxalate and cyanide levels were low. Phytic acid was the largest ranging from 34.87±0.27 in Super-6 to 42.56±0.28 in Oba-6 with significant differences observed in the maize varieties (p<0.05). The anti-nutritional values were all below their respective WHO permissible limits. Comparative mean composition of the anti-nutrients revealed that mean phytic acid (38.4mg/100g) was 32 times higher than the level of oxalate and 60 times higher than cyanide. Oba-98 had the lowest amount of phytic acid. Correlation analysis showed that carbohydrate in maize had high negative relationship with lipid (-0.895), protein (-0.935) and oxalate (-0.793) but protein had high positive relationship with oxalate (0.796). Oba-98 was the most preferred among the three varieties since it has the lowest amount of phytic acid anti-nutrient. Moisture level was the highest recorded while carbohydrate content was as high as other two varieties. There is need to improve on the nutritional qualities of the three maize varieties in protein and lipid and reduce the phytic acid content. Also, improvement on the level of carbohydrate may further reduce the oxalate level in these varieties.

Key words: Maize varieties, Proximate analysis, Anti-nutritional factors, Food security

Introduction
Maize (*Zea mays* L., 2n = 2x = 20) belonging to family Poaceae is one of the most important crops in the word and preferred staple food for more than 1 billion people in sub Saharan Africa and Latin

America (Rodrigues *et al.,*2019). The crop is well adapted to different environment due to its ability to grow in diverse climate conditions. 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.,* 2021). Its grains are important for the production of oil, starch and glucose (Rodrigues *et al.,* 2019). It provides more food energy worldwide than any other type of crop and are rich source of vitamins, minerals, carbohydrate, fat, oils and protein. Grain types utilized as food includes sweet corn, popcorn, dent corn, and flint (Oladapo *et al.,* 2017)

Most commercially grown maize has been bred for high yield, and resistance or tolerance to stresses (abiotic and biotic) among other agronomic values. There are number of maize grain varieties distinguished by differences in the chemical compounds stored in the kernel (Abdin, 2018). Flint maize variety has high starch content and therefore suitable for food dishes as ogi and Tuwo (Abdin, 2018). White grain varieties are preferred for this purpose. Yellow maize varieties are increasingly being requested for producing livestock feed in order to impact yellow colour on the egg yolk (Aguk *et al.,* 2021). Apart from the beneficial nutrients present in cereals, there are anti-nutritional factors that that are antagonistic to the digestion and absorption of the kerned when consumed (Afzal *et al.,* 2021).

There is dearth of information on the nutritional quality of the different types of maize consumed in Nigeria. Considering that a significant number of metabolic disorders and diseases are caused by malnutrition and the fact that the majority of the world population consumes maize as the main bread grain, one of the important objectives in this research is the identification of varieties with the improved nutritive value. Development of maize cultivars with high productivity coupled with enhanced sugar and starch content in the kernels may cater to their enhanced use in human consumption and industrial usage Therefore, a more detailed knowledge of nutritional properties of maize genotypes will be beneficial in the production of maize food with improved nutritional quality. The work therefore aimed at investigating the proximate and anti-nutritional factors of three selected varieties of maize

Materials and Methods

Sample Collection and Identification

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

Proximate Analysis

Moisture

The procedures outlined in the analytical methods of the Association of Official Analytical Chemists (AOAC, 1995) was adopted for moisture determination using the gravimetric approach and as percentage of sample weighed according to the formula given below:

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

w1 = weight of the empty moisture can
w2 = weight ofcan and sample before drying
w3 = weight of can and sample after drying

Crude protein

Crude protein was determined using the micro-kjeldahl method (AOAC; 1995; Kumar *et al.*, 2021) where 2g of sample mixed with 10ml of concentrated tetraoxosulphate (VI) acid was heated in a fume cupboard, followed by titration. The total nitrogen was calculated and multiplied with the factor 6.25 to obtain the crude protein content.

