PHYSICO-CHEMICAL PROPERTIES, ENERGY, MINERAL, VITAMIN AND SENSORY EVALUATION OF WHEAT-BASED BREAD SUPPLEMENTED WITH LEGUME, ROOT, TUBER AND PLANTAIN FLOUR

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ABSTRACT

The chemical and physical properties, mineral, vitamin and sensory evaluation of breads based on wheat supplemented with legume, tuber, root and plantain flour were examined. The food grains were picked clean, hammer milled into flour (40mm mesh screen) and put in a polyethylene bag. Root, tuber and plantain were first peeled, sliced, sun-dried and milled into flour (40mm mesh screen) and also put in polyethylene bag. The flour batches were separately put in a container and were subjected to natural fermentation in de-ionized water in the ratio of 1:3 (w/v) at 28 ± 2^0C for 24 hours as pilot studies indicated that fermenting beyond this period produced offensive odour in tuber, root and plantain. The fermented samples were dried at 55 ± 2^0C in a drought air oven (Gallenkamp BS Model 250 Size 2 UK), hammer milled into fine flour (70mm mesh screen) and stored in a refrigerator until used for the chemical analysis and production of biscuits. The composites were formulated thus: wheat flour, 70% while legume, tuber, root and plantain supplied 25%, 5%, 3% and 2%, respectively, depending on the blend. The 100% wheat flour served as the control. The nutrient content, physical properties and the organoleptic attributes of the breads were evaluated using standard techniques. The test breads had high nutrient content that ranged from protein (13.86 – 16.40%), carbohydrate (69.70 – 74.60%), ash (4.64 - 5.80%), fat (2.10 - 2.40%), fibre (5.56 – 6.96%) and energy (358.74 - 383.80 kilocalories. The control had 406.54 kilocalories. Mineral levels were low except for calcium, phosphorus, potassium and sodium that ranged from (73.20 – 77.30mg, 75.40 – 114.00mg, 168.30 – 176.20mg and 716.30 – 726.26mg, respectively). The vitamin values were low relative to the control except the niacin. The physical parameters indicated that fermentation and type of supplements had negative effect ($P \geq 0.05$) on the weight and width of the test breads relative to the control. On the other hand, it did not markedly affect proofing ability, oven spring and specific volume of the experimental breads. The sensory analysis showed that all the test breads had high sensory ratings for the evaluated attributes that compared favourably with the wheat flour bread except for the breads containing AYB and PP that were much lower. The findings of the present study showed that wheat flour breads supplemented with legume, root, tuber and plantain flour produced acceptable and high nutrient density breads than 100% wheat flour breads.

KEYWORDS: Physico-chemical properties, sensory attributes breads, composites, fermentation, nutrient density.

INTRODUCTION

In Nigeria today, consumption of baked foods is greatly increasing. Moreover, the ever increasing urbanization in the country also adds pressure to the demand for baked products. Consequently, a greater percentage of the family income is spent on bakery products mainly for breakfast or as snacks. Nevertheless, these baked foods are poor sources of essential nutrients required for good health (McWatters, 1982; Uwaegbute and Anyika, 2008). Many researchers have used composite flour to produce bakery products that are higher in nutrient density than the 100% wheat products (Nout, 1977; Okaka and Potter, 1977; McWatters, 1982; Dhingra and Jood, 2000).

Supplementation of cereal-based foods with legume, root, tuber and plantain for the production of bakery products to improve their nutrient density has been reported (Impar, 1977; Natalie, 1988; Onoja and Obizoba, 2007; Akubor, 2008). This is because legume proteins for instance are high in lysine, an essential limiting amino acid in most cereals. Cereals on the other hand, are high in methionine and cystine which are deficient in legumes (FAO, 2004). Therefore blending legume with cereal will provide desirable protein pattern that would enhance nutritional status of the population. Also the high mineral and vitamin contents of these food crops are responsible for the increased nutritive quality of the supplemented products (Hotz and Gibson, 2007). The functional properties of composite flour made from wheat and other food crops have been found to be suitable for the production of bakery products (Hamad and Fields, 1979; Raidi and Klevin, 1983; Honda, 2005; Kubuo, 2007; Akubor et al., 2008). Legume, tuber, root and plantain due to their high fibre content have also been included within the group of functional foods due to their hypocholesterolemic and hypoglycemic effects (Trowell, 1973; Melissa and Mary, 1979); Usha, Vijayamma, and Kurups, 1989; Boby and Leelamma, 2003).

