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Nutritional and Physicochemical Properties of Wheat (*Triticum vulgare*), Cassava (*Manihot esculenta*) and Sweet Potato (*Ipomoea batatas*) Flours

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Abstract: The flours from cassava *(Manihot esculenta*), sweet potato (*Ipomoea batatas*) and wheat (*Triticum vulgare*), were analyzed for proximate composition, functional properties and some anti-nutritional factors using standard methods. Results of proximate composition indicates that the ash contents ranges between 2.18-6.26%, with potato flour having the highest and cassava the least. The protein content ranges between 7.21-20.96% with cassava flour having the least and wheat the highest value. The fat content ranges between 0.45% for cassava to 9.60% for wheat, crude fiber 2.80% for potato to 6.19% for cassava, moisture content 7.20% for wheat to 8.23% for cassava, carbohydrate 53.89% for wheat to 75.74% for cassava and energy content 327.81kcal for cassava to 385.56kcal for wheat. The result of functional properties indicates that water absorption capacity ranges between 125 to 210%, oil absorption capacity 168.30 to 191.68%, foaming capacity 4 to 27%, foaming stability 1 to 4%, emulsion stability 47 to 53%, least gelation 2 to 4%, bulk density 59.98 to 66.03%. Anti-nutritional factor indicates that the samples were richer in phytate than oxalates which ranges between 9.06 to 14.83 and 2.07 to 4.50 mg/g, respectively. These result shows that cassava and potato are suitable for the baking industry and blending makes them more acceptable due to synergetic effect.

Key words: Cassava, potato, wheat, flours, proximate composition, functional properties

INTRODUCTION

Cassava (*Manihot esculata*, *crantz*) as an all season crop, as food in several parts of Africa (Nigeria inclusive), Asia and Latin America is well documented (Longe, 1980; Rosling, 1987; Bradbury *et al*., 1991). Nigeria alone, currently produces over 14 m tones annually, representing about 25% of sub-Saharan Africans output (Ayodeji, 2005). Although it is the third most important food source in the tropical world after rice and maize and provides calories for over 160 million people in Africa (Polsen and Spencer, 1991), its food value is greatly compromised by the endogenous presence of cyanogenic glucosides. These glucosides typified by linamer in [2-(S-D- glucopryanosylxy) methylbutyronitrile] are hydrolyzed to hydrocyanic acid (HCN) by endogenous linamarase, when cassava tissues are disrupted by cutting, grating, bruising or other mechanical means (Conn, 1969; Bradbury *et al*., 1991). Cassava, being very rich in starch (90% of the dry matter), it is mainly used in traditional human foods after more or less elaborate processing. It is estimated that about 70% of the total cassava harvested is processed into garri (a fried product prepared from pealed and grated cassava root), (Ngoddy, 1977). Lafun (fermented cassava root flour), fufu (fermented cassava root paste) are very popular in the western and eastern states of Nigeria respectively (Bassey and Dosunmu, 2003b).

Sweet potato (*Ipomoea batatas*) is believed to have originated from South America and spread throughout the tropical America in to the Caribbean and across the South Pacific to East Island. It is grown on various types of soil but best result and highest yields will be obtained on solid that are loose, free from rocks, fairly fertile with a pH of 5.0-6.0 and with good drainage (Peksa *et al*., 2002).

Wheat (*Triticum vulgare*) is the world's most widely cultivated plant. It is grown from the equator to 60°N and 40°S, with the greatest concentration in the temperate regions where the winters are cool followed by relatively dry and warm summer for ripening and with moderate rainfall between 30 and 90 cm (Kochhar, 1986).

However, due to the huge importation bill on wheat, it is believed that by reducing the level of wheat flour incorporated in the bakery industry with cassava and potato flour, the foreign exchange expenditure will be reduced significantly.

In this study, potato, cassava and wheat flours were produced and their proximate composition determined.

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Various blends of the flours were also produced and their physicochemical properties studied in order to determine their suitability for the bakery industry.

MATERIALS AND METHODS

Cassava and potato tubers were collected from local farmers in Offa, Kwara State, Nigeria. The tubers were washed, peeled, washed and sliced to sizes to expose large surface area. The slices were blanched in 90°C hot water for 90 sec, sun dried, milled, sieved to obtain the flour and packaged in polythene bags. The wheat grains were collected from the local market in offa, sorting of the grains was done to separate bad grains, stones and other non-wheat particles. The dried whole wheat grains (without shaft) were dry-milled into flour and sieved with a screen mesh of aperture 425 microns and packaged in clean polythene bags.