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

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

W = weight of the sample
N = Normality of filtrate ((H_2SO_4) = 0.02N
V_F = Total volume of the digest = 100ml
V_A = Volume of the digest distilled

Fat content

The solvent extraction method was used to determine the fat content of 5g of the sample in a soxlet apparatus (AOAC, 1995; Mathias *et al.,* 2020), followed by heating, drying and weighing that lasted for 4 hours. 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

The furnace incineration gravimetric method was used to quantify the ash content of 5g of sample in the crucible followed by cooling and weighing a (AOAC (1995; Mathias *et al.,* 2020). The crucibles containing the samples were weighed and the percentage ash content was determined as follows:

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

W_1 = weight of the crucible
W_2 = weight of sample crucible
W_3 = weight of crucible + ash

Crude fibre

Fibre content was quantified using defatted samples boiled for 30minutes with 200ml of 1.25M NaOH solution (AOAC, 1995). Sample was carefully transferred into a weight porcelain crucible and dried in the oven at 150°C for 3hours, cooled in desiccator and weighed, then ashed in a muffle at 550°C for 2hours, cooled in a desiccator and reweighed. The crude fibre content was calculated as:

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

$$= \frac{w2 - w3}{\text{weight of sample}}$$

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

Determination of Carbohydrates

The amount of carbohydrates was obtained using the formula: 100 - % protein +% fat+ % fibre + % ash % moisture (AOAC, 1995).

Determination of Anti-Nutritional Factor

Oxalate determination

This was determined according to the method described by AOAC (1995). About 0.5g of samples was weighed into 100ml conical flask. 15ml, 3M H_2SO_4 was added and stirred for 1hour with magnetic stirrer. This was filtered using no 1 What man 5ml of filtrate was taken hot and titrated with 0.05M of KMnO4 solution until faint pink colour persist for at least 30 seconds. The oxalate content was calculated by taking 1ML of 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
The data analysis was conducted for all parameters using minitab 16.0 and Microsoft excel. Descriptive statistics (mean, standard error of the mean, coefficient of variation, minimum value, maximum ranges) were analyzed. Graphs (charts and box plots) were plotted. Inferential statistics (chi square test of dependence, oneway ANOVA and Pearson's correlation) were also carried out. Mean separation was done using Turkey's method at 95% confident limit (P value =0.05 limit). Level of significance was determined at $P < 0.05$.

Results and Discussion
Table 1 presents the proximate analysis in the three varieties of maize. Moisture content ranged between 7.83+0.17 (super 6) and 8.33±0.17 (Oba 98). The Ash content of sampled, maize defers in percentage ranging from (1.50±0.29 to 2.5±0.29). The super 6 has the highest protein and low moisture content. The super 6 also has the highest percentage in fibre and Lipid. Oba-6 had the highest amount of carbohydrate (63.2%) followed by Oba-98 (61.5%). There was a significant difference among the varieties in all contents. Grand mean of all nutritional components in all maize samples showed high presence of carbohydrate (61%) followed by protein (21%). Moisture content was 8% while lipid, fiber and ash were 3.8%, 3.7% and 2.1% respectively as shown in figure 1. This work study elucidated the nutritional qualities of the three maize varieties. Results were in tandem with other reports in maize (Kataria, 2014; Oladapo *et al.,* 2017; Galani *et al.,* 2022). The reported amount of protein suggests the need to fortify the energy-rich grain with amino acid supplementation such as lysine and tryptophan as previously suggested by some authors (Gallagher *et al.,* 2014; Allameh and Toghyani, 2019; Zhang *et al.,* 2022). The quality of maize protein depends upon its genotype. Recent researches have shown that with genetic modification, the quality of maize protein can be improved (llameh and Toghyani, 2019; Zhang *et al.,* 2022). The grand mean protein content (21%) was higher protein values reported in many maize ecotypes and cereals (Kumar and Jhariya, 2013; Galani *et al.,* 2022). This implies that the varieties are of good nutritional quality, although some appreciable amounts of anti-nutrients were found.

Cyanide content ranged from 0.47in Super-6 to 0.73mg/100g in Oba-98. Oxalate content was lowest in Oba-6 (1.03mg/100g) and highest in Super 6 (1.47mg/100g). The observed differences in cyanide and oxalate among the three varieties are insignificant ($p>0.05$), indicating the same amount of each anti-nutrient in three varieties of maize. Phytic acid was the largest among the three anti-nutrients ranging from 34.87±0.27 in Super-6 to 42.56±0.28 in Oba-6 with significant differences observed in the maize varieties ($p<0.05$). The anti-nutritional values were all below their respective WHO permissible limits. Box plots indicate that

Super-6 had the lowest amount of cyanide (figure 2) while Oba-6 was lowest in oxalate (figure 3). Oba-98 had the lowest amount of phytic acid (figure 4). Comparative mean composition of the anti-nutrients revealed that mean phytic acid (38.4mg/100g) was 32 times higher than the level of oxalate and 60 times higher than cyanide (figure 5) Correlation analysis (Table 2) showed that carbohydrate had high negative relationship with lipid (-0.895), protein (-0.935) and oxalate (-0.793) but protein had high positive relationship with oxalate (0.796).