The production of any food product depends on its raw material availability. The major problem facing bakery industry in Nigeria is the total dependence on

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importation of wheat to sustain its production. It is, therefore, imperative that alternatives to wheat which is traditionally used for bakery products be developed either as an extension or a replacement. African yam-bean (*Sphenostylis stenocarpa*), cowpea (*Vigna unguiculata*), corn (*Zea mays*), pigeon pea (*Cajanus cajan*), plantain (*Musa paradisiaca*), water-yam (*Dioscorea alata*) and cocoyam (*Xanthosoma sagittifolium*) are produced abundantly in Nigeria but a greater percentage is wasted through post-harvest losses (Oyenuga, 1968; Onwueme, 1979). Nigerians are familiar with fermented foods and the application of fermentation as an economic food processing technique will encourage increase farm production of these under-utilized food crops, decrease antinutrients, increase quality and guarantee adequate nutrients intake of the population. There is no available literature on the supplemented wheat flour with flour from these selected food materials for the production of bakery products, notably, bread. The study was instituted to produce flour blends from these food crops for the production of bread.

MATERIALS AND METHODS
Materials

Wheat (*Triticum aestivum*), African yam-bean (*Sphenostylis stenocarpa*), cowpea (*Vigna unguiculata*), pigeon pea (*Cajanus cajan*), plantain (*Musa paradisiaca*), water-yam (*Dioscorea alata*) and cocoyam (*Xanthosoma sagittifolium*) were purchased from the local market in Nsukka, Enugu State, Nigeria.

Processing methods

3000 grams of each of the batches of different food materials were separately cleaned for the study. A batch of each food grain was hammer milled into flour (40mm mesh screen) and put in polyethylene bag. Tubers, roots and plantain were first peeled, sliced, sun-dried and milled into flour (40mm mesh screen) and also put in polyethylene bag. Wheat flour was purchased already milled as sold in Nsukka main market. The 100% wheat flour served as the control. The batches of the flour samples as well as the control were separately put in a container and fermented in de-ionized water in the ratio of 1:3 (w/v) at 28 ± 2^0C for 24h, as pilot studies indicated that fermenting beyond this period produced off-odour in tubers, roots and plantain. The fermented samples were dried at 55 ± 2^0C in a hot air oven (Gallenkamp BS Model 250 Size 2 UK) , hammer milled into fine flour (70mm mesh screen) and used for the production of breads. The bread produced from 100% wheat flour served as the control.

Formulation of composites

Flour blends were formulated in the ratio of 70:30 (protein basis) where wheat supplied 70%, while legume contributed 25% and water-yam, cocoyam, and plantain contributed 5%, 3% and 2% respectively, depending on the blend as shown below.

The Composites were thus;

W_{24} AYB_{24} WY_{24}: wheat: African yam-bean: water-yam, 70:25:5

W_{24} $CP_{24}WY_{24}$: wheat: cowpea: water-yam, 70:25:5

W_{24} $PP_{24}WY_{24}$: wheat: pigeon pea: water-yam, 70:25:5

W_{24} $CP_{24}CY_{24}$ PT_{24}: wheat: cowpea: cocoyam: plantain, 70:25:3:2

where W_{24} = 24 -h fermented wheat, AYB_{24} = 24 -h fermented African yam bean, WY_{24} = 24 -h fermented water -yam, CP_{24} = 24 -h fermented cowpea, PP_{24} = 24 -h fermented pigeon pea, CY_{24} = 24 -h fermented cocoyam, PT_{24} = 24 -h fermented plantain.

