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The Proximate, Functional and Anti-Nutritional Properties of Three Selected Varieties of Maize (Yellow, White and Pop Corn) Flour

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Abstract— *The study is on proximate, functional and anti-nutritional properties of three selected varieties (yellow corn flour (YCF), white corn flour (WCF) and pop corn flour (PCF) of maize flour (Zea mays) using standard method of AOAC. The corn samples were obtained from IART, Ibadan, Oyo State, Nigeria. The proximate composition of the flour showed that the amount of protein ranged from 12.32 % to 13.50%, fibre content of 1.05 % to 6.47 %, fat content of 12.90 % to 14.02 %, ash content ranged from 0.99% to 1.04%, moisture content ranged from 9.74.73 % to 10.94 %, carbohydrate content ranged from 16.28% to 62.38%, the organic matter ranged from 98.60 % to 99.10 % and the energy content of the three corn flour ranged from 1672.73kg/g to 1769.40 kg/g. The functional properties of the flour showed that WAC ranged from 173 % to 235 %. OAC ranged from 63 % to 82 %, the pH ranged from 5.9 to 6.2, bulk density ranged from 0.78 g/cm^3 to 0.81 g/cm^3, then the solubility ranged from 0.79 % to 1.01 %, the foam capacity of the flour ranged from 0.5 ml to 6.1 ml, while the foam stability in 30mins was nil for all the flour. The swelling power ranged from 1.97 to 6.13. The anti-nutritional properties showed that oxalate ranged from 0.90 % to 0.99 %, phytates ranged from 0.64 % to 1.00 % while tannins ranged from 0.09 % to 0.11 %. From the results obtained, it was observed from the results that PCF had the highest proximate properties except carbohydrate and ash content. There was reduction in anti-nutritional properties of PCF and there is no significant difference ($p\leq 0.05$) between PCF, WCF and YCF in terms of OAC, pH, bulk density, solubility, foam capacity and foam stability. But there is significant between the three in water absorption capacity (WAC). Therefore, popcorn flour could be used in the formulation of weaning foods for infant children.*

Keywords— *Proximate composition, functional properties, corn maize flour, anti-nutritional properties.*

I. INTRODUCTION

Maize is a corn and one of the cereal grains, members of the monocot families Poaceceae or Gramineae. Cereal grains are grown in greater quantities all over the world. Current maize production in the world is estimated to be 784 million tons in 2007 and expected to increase in years ahead (FAO, 2006; 2009). In Nigeria, the most important cereals are rice, millet, wheat, sorghum and maize (Wuditi, 1999). Among those cereals, maize remains popularly grown and consumed in ecological zone of Nigeria. It provides more food energy worldwide than any other type of crop and are rich source of vitamins, minerals, carbohydrate, fat, oils and protein (Kouakoua *et al.,* 2008). The amount of crude protein found in grain is measured as Grain Crude Protein Concentration (GCPC) (Vogel, 2003). Maize (*Zea mays*) is known as corn in many English-speaking countries and cultivated by indigenous people in Mesoamerica in prehistoric times. The Aztecs and Mayans cultivated it in numerous varieties throughout Central and southern Mexico. Most commercially grown maize has been bred for a standardized height of 2.5 metres (Karl, 2008). Maize spreads to the rest of the world due to its popularity and ability to grow in diverse climate conditions. Grain types utilized as food includes sweet corn (*Saceharata sturt*), popcorn (*Praecox sturt*), dent corn(*Identata sturt* or floury corn), anyata sturt and flint corn (*Indurata sturt*) (Khawar and Muhammad, 2007). Tere are number of maize grain varieties distinguished by differences in the chemical compounds stored in the kernel (Ejigue *et al.,* 2005). Flint maize is relished as given maize whereas the dent variety have starch content preferably with minimal craft and therefore suitable for food dishes as ogi, Akamu and Tuwo (Iken and Amusa, 2004). 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 (Iken and Amusa, 2004). Popping corn is known as popcorn, is a type of corn (maize, zea mays varie. Everta) that expands from the kernel and puffs up when heated. Its kernel has a hard moisture sealed hull and a dense starch interior with techniques for popping corn.