Liebman and Costa (2000) found that high levels of phytic acid in cereals significantly lowered the nutritional quality. The present work agrees with this position since it was established that oxalate lowered the carbohydrate content based on the outcome of correlation analysis. Phytic acid phosphorus constitutes the major portion of total phosphorus in several seeds and grain. Studies have shown that the phytic acid and cyanide contents are influenced by cultivar, climatic conditions and method of processing (Bolarinwa *et al.,* 2016; Ali *et al.,* 2017; de Lima *et al.* 2017). The level of cyanide and oxalate must be maintained since oxalate chelates various minerals such as sodium, calcium, potassium, magnesium, to form a complex called oxalate salt (Liebman and Costa, 2000; Mihrete, 2019). The salt of calcium (calcium oxalate) is the most important in relation to the toxicity associated with this compound. Unlike other oxalates, calcium oxalate is not soluble in water and therefore, high levels has the potency to precipitate in the kidney or urinary tract as crystals of calcium oxalate, which could results to the formation of kidney stones (Liebman and Costa, 2000; Mihrete, 2019).

Table 1: Proximate composition in three varieties of maize

Varieties	Moisture (%)	Ash (%)	Fiber (%)	Lipid (%)	Protein (%)	Carbohydrate (%)
Oba 6	8.00±0.29	2.5±0.29	3.50±0.58	2.50±0.29	20.30±0.10	63.20±0.35
Super-6	7.83±0.17	2.17±0.17	4.00±0.29	5.27±0.03	22.29±0.16	58.45±0.45
Oba-98	8.33±0.17	1.50±0.29	3.50±0.29	3.67±0.17	21.53±0.10	61.47±0.64
Grand mean	**8.05±0.15**	**2.06±0.29**	**3.67±0.17**	**3.81±0.80**	**21.37±0.58**	**61.04±1.39**

Moisture: χ^2 (Variety Vs Moisture content) = 0.016, P=0.992 (P>0.05)
Ash: χ^2 (Variety Vs Ash content) = 0.252, P=0.881 (P>0.05)
Fiber: χ^2 (Variety Vs Fiber content) = 0.045, P=0.978 (P>0.05)
Lipid: χ^2 (Variety Vs Lipid content) = 1.014, P=0.602 (P>0.05)
Protein: χ^2 (Variety Vs Protein content) = 0.094, P=0.974 (P>0.05)
Carbohydrate: χ^2 (Variety Vs Carbohydrate content) = 0.189, P=0.910 (P>0.05