Preparation of breads

The breads were prepared from the different blends. The bread samples were prepared according to the method described by Ceserani et al. (1995). The recipe included 200 grams of the composite flour, 125 ml (milk and water), 5 grams of yeast, 10 grams of margarine, 5 grams of sugar and 2 grams of salt. Each appropriately weighed composite flour and ingredients were thoroughly mixed using a modified straight dough mixing method to produce the dough. The dough obtained after the mixing process was weighed, cut to uniform sizes, manually kneaded, moulded, brushed with egg and covered with a cheese cloth and left to proof for 105 minutes at 35 ± 2^0C. The leavened dough was carefully transferred to the baking oven at 180 ± 2^0C for 35 minutes. The baked products were cooled to room temperature and packaged in polyethylene bags.

Chemical and physical analysis

The flour blends and breads were analyzed for proximate, mineral, vitamin content and physical properties using standard method (AOAC, 2005). In order to correct for variability from different moisture levels, residual moisture was determined in all the samples. With this a factor (F) was computed which enabled all calculations to be done on dry matter basis (Polachi, 1968). Thus: F = 100/100-moisture content (determined). All analyses were performed in triplicate. The microKjeldahl method was used to estimate the protein nitrogen (N) which was then multiplied by the factor 6.25 to get the percent protein content (N x 6,25%)(AOAC, 1995).

Ash was estimated by incinerating 1g of the sample at between 550-600^{0}C for 6h in a muffle furnace until ash was obtained. Fat was estimated by extraction with petroleum ether using Tecator Apparatus. The carbohydrate content was obtained by difference. Mineral estimation was done using wet digestion with nitric and perchloric acids. The values were then read in Atomic Absorption Spectrophotometer. The vitamins B_1, B_2 and niacin content were estimated according to the method of Pearson (1976). The physical characteristics of the breads investigated included height, breath, weight, length, oven spring, proofing ability and specific volume according to the method described by Ceserani et al.(1995). The height, breadth and length, were measured by a metal rule. The weight was determined using a weighing balance. The proofing ability was measured by subtracting the initial height of the dough before proofing from the final height after proofing and multiplying the value by 100. Specific volume was determined from the volume of a known weight of bread using the formula according to Ceserani et al. (1995).

Thus specific volume (cm^3/g) $\dfrac{L \ x \ B \ x \ H}{W}$

Where L   =   bread length
      B   =   bread breadth
      H   =   bread height
      W   =   bread weight

Oven spring was estimated as the difference in dough height before and after baking.

Sensory evaluation

A five point Hedonic scale (Derek and Richard, 1982), where 5 represented the highest score and 1 the lowest was employed to evaluate the product for flavour, texture (crumb, crust), colour (crumb, crust) and general acceptability. Forty (40) trained panelists were randomly selected from students and lecturers of the Department of Home science, Nutrition and Dietetics, University of Nigeria, Nsukka, and participated in the tasting sessions. The tasting was carried out at the department. Each judge (panel member) was seated in an individual compartment free from noise and distraction. The breads were properly coded and served to the panelists for evaluating of taste, flavour, colour (crumb, crust), texture (crumb, crust) and general acceptability. Each judge was presented with a glass of water after each tasting session to rinse mouth so as to prevent carry-over effect.

Statistical analysis

Analysis of variance (ANOVA) and Duncan's New Multiple Range Tests (DNMRT) were used to test the significance of the difference among means. (Steel and Torrie, 1980).