Maize has a multitude of uses and ranks second to wheat among the world's cereal crops in terms of production (Abdulrahaman and Kolawole, 2008). Maize could be cook or grind in a process called Nixtamalization. It is a major source of corn starch (maize flour), which is a major ingredient in home cooking and in many industrialized food products. Maize also is a major source of cooking oil and gluten. Maize starch can be hydrolyzd and enzymatically treated to produce syrups, a sweetener; which is also fermented and distilled in order to produce grain alcohol. Starch from maize can also be processed into plastics, fabrics, adhesives and many other chemical products (Karl, 2008). Maize (*Zea mays*) grains are used in the production of several traditional foods; unfortunately, they lack adequate micro nutrients. Within the

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developing world, maize is a major staple food and the per capital human consumption reaches high level. In addition to its uses as food for humans, it is also used as a feed grain, a fodder crop and for various industrial purposes.

The work is aimed at investigating the proximate, functional and anti-nutritional properties of three selected varieties of maize flour for food formulation, especially for infant and allied industries.

II. MATERIALS AND METHODS

Sample Collection and Treatment

The three selected maize (corn) varieties samples were obtained from IART, Ibadan, Oyo State. Nigeria. They were sorted, grinded into powdery form using Marlex Exceller Mixer Grindr with 3 S.S jars (Model: Exceller Qty), packaged and labelled in a polythene bag and kept for further analysis.

Proximate Composition Determination

The moisture, crude protein (N × 6.25), crude fat, crude ash was determined by the method described by the Association of Analytical Chemists (AOAC, 1998). The total carbogydrate content of the sample was calculated by difference method (subtracting the percent crude protein, moisture crude, crude fibre, crude fat and ash from 100%). Total energy values were calculated by multiplying the amounts of protein and carbohydrate by the factor of 4kcal/g and lipid by the factor of 9kcal/g as described by Bazi-Yabani *et al.*, (2009).

Functional Properties Determination

The bulk density of the samples was determined according to the method described by Akpanunam and Markalis (1981). Water and oil absorption capacities of the flour were also carried out according to the modified method of Prinyawiwatkul *et al.*, (1997). Swelling power and solubility of flours were determined by method described by Muhammad *et al.*, (2011). The method of Muhammad *et al.*, (2011) was employed in the study of foaming capacity and stability.

Determination of Anti-Nutritional Factors

Tannic acid content was determined by the method described by Kadhakrishna and Sivaprasad (1980). Phytic phosphorus was determined according to the method described by Nelson (1968). Oxalate was also determined by the permanganate titration method of Dye (1956).

Statistical Analysis

The experimental design was complete randomized block design according to the analysis of variance were conducted on the data at $p \leq 0.05$ (ANOVA) procedures (Gomez and Gomez, 1984). The Duncan's multiple range tests was then used to determine the significance of any difference between the means.

III. RESULTS AND DISCUSSION

The result for the proximate composition of three varieties of corn flour is shown in table I. In terms of ash content, there was no significant difference ($p \leq 0.05$) in the three varieties of corn (white corn flour, popcorn flour and yellow corn flour). The WCF has the highest ash content (1.04%) while the least value was seen in popcorn (0.90%). Comparing the three varieties of corn flour with pigeon pea (Amarteifio *et al.*, 2002), the values reported for pigeon pea have low mineral content.

TABLE I. Proximate composition of three selected varieties of corn flour.

PARAMETER (%)	WCF	PCF	YCF
Ash	$1.04^{a} \pm 0.01$	$0.90^{a} \pm 0.03$	$1.00^{a} \pm 0.01$
Moisture	$9.74^{b} \pm 0.04$	$10.94^{c} \pm 0.20$	$9.75^{b} \pm 0.03$
Crude fat	$12.90^{c} \pm 0.03$	$14.20^{c} \pm 0.03$	$13.50^{d} \pm 0.02$
Crude fibre	$1.50^{a} \pm 0.20$	$6.74^{b} \pm 0.02$	$1.05^{a} \pm 0.02$
Crude protein	$13.18^{a} \pm 0.04$	$13.50^{d} \pm 0.10$	$12.32^{c} \pm 0.05$
Carbohydrate	$16.28^{c} \pm 0.04$	$53.99^{f} \pm 0.02$	$62.38^{c} \pm 0.50$
Organic matter	$98.60^{f} \pm 0.10$	$99.10^{g} \pm 0.01$	$99.00^{f} \pm 0.01$
Energy content (kg/g)	$1743.12^{g} \pm 0.01$	$1672.73^{h} \pm 0.01$	$1769.40^{g} \pm 0.01$

Mean ± standard error of mean for triplicate determination. Values not followed by the same superscript in the row are significantly different ($p \leq 0.05$). Key: WCF = White corn flour, PCF = Pop corn flour and YCF = Yellow corn flour.