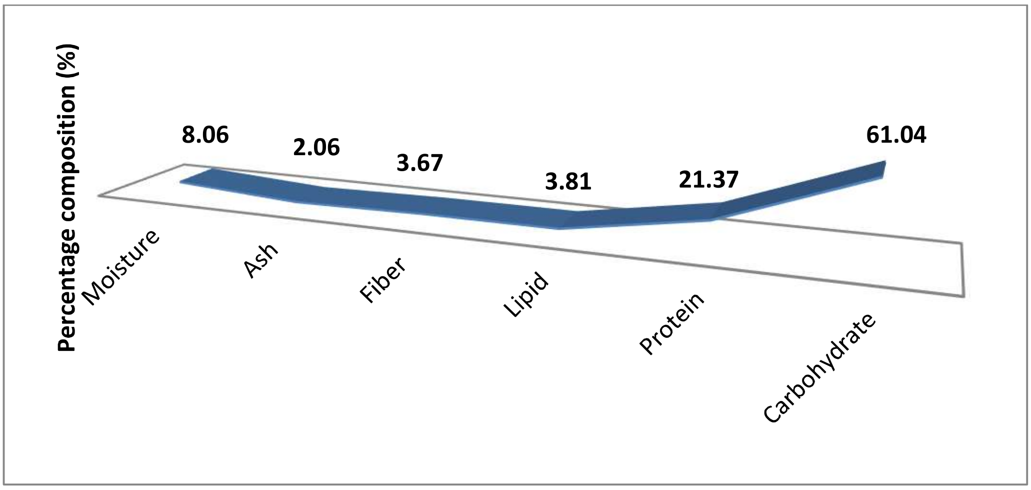

Figure 1: Grand mean of proximate composition in maize seeds

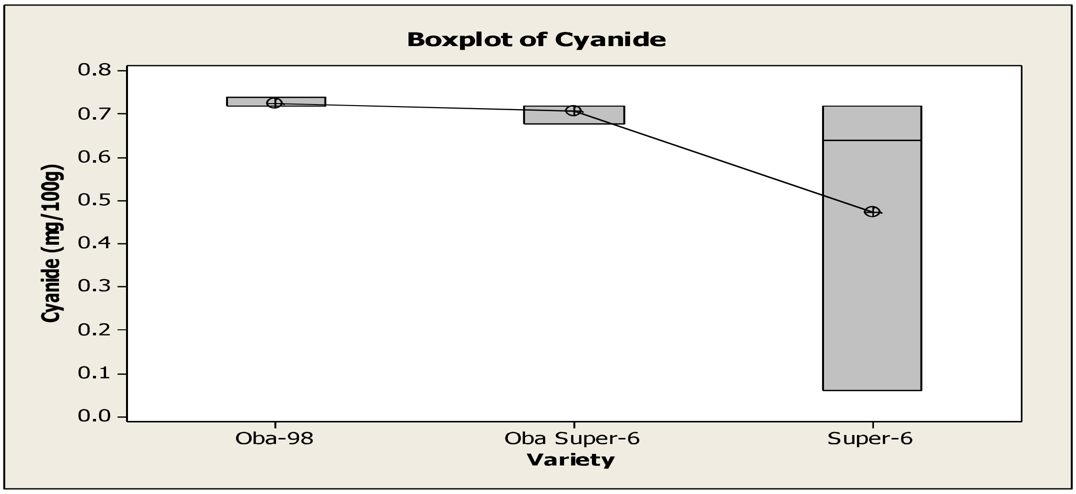

Figure 2: Boxplot of cyanide content in three varieties of maize

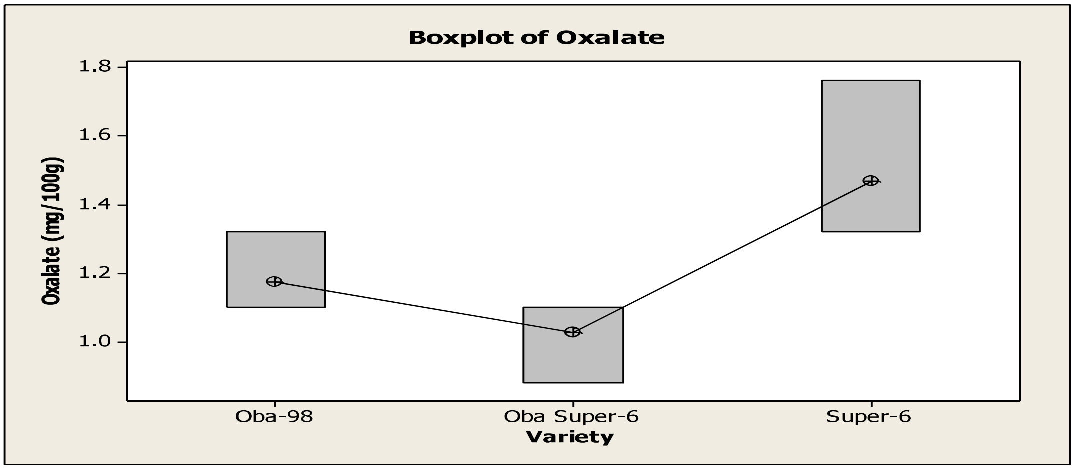

Figure 3: Boxplot of oxalate content in three varieties of maize

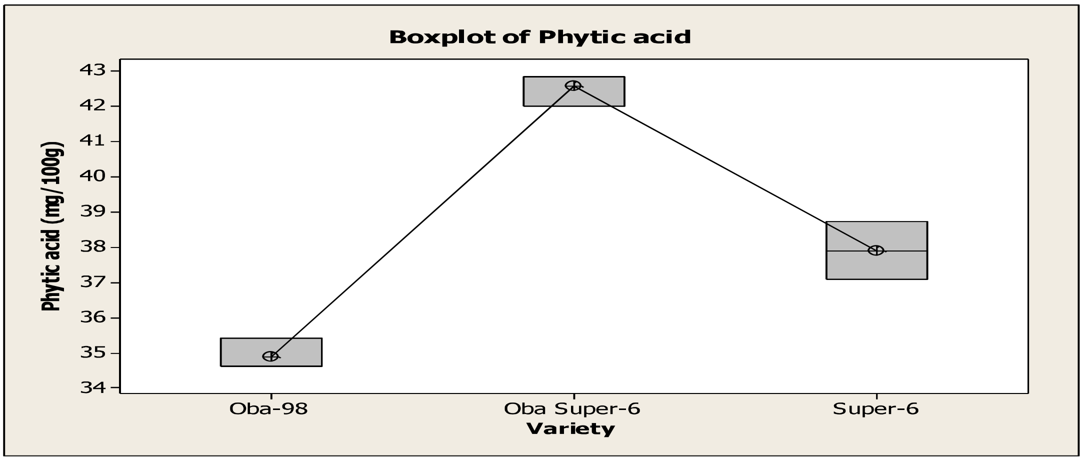

Figure 4: Boxplot of phytic acid content in three varieties of maize
F (Phytic acid content) = 119.09, P=0.000 (P<0.05)

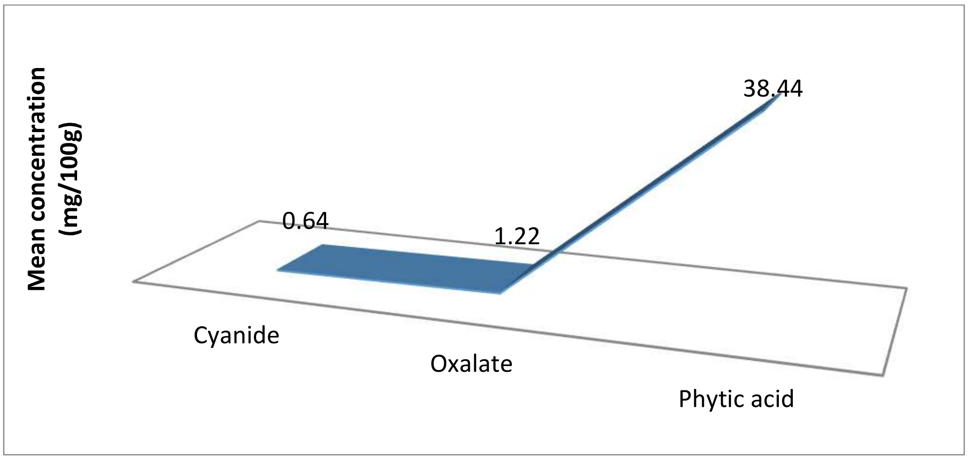

Figure 5: Comparative analysis of anti-nutritional factors in maiz

Table 2: Pearson's Correlation Matrix

	Moisture	Ash	Fiber	Lipid	Protein	Carbo-hydrate	Cyanide	Oxalate	Phytic acid
Moisture	1								
Ash	-0.015	1							
Fiber	-0.645	0.054	1						
Lipid	-0.324	-0.304	0.364	1					
Protein	-0.100	-0.256	0.369	0.908	1				
Carbohydrate	0.242	-0.005	-0.552	-0.895	-0.935	1			
Cyanide	0.576	-0.037	-0.541	-0.454	-0.406	0.487	1		
Oxalate	0.063	0.042	0.111	0.746	0.796	-0.793	-0.222	1	
Phytic acid	-0.414	0.632	0.001	-0.489	-0.698	0.460	-0.052	-0.411	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

Oba-98 was the most preferred among the three varieties since it has the lowest amount of phytic acid anti-nutrient. Moisture level was the highest recorded while carbohydrate content was as high as other two varieties. There is need to improve on the nutritional qualities of the three maize varieties in protein and lipid and reduce the phytic acid content. Also, improvement on the level of carbohydrate may further reduce the oxalate level in these varieties.