RESULTS

The proximate composition of the fermented composite flour is presented in Table 1 while that of the breads is presented in Table 2. There were no significant differences (P>0.05) in protein, carbohydrate, fat, ash, and crude fibre contents among the blends. This showed a good blending of all the samples with the average protein value of 10.10%. The protein content of breads produced from the flour blends and the control ranged from 10.20 to 16.40%. The CP_{24} C_{24} CY_{24} PT_{24} blend had the highest protein (16.40%) that was significantly different (P<0.05) from the rest as well as the control (10.20%). The AYB_{24} C_{24} WY_{24} blend had the least (13.86%), however, it was somewhat similar to that of PP_{24} C_{24} WY_{24} (14.36%) (P>0.05). The CP_{24} C_{24} WY_{24} blend had 15.26% protein.

Table 1: Nutrient content* of the composite flour made from fermented wheat, African yam- bean, cowpea, pigeon pea, water yam, cocoyam and plantain flours per 100g sample (dry weight)

Parameters/ blends/ ratios	Crude protein (%)	CHO (%)	FAT (%)	ASH (%)	FIBRE (%)
$W_{24}AYB_{24}WY_{24}$ 70:25:5	9.68 ± 0.30^b	66.86 ± 1.20^d	2.96 ± 0.20^b	3.64 ± 0.30^b	3.26 ± 0.36^a
$W_{24}CP_{24}WY_{24}$ 70:25:5	11.10 ± 0.26^a	68.58 ± 1.30^c	3.01 ± 0.26^a	3.50 ± 0.26^b	2.84 ± 0.16^b
$W_{24}PP_{24}WY_{24}$ 70:25:5	9.50 ± 0.10^b	70.40 ± 1.30^b	3.10 ± 0.30^a	3.86 ± 0.12^a	2.40 ± 0.20^c
$W_{24}CP_{24}CY_{24}PT_{24}$ 70:25:3:2	10.10 ± 0.20^c	72.50 ± 2.50^a	2.86 ± 0.30^b	3.76 ± 0.20^a	3.36 ± 0.26^a

*   Means ± SD of 3 replications
     Values in the same column with same letter superscripts are not significantly different (P>0.05).
     W_{24} = 24h-fermented wheat, AYB_{24} = 24h – fermented African Yam bean, CP_{24} =24h – fermented cowpea, PP_{24} = 24h – fermented pigeon pea, WY_{24} = 24h – fermented water yam, CY_{24} = 24h – fermented cocoyam, PT_{24} = 24h – fermented plantain, CHO = Carbohydrate

Table 2 Proximate composition and energy content of breads prepared from different composites and the control per 100g sample (dry weight)

Parameters/ composites/ ratios	$W_{24}AYB_{24}WY_{24}$ 70:25:5	$W_{24}CP_{24}WY_{24}$ 70:25:5	$W_{24}PP_{24}WY_{24}$ 70:25:5	$W_{24}CP_{24}CY_{24}PT_{24}$ 70:25:3:2	Wheat flour 100
	1	2	3	4	5
Protein (%)	13.86 ± 1.30^d	15.26 ± 0.36^b	14.36 ± 0.20^c	16.40 ± 1.20^a	10.20 ± 1.10^e
CHO (%)	73.40 ± 1.20^c	69.70 ± 1.10^e	70.60 ± 1.20^d	$74.60 \pm 1.30b$	84.10 ± 1.20^a
ASH (%)	4.64 ± 0.30^d	5.80 ± 1.20^a	5.10 ± 1.26^c	5.26 ± 1.24^b	2.96 ± 0.50^e
FAT (%)	2.20 ± 0.20^c	2.40 ± 0.10^b	2.10 ± 0.10^d	2.20 ± 0.20^c	3.26 ± 0.16^a
Fibre(%)	6.96 ± 1.30^a	5.56 ± 1.40^d	5.78 ± 1.10^c	6.10 ± 0.20^b	1.16 ± 0.02^e
Energy (kilocalories)	368.84^c	276.96^e	358.74^d	383.80^b	406.54^a

*Means ± SD of 3 determinations
Data in the same horizontal line with different letter superscripts are significantly different (P<0.05).
n:Energy calculation was based on ATWater factor (protein x 4, CHO x 4, Fat x 9).
Abbreviations as already defined.