In terms of moisture content, there was no significant difference ($p > 0.05$) in PCF and WCF with value 9.74%. The value indicated that the grains were within limit for safe storage since moisture contents of 12 % at 30 ^{0}C have been generally recommended as safe for the storage of maize and similar cereal products (Herm *et al.*, 1999). Maiziza-Dixon *et al.*, (2000), Ingbian and Oduyela (2010) on maize varieties showed that the moisture content was in agreement with the findings. The fibre contents ranged from 1.06 – 6.48; although PCF had significant difference of ($p \leq 0.05$) to WCF and YCF. The protein content in the three varieties of corn flour ranged from 12.32 % - 13.50%. Although a significant difference ($p \leq 0.05$) was seen in YCF to that of WCF and PCF. The values obtained in this work for protein is higher that the value reported by Ingbian and Oduleya (2010) in their study on local cereal flours. The carbohydrate value ranged from 53.99% - 62.99%. PCF has a significant difference ($p \leq 0.05$) when compared to WCF and YCF. These values are not in collaboration with the work done by Ingbian and Oduleya (2010).

In terms of organic matter, the values obtained ranged between 96.69% - 99.70%. The value obtained for PCF was significantly different ($p \leq 0.05$) to YCF and WCF. The daily energy requirement that should be taken by an adult is 10,500 – 12,600 KJ and this was reported by FAO/WHO/UHU (1985). In terms of energy content, PCF has significant difference ($p \leq 0.05$) to WCF and YCF, their value ranged from 1672.73% - 1769.04%. The difference in the energy level is due to differences in the proximate composition of the varieties. The results of the present study showed that these maize varieties are rich sources of energy.

Table II depicts the anti-nutritional properties of the three selected varieties of maize. WCF and YCF exhibited the highest level of oxalates (0.99% and 0.95%) followed by PCF (0.90%). The data suggested that a daily portion of maize flour would supply a constant intake of soluble and insoluble oxalates but this would be relatively small intake compared to other oxalate containing food that may be eaten in the diet (Boontaganon *et al.*, 2009).

TABLE II. Anti-nutritional factor of three selected varieties of corn flour.

PARAMETER (%)	WCF	PCF	YCF
Oxalates	$0.99^{c} \pm 0.03$	$0.90^{a} \pm 0.03$	$0.95^{c} \pm 0.03$
Phytates	$0.85^{b} \pm 0.04$	$0.64^{b} \pm 0.02$	$1.00^{c} \pm 0.01$
Tannins	$0.11^{b} \pm 0.03$	$0.10^{a} \pm 0.0$	$0.09^{c} \pm 0.02$

Mean ± standard error of mean for triplicate determination. Values not followed by the same superscript in the same row are significantly different ($p \leq 0.05$). Key: WCF = White corn flour, PCF = Pop corn flour and YCF = Yellow corn flour

The oxalate content was found to be higher in the whole grain than in refined grain cereals. This suggests that oxalic acid is primarily located in the outer layers of cereal grains (Satinder *et al.*, 2011). The phytate in YCF and PCF are in the same range of 0.85% and o.64%. Phytic acid also has a strong binding capacity and forms complexes with multivalent cation, including Ca, Mg, Fe and Zn and render them biologically unavailable (Reddy *et al.*, 1982). Thus, phytic acid present in the cereal is a nutritional concern. The adverse effects of high phytate content in the cereals on Ca absorption have been demonstrated by several workers (Casey and Lorez, 1977). Tannin content of all the selected maize corn ranged from 0.09% to 0.11%. Percentages of tannins in different cereals as reported by Juliano (1985) are oat 1.1%, barley 0.7%. Tannins are concentrated mainly in the seed coat, preliminary de-hulling constitutes the simplest method for their removal. Significant differences in the tannin content were seen among rice, wheat, barley and oat bran. The tannins form complexes with protein and reduce their digestibility (Eka, 1985).

TABLE III. Functional properties of three selected varieties of corn flour.

SAMPLES	WAC (%)	OAC (%)	pH	Bulk Density (%)	Solubility	Foam cap (ml)	Foam sta (ml)
WCF	199 ± 0.02^{b}	82 ± 0.02^{a}	$6.1a \pm 0.2^{a}$	0.81 ± 0.4^{a}	0.79 ± 0.01^{a}	0.5 ± 0.5^{a}	0.0 ± 0.0
PCF	173 ± 0.3^{a}	63 ± 0.02^{a}	6.2 ± 0.02^{a}	0.78 ± 0.03^{a}	0.82 ± 0.01^{a}	6.1 ± 0.5^{c}	0.0 ± 0.0
YCF	235 ± 0.02^{c}	66 ± 0.02^{a}	5.9 ± 0.01^{a}	0.79 ± 0.01^{a}	1.01 ± 0.3^{b}	1.5 ± 0.2^{b}	0.0 ± 0.0

Mean ± standard error of mean for triplicate determination. Values not followed by the same superscript in the same row are significantly different ($p \leq 0.05$). Key: WCF = White corn flour, PCF = Pop corn flour, YCF = Yellow corn flour, WAC = Water absorption capacity and OAC = Oil absorption capacity.