References

Abdin, E. B. A. (2018). Development of Gluten Free Cake from Beans (*Phaseolus vulgaris* L.) and Maize (*Zea mays* L.) Flours (Doctoral dissertation, Sudan University of Science and Technology

Afzal, M., Ahmad, I., Wang, D., Fahad, S., Ghaffar, A., Saddique, Q. and Nasim, W. (2021). Influence of semi-arid environment on radiation use efficiency and other growth attributes of lentil crop. *Environmental Science and Pollution Research*, 28(11): 13697-13711.

Aguk, J., Onwonga, R. N., Chemining'wa, G. N., Jumbo, M. B., and George, A. (2021). Enhancing yellow maize production for sustainable food and nutrition security in Kenya. *East African Journal of Science, Technology and Innovation*, 2

Ali, S., Singh, B. and Sharma, S. (2017). Development of high quality weaning food based on maize and chickpea by twin screw extrusion process for low income populations. *Journal of Food Process Engineering*, 40(3): e12500.

Allameh, S., and Toghyani, M. (2019). Effect of dietary valine supplementation to low protein diets on performance, intestinal morphology and immune responses in broiler chickens. *Livestock Science*, 229: 137-144.

Association of Official Analytical Chemist (AOAC) OfficialMethod of Analysis (1995), *Washington DC USA, Official Method of analysis.*

Bolarinwa I.F.; Olaniyan S.A.; Olatunde S.J.; Ayandokun F.T.; Olaifa I.A. (2016). Effect of Processing on Amygdalin and Cyanide Contents of some Nigerian Foods. *Journal of Chemical and Pharmaceutical Research,* 8: 106-113.

de Lima, R. F., Dionello, R. G., Peralba, M. D. C. R., Barrionuevo, S., Radunz, L. L., and Júnior, F. W. R. (2017). PAHs in corn grains submitted to drying with firewood. *Food Chemistry*, 215: 165-170.

Galani, Y. J. H., Orfila, C., and Gong, Y. Y. (2022). A review of micronutrient deficiencies and analysis of maize contribution to nutrient requirements of women and children in Eastern and Southern Africa. *Critical Reviews in Food Science and Nutrition*, 62(6): 1568-1591.

Gallagher, E., Gormley, T.R. and Arendt, E.K. (2014). Recent advances in the formulation of gluten free cereal-based products and trends. *Food Science and Technology*, 15:143-152

Kataria, R. (2014). Proximate nutritional evaluation of maize and Rice-gluten free cereal. *Journal of Nursing and Health Science*, 3(2):01-06

Kumar, D. and Jhariya, N.A. (2013). Nutritional, medicinal and economical importance of corn: A mini review. *Research Journal of Pharmaceutical Sciences*, 2:07-08

Kumar, S., Singh, R. and Gupta, R. (2021). Anti-nutrients and their removal methods from pulses—a review. *Food Reviews International*: 37(2): 152-186.

Liebman, M. and Costa, G. (2000). Effect of calcium and magnesium on urinary oxalate excretion after oxalate overload. *Journal of Urology*, 163: 1565- 156

Mathias, P. M., Amado, L. L., Oliveira, L. M., and da Silva, E. A. (2020). A comparison of solvent extraction methods for the determination of fat content in food samples. *Food Chemistry*: 3(09): 125739.

Mihrete, Y (2019). Review on Anti Nutritional Factors and their Effect on Mineral Absorption. Acta Scientific Nutritional Health, 3(2): 84–89.

Oladapo, A. S., Adepeju, A. B., Akinyele, A. A., and Adepeju, D. M. (2017). The proximate, functional and anti-nutritional properties of three selected varieties of maize (Yellow, White and Pop Corn) flour. *International Journal of Scientific Engineering and Science*, 1(2): 23-26.

Rodrigues, R. R., Taschetto, A. S., Sen Gupta, A., and Foltz, G. R. (2019). Common cause for severe droughts in South America and marine heatwaves in the South Atlantic. *Nature Geoscience*, 12(8): 620-626.

Zhang, Q., Zhang, S., Wu, S., Madsen, M. H., and Shi, S. (2022). Supplementing the early diet of broilers with soy protein concentrate can improve intestinal development and enhance short-chain fatty acid-producing microbes and short-chain fatty acids, especially butyric acid. *Journal of Animal Science and Biotechnology*, 13(1):