Proximate analysis: The moisture content (hot air oven method), fat (Soxhlet extraction methods) were determined according to Pearson (1976), while the ash and protein were determined using AOAC (1990) methods. The carbohydrate content was determined by simple differences and calorie value was estimated using Atwater factors by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel values of 4, 9 and 4 kcal/g, respectively and taking the sum of the products (Eneche, 1999).

Functional properties: The apparent water Absorption capacity (WAC) and oil Absorption capacity (OAC) were evaluated according to the methods of Sathe and Salunkhe (1981). Foaming stability (FS), foaming capacity (FC) and Least Gelation Concentration (LGC) were studied according to the method of Coffman and Garcia (1977). Emulsion capacity (EC) and Emulsion Stability (ES) were evaluated essentially according to the methods of Yatsumatsu *et al.* (1972) while protein solubility (PS) was determined according to the method of Anderson *et al.* (1969) and Bulk Density (BD) of the flours was determined according to the method of AOAC (1990).

Anti-nutrients: Phytin was determined according to the method of Young and Graves (1940) and oxalate according to the methods of Day and Underwood (1986).

RESULTS AND DISCUSSION

The proximate composition shows the following values for Ash 4.91, 2.18 and 6.26; for crude protein 20.9, 7.21 and 9.21; for fat 9.60, 0.45 and 2.54, for crude fibre 3.43, 6.19 and 2.80 and for carbohydrate 53.89, 73.74 and 71.61, for wheat, cassava and potato flours, respectively. This result is depicted in Table 1.

The protein content of cassava flour 7.21±0.02% was lower compared to that of potato 9.12±0.02% and wheat

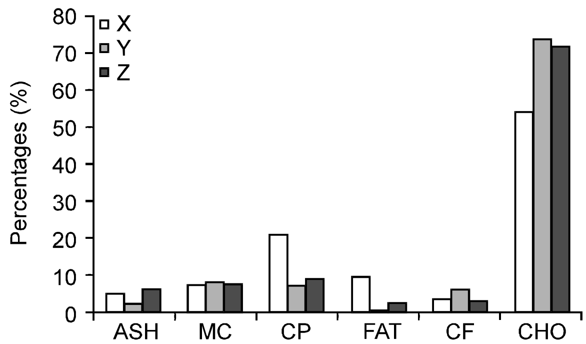

Fig. 1: Barchart depicting proximate compostion of wheat, potato and Cassava flour.
X = wheat: y = cassava flour: z = potato flour: CP = crude protein: MC = moisture content: CHO = carbohydrate: CF = crude fibre

20.96±1.01%. These results were higher compared to those reported for plantain flour 1.43±0.68%, (Bassey and Dosunmu, 2003a), egg plant varieties 0.88±0.8-1.75±0.12% (Olajide *et al.*, 2003), taro varieties 2.57±0.16-5.41±0.22% (Mbofung *et al.*, 2006) and sweet potato powder 5.23 ± 0.03% (Oladimeji, 2001), the value for wheat was higher but that of cassava and potato was lower than that of maize flour 10.60±0.17% (Oladimeji, 2001).

The fat content of cassava flour 0.45±0.02% was lower than potato 2.54±0.04% and wheat flour 9.60±0.01. The value for cassava flour was comparable to that Taro varieties flour 0.34±0.08-0.73±0.17% (Mbofung *et al.*, 2006) and higher than plantain flour 0.13±0.01 (Bassey and Dosunmu, 2003a). The percentage CV was high in most of the parameters but low in moisture content, these shows that, significant difference existed among the samples.

Figure 1 Shows a multiple bar chart depicting the flours. The higher bars depicted carbohydrate, with cassava being the highest and the lowest bars depicting crude fat, with cassava being the lowest. Wheat was better in protein than the others, in terms of fibre and moisture they were comparable.

Functional properties: The functional properties of the different flour bends were presented in Table 2. The water absorption capacity (% WAC) ranges from 125-210%, oil absorption capacity (% OAC) 68-191.68%. The value for WAC was lower while OAC was comparable to that reported for six taro varieties (WAC, 242.45±9.36-374.86±8.97%, OAC 174.37±0.73%-186.53±0.42%) (Mbofung *et al.*, 2006). The foaming capacity ranges from 4% for (G) 100% potato to 27% for (A) 100% wheat. The values were lower than that reported for legume flours and protein concentrates, except for Africa yam beans flours 25 and 27% for wheat (Akintayo *et al.*, 2000).