Water and oil holding capacities of the selected maize varieties were: WCF; 199% and 82%, PCF; 173% and 63%, YCF; 235% and 66% respectively. There is significant difference in WAC of the three selected varieties. PCF was found to possess less water and oil holding capacity than cashew nut flour (WAC 240% and OAC 220%) but YCF had the highest WAC among the three, still higher than that of the cashew nut flour as reported by Ibrahim *et al.*, (2011). The water and oil holding capacities are essential functional properties of cereal which may be defined as the amount of water or oil retained by a known weight of flour under specific conditions. The water holding capacity depends on the capillary, pore size and charges of the protein molecules. This is due to strong correlation of extent of protein hydration with polar constituents along with the hydrophilic interaction through hydrogen bonding and high electrostatic repulsion (Altschul and Wilcke, 1985). The oil holding capacity is also due to enhanced hydrophobic character of proteins in the flours. The results of foaming capacity (FC) and foaming stability (FS) of selected maize flours were found to be WCF 0.5% and 0.0%, PCF 6.1% and 0.0% and YCF 1.5% and 0.0% respectively. The values of foaming stability 0.0% for the selected maize flour was the same with value obtained in the work of Adebayo *et al.*, (2013). The values of FC and FS were found to be low compared with those reported by other workers for different flours as reported in the work of Muhammad *et al.*, (2011) (FC, 18% and FS, 5.23%). The low formability of the selected cereals flours indicates the presence of highly ordered globular protein molecules which increase the surface tension. Foaming properties are much imperative in the safeguarding of the texture and structure of different food products (ice creams and bakery products) during and after processing. The foam ability of the flour depends on the presence of the flexible protein molecules which may decrease the surface tension of water (Sath *et al.*, 1982). The bulk density of flour were found to be 0.81g/cm (WCF), 0.78g/cm (PCF) while YCF was 0.79g/cm but there is no significant difference between the three flour. These values were found to be comparable to those reported for jack fruit flour (Odoemelam, 2005) (Raw flour 0.6 and processed flour 0.54g ml). The low values of bulk densities make the flour to be more suitable for baking process. The pH of the three selected maize flour was near neutral and no significant difference among them but YCF had higher solubility than WCF and PCF.

TABLE IV. Swelling powers of three selected varieties of corn flour.

Sample	Swelling power			
	60^{0}C	70^{0}C	80^{0}C	90^{0}C
WCF	$1.97 \pm {}^{a}0.02$	$3.15 \pm {}^{b}0.15$	$4.30 \pm {}^{a}0.02$	$5.81 \pm {}^{b}0.01$
PCF	$2.05 \pm {}^{b}0.05$	$2.86 \pm {}^{a}0.06$	$4.33 \pm {}^{a}0.03$	$5.20 \pm {}^{a}0.04$
YCF	$2.52 \pm {}^{c}0.02$	$3.76 \pm {}^{c}0.06$	$4.88 \pm {}^{b}0.08$	$6.13 \pm {}^{c}0.03$

Mean ± standard error of mean for triplicate determination. Values not followed by the same superscript in the same row are significantly different ($p \leq 0.05$). Key: WCF = White corn flour, PCF = Pop corn flour, YCF = Yellow corn flour

The result of the swelling power of the three selected varieties of corn flour was as shown in Table IV. There was significant difference ($p \leq 0.05$) at 60^{0} between the selected maize flour, the value ranged between WCF 1.97 – 2.52 YCF. Swelling power at 70 ^{o}C indicated that there was significant difference ($p \leq 0.05$) between PCF 2.86 – 3.76 YCF. The swelling power at 80 ^{o}C shows that there is significant difference ($p \leq 0.05$), the value ranged between WCF 5.81 – 6.13 YCF. At 90 ^{o}C, the swelling power of the three selected

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flour were higher to that of tiger nut flour (Oladele and Aina, 2007).

IV. CONCLUSION

The corn flour has some nutrients and appreciable functional properties which can be an advantage of being used in bakery and food products. Pop corn flour has some potential in the formulation of weaning foods for the management of protein energy malnutrition.

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