Table 1: Proximate composition of wheat, potato and cassava flour

Sample	ASH (%)	MC (%)	CP (%)	FAT (%)	CF (%)	CHO (%)	Energy content (Kcal)
X	4.91±0.02	7.20±0.02	20.9±0.01	9.60±0.01	3.43±0.01	53.89±0.04	385.56
Y	2.18±0.01	8.23±0.03	7.21±0.02	0.45±0.02	6.19±0.03	73.74±0.04	372.81
Z	6.26±0.02	6.67±0.02	9.12±0.02	2.54±0.04	2.80±0.03	71.61±0.08	345.78
Mean	4.45	7.70	12.43	4.20	4.14	67.08	353.05
Median	4.91	7.67	9.12	2.54	3.43	71.61	345.78
CV (%)	46.74	6.75	59.94	87.50	43.55	17.30	8.37
SK	-0.66	0.17	1.33	1.08	1.18	-1.17	0.74
Range	4.08	1.03	13.75	9.15	3.39	21.85	57.75
SD	2.08	0.52	7.45	4.80	1.80	11.61	29.55

X: Wheat flour; SD: Standard deviation; Y: Cassava flour; CP: Crude protein; CF: Crude fibre; Z: Potato flour; CV: Coefficient of variation; SK: Skewness; Mean: ±SD; n = 3; MC: Moisture content; CHO: Carbohydrate

Table 2: Functional properties of blended cassava, potato and wheat flours

Samples	WAC (%)	OAC (%)	FC (%)	FS (%)	EC (%)	ES (%)	LG (%)	BD (%)
A	140±0.00	177.50±13.4	27±9.90	4±2.80	50.51±2.22	47±1.41	2±0.00	64.98±0.02
B	205±7.10	187.00±0.00	6±0.00	1.50±0.10	48.04±0.06	53±1.41	4±2.83	60.21±0.03
C	170±14.1	168.30±26.4	11±1.41	1±0.00	44.85±0.58	51±1.41	3±1.41	63.81±0.01
D	125±7.10	191.68±6.61	14±0.00	1±0.00	48.95±0.05	48.50±2.12	3±1.41	66.03±0.03
E	180±0.00	191.68±6.61	15±7.10	2.50±0.71	46.95±1.36	52±2.83	2±0.00	62.43±0.01
F	205±7.10	177.65±13.4	8±0.00	2±0.00	48.74±1.79	50±2.83	3±1.41	59.98±0.02
G	210±0.00	191.68±6.61	4±0.00	2±0.00	46.39±0.79	52±0.00	2±0.00	62.59±0.00
RANGE	85.00	23.38	23.00	3.00	5.66	6.00	2.00	6.05
MEAN	176.43	183.66	12.14	2.00	47.78	50.50	2.71	62.86
SD	33.63	9.24	7.69	1.04	1.96	2.14	0.76	2.38
CV (%)	19.10	5.03	63.34	52	4.10	4.24	28.04	3.79
SK	-0.32	-1.08	0.44	0	-0.40	-0.70	-1.14	0.34

A: 100% wheat; B: 50% potato and 50% cassava; C: 50% wheat and 50% potato; D: 50% cassava and 50% wheat; E: 331/3 cassava; 331/3 potato and 331/3 wheat; F: 100% cassava; G: 100% potato; Mean±SD, n = 2; SK: Skewness; WAC: Water absorption capacity; OAC: Oil absorption capacity; FC: Foaming capacity; FS: Foaming stability; EC: Emulsion capacity; ES: Emulsion stability; LG: Least gelation; BD: Bulk density; SD: Standard deviation

The emulsion capacity ranges from 44.85% for (C) 50% wheat and 50% potato to 50.51% for (A) 100 wheat. The values were much higher than that reported for soya flour 15% and wheat 11.70% (Lin *et al*., 1994). Under the conditions of the present study, the different blends of flours show significant, difference in foaming capacity and foaming stability. The foaming stability ranges from 1% for (D) 50% cassava and 50% wheat to 4% for (A) 100% wheat. These range for foaming capacity was comparable to that different varieties of Taro flours 9 to 14% except for (A) 100% wheat which was 27% (Mbofung *et al*., 2006). The range for (FC) foaming capacity was also significantly lower than (27-32%) for raw and precooked taro (*Colocasia esculenta*) flours reported by Tagodoe *et al*. (1994). Comparatively, the foaming capacity of the blended flours was significantly lower than that of common beans reported by Njintang *et al*. (2001). Stable foams are known to occur when low surface tension and high viscosity occur at the interface forming a continuous cohesive film around the air vacuoles in the foam. Soluble protein in general plays an important role on the formation of foam and this probable justify why legumes exhibit higher foaming capacity (Mbofung *et al*., 2006).

The range of the flour bulk density value 59.98 to 66.03% of the different flours was significantly higher than that of taro varieties flour 0.57 to 0.71% (Mbofung *et al*., 2006) and also significantly higher than that of raw and precooked taro (*Colocasia esculenta)* flours reported by Tagodoe *et al*. (1994).

Protein solubility: The solubility of protein in the samples as a function of pH is depicted in Table 3 and Fig. 2. The lowest solubility were recorded at pH 3-4 for samples A-E (i.e (A) 100% wheat, (B) 50% potato and 50% cassava, (C) 50% wheat and 50% potato, (D) 50% cassava and 50% wheat, (E) 331/3% wheat. 331/3% potato and 331/3% cassava) for sample (F) 100% cassava flour, it was at pH 1 and (G) 100% potato pH 2 i.e. the minimum solubility of all the flours were in the acidic region between pH 1-4 and it ranges from 5.19-31.02%. The maximum protein solubility was observed at pH 6 for A, pH 8 for B and D, pH 12 for C,E,F and G. Though samples E and G have double peak at pH 6 and 12 for E and pH 9 and 12 for G.

The maximum protein solubility ranges between 25.53-83.08% for 100% cassava (F) and 100% potato (G), the maximum solubility was in the alkaline region between pH 9-12, but for 100% wheat (A), the maximum solubility was in the neutral region between pH 6-8. These may account for the high foaming capacity of wheat in this study, since distilled water was used which is neutral. The results depicts that potato protein were more soluble than that of cassava and wheat because of it low protein content but high percentage of protein solubilities. The high solubility of cassava and potato in the alkaline region, suggest that the flours may not be useful in the formulation of acid foods but basic food

Table 3: Protein solubility of blended wheat, potato and cassava flour

pH	A	B	C	D	E	F	G
1	29.26	15.15	14.51	31.03	26.13	5.31	37.33
2	25.94	10.38	10.81	26.87	19.46	10.40	31.02
3	16.28	5.19	7.41	22.33	13.34	13.05	37.33
4	12.97	7.79	18.22	17.79	19.46	13.05	43.12
5	22.63	10.38	10.81	22.33	26.13	15.71	43.12
6	38.92	15.14	14.51	26.87	32.80	16.81	55.73
7	32.57	20.34	18.22	31.03	29.46	15.71	43.12
8	35.60	25.53	10.81	35.58	26.13	23.45	49.43
9	25.94	20.34	14.51	31.03	19.46	15.71	83.08
10	19.60	15.14	21.92	26.87	22.79	28.53	80.45
11	25.94	17.74	25.32	22.33	26.13	15.71	74.14
12	22.63	20.34	29.03	24.60	32.80	36.50	83.08

A: 100% wheat; B: 50% cassava and 50% potato; C: 50% wheat and 50% potato; D: 50% wheat and 50% cassava; E: 33$^1/_3$ wheat 33$^1/_3$ cassava and 33$^1/_3$ potato; F: 100% cassava; G: 100% potato

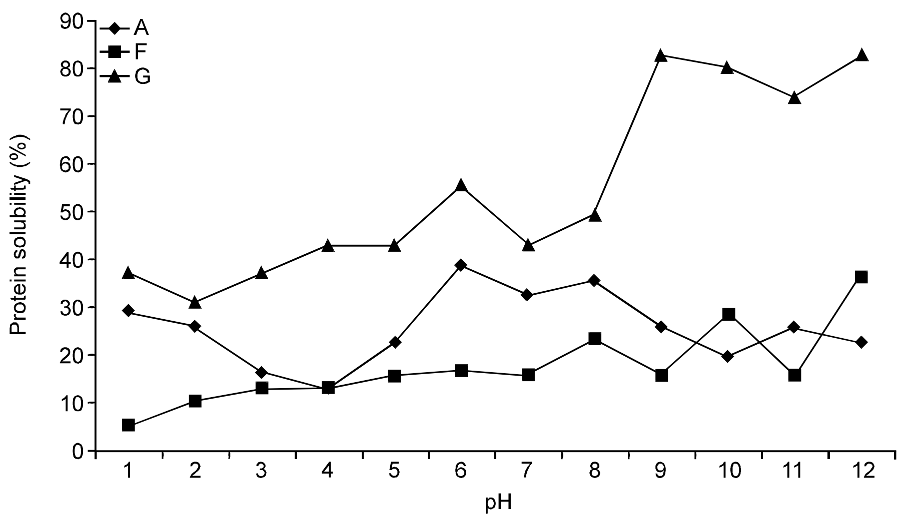

Fig. 2: Variation of protein solubility of sample f,g and a with ph using distilled water

(Akintayo *et al*., 2000; Clerge *et al*., 2006) and that it will be possible to produce their concentrate/isolates by alkaline extraction followed by precipitation at pH of minimum solubility. Melon seed protein also presented minimum solubility at about pH 3.0 and 5.5 (Ige *et al*., 1984). Fluted pumpkin seed flour pH 4 and maximum% protein solubility at pH 9 and isoelectronic point at pH 4 and (Fagbemi *et al*., 2006); T. Conophoru and R. heudeotti at pH 4.0 and 8.0 (Clerge *et al*., 2006). These result suggest that there may be more than one protein in the flours.

Generally, vegetable proteins have been reported to have isoelectronic points (IEP) at about pH 4 -5 and show high protein solubility at alkaline P^H (Del Rasario and Flores, 1981; Chan and Cheung, 1998; Abbey and Ibeh, 1988). The dependency of protein solubility on pH has been attributed to the change in the net charges carried by the protein as the pH changes.

Anti-nutrients: Table 4 shows the anti-nutritional constituent of the flours and blends. These study, shows the level of toxic substance in the samples. The result shows that the values of 2.251, 3.422, 3.151, 2.071, 3.423, 2.251 and 4.502 (mg/g) of oxalate for (A) 100% wheat, (B) 50% potato and 50% cassava, (C) 50% wheat and 50% potato, (D) 50% cassava and 50% wheat, (E) 33 1/3% wheat, 33 1/3% cassava and 331/3% potato, (F) 100% cassava and (G) 100 potato respectively. The presence of toxic substance otherwise known as anti-nutritional factors is one of the main draw-backs limiting the nutritional and food qualities of the legumes (Liener, 1976). The values ranges from 2.251±0.2mg/g for 100% wheat to 4.502±0.3 mg/g for 100% potato. The results shows that wheat and cassava have the same concentration of oxalate 2.251±0.2 mg/g. These result falls within the ranges (1.7-6.5) reported for some oil seeds (Victor and Olubunmi, 2003), higher than the range reported for two edible tropical land snails in Nigeria, A Marginata 1.50±0.03 and A achatin 1.7±0.03 (Ebenso *et al*., 2006), comparable to that reported for L. Aurora 3.81 mg/g (Udo *et al*., 1995).

The phytate values present in the sample are 12.3567, 12.3567, 14.8280, 9.0616, 13.1804, 18.9469 and 10.7091 (mg/g) for samples A,B, C, D, E, F and G

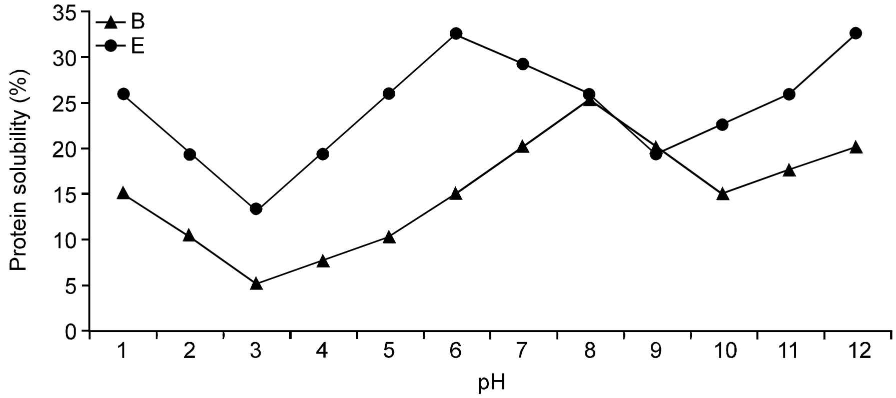

Fig. 3: Variation of protein solubility of sample b and e with pH using distilled water

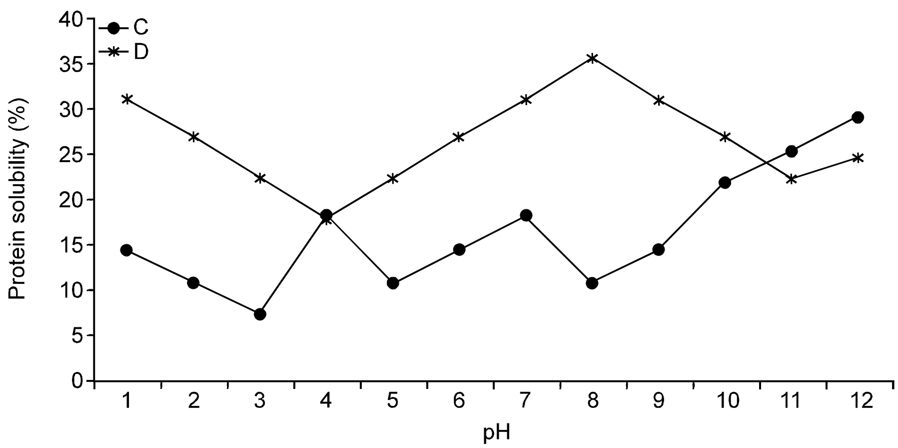

Fig. 4: Variation of protein of solubility of sample c and d with pH using distilled water

Table 4: Anti-nutrient of wheat, potato and cassava flour and their blends

Samples	Oxalate (mg/g)	Phytate (mg/g)
A	2.251±0.2	12.3567±0.2
B	3.422±0.3	12.3567±0.4
C	3.151±0.3	14.8280±0.3
D	2.071±0.2	9.0616±0.4
E	3.423±0.3	13.1804±0.5
F	2.251±0.2	18.9469±0.2
G	4.502±0.3	10.7091±0.1
Mean	3.010	13.0628
SD	0.8776	3.170
CV (%)	29.16	24.27
SK	-0.16	0.22

A: 100% wheat; B: 50% potato and 50% cassava; C: 50% wheat and 50% potato; D: 50% cassava and 50% wheat; E: 33 1/3 cassava 33 1/3 wheat 331/3 potato; F: 100% cassava; G: 100% potato; SD: Standard deviation; CV: Coefficient of variation; SK: Skewness

respectively. The phytate value ranges from 9.0616±0.4mg/g for (D) 50% cassava and 50% wheat to 18.9469±0.2 for 100% cassava (F). Cassava was richer in phytate than wheat and potato but potato was richer in oxalate than both. The values were higher than that reported for cassava leaves varieties which ranges from 1.073-2.391 mg/g (Ayodeji, 2005); A. Marginata 0.0126 mg/g and A. achatina 0.116 mg/g (Ebenso *et al.*, 2006).

The level of phytate in these samples seemed to be much higher than that reported for moth bean cultivars (8.52-8.99) mg/kg (Santish and Chauhan, 1986) and other beans such as kidney bean (Lolas and Markakus, 1975), black grain (Reddy *et al.*, 1978), Soyabean (De Boland *et al.*, 1975) and diolea reflexa seed (Aiyesanmi and Oguntokun, 1996). This suggests that nutritive value of these samples would be impaired. Phytate which represents about 89% of the total phosphorus concentration, is widely distributed in food grains (De Boland *et al.*, 1975). It lowers the bio-availability of minerals and inhibits several proteolytic enzymes and amylases (Erdman, 1979; Deshplande and Chevyan, 1984).

Several studies including (Rackis, 1974; Reddy *et al.*, 1982; Forbes and Erdman, 1983; Aletor, 1990) have implicated dietary phytic and oxalic acids in the impairment of the efficient utilization especially of divalent minerals such as calcium and magnesium and the subsequent development of rickets when certain legumes and cereals are fed. These result suggest fairly high level of phytic acid (phytates) and lower levels of oxalates in the samples. The feeding of high phytin and or oxalate species may require dietary supplementation of the divalent minerals.

Conclusion: The result of these study have demonstrated that, from the observed proximate analysis, functional properties and anti-nutritional factors, cassava and potato compares favourably with wheat. From other researches in Cassava flour or starch as a component of the composite flour, have shown that cassava can substitute 10-30% of wheat flour in bread. Cassava flour are particularly suitable since they have very low or zero fat content, which is important for long storage life, since there is less opportunity for hydrolysis of the fat or its oxidation. Other consideration in favour of cassava flour, include its bland taste, offering no foreign odour or flavour, high dilution levels and the potential abundance of cassava. The decreases in the protein content of the composite flour due to introduction of cassava and potato can be overcome be the addition of 5% Soya beans flour.

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