Table 3: Mineral and vitamin composition* of breads produced from composite flours from all vegetable sources and the control per 100g sample (dry weight).

Composites/ Ratios/ Parameters	$W_{24}AYB_{24}WY_{24}$ 70:25:5	$W_{24}CP_{24}WY_{24}$ 70:25:5	$W_{24}PP_{24}WY_{24}$ 70:25:5	$W_{24}CP_{24}CY_{24}PT_{24}$ 70:25:3:2	Whole wheat 100
Fe(mg)	1.36 ± 0.01^a	1.28 ± 0.02^b	1.12 ± 0.01^c	1.16 ± 0.01^d	1.06 ± 0.01^e
Cu(mg)	0.67 ± 0.01^a	0.46 ± 0.02^c	0.48 ± 0.01^c	0.54 ± 0.01^b	0.38 ± 0.01^d
Ca(mg)	73.20 ± 2.30^d	75.26 ± 2.50^c	76.00 ± 2.00^b	77.30 ± 2.3^a	32.50 ± 1.20^e
P(mg)	78.26 ± 1.10^b	75.40 ± 1.20^d	76.30 ± 1.20^c	114 ± 2.50^a	64.20 ± 2.00^e
I_2 (mg)	NS	NS	NS	NS	NS
K (mg)	176.20 ± 2.50^a	174.20 ± 1.20^b	171.20 ± 2.6^b	168.30 ± 2.10^c	173.00 ± 2.20^b
Mn (mg)	0.32 ± 0.01^b	0.30 ± 0.01^c	0.35 ± 0.02^a	0.33 ± 0.01^b	0.30 ± 0.01^c
Na (mg)	726.20 ± 2.40^a	716.30 ± 2.00^b	726.26 ± 1.20^a	724.10 ± 1.00^a	722.20 ± 2.50^a
Zn (mg)	0.68 ± 0.01^a	0.66 ± 0.01^a	0.58 ± 0.01^d	0.64 ± 0.01^b	0.61 ± 0.01^c
Mg (mg)	24.20 ± 0.20^a	20.20 ± 1.20^b	23.00 ± 1.20^a	20.20 ± 1.00^b	22.20 ± 1.20^a
Cd (mg)	0.002 ± 0.001^a	0.002 ± 0.001^a	0.003 ± 0.001^a	0.002 ± 0.001^a	0.002 ± 0.001^a
Cr (mg)	0.026 ± 0.001^b	0.032 ± 0.001^a	0.023 ± 0.001^b	0.022 ± 0.001^b	0.031 ± 0.001^a
B_1(mg)	0.20 ± 0.01^d	0.19 ± 0.01^d	0.24 ± 0.01^b	0.22 ± 0.01^c	0.076 ± 0.01^a
B_2 (mg)	0.28 ± 0.01^b	0.26 ± 0.01^c	0.28 ± 0.01^b	0.22 ± 0.01^d	0.075 ± 0.01^a
Niacin (mg)	1.12 ± 0.01^c	1.34 ± 0.02^a	1.24 ± 0.01^b	1.22 ± 0.01^b	0.54 ± 0.01^d

*   Means ± SD of 3 replications
     Values on the same horizontal line with the same letter superscripts are not significantly different (P>0.05).
     Data expressed as mg/100g product.
     NS = Not significant. Abbreviations as already defined.

Table 4: Physical qualities of breads produced from blends of all vegetable sources and the control

Composites/ Ratios/ Parameters	WAYBWY 70:25:5	WCPWY 70:25:5	WPPWY 70:25:5	WCPCYPT 70:25:3:2	Whole wheat 100 (Control)
Weight (g)	166.20±1.20	167.30±1.50	176.20±2.50	170.30±1.20	134.50±2.60
Width (cm)	4.68±0.20	4.50± 0.26	4.90±0.20	4.80±0.10	5.20±0.26
Height (cm)	4.30±0.20	4.26±0.10	3.96±0.40	4.10±0.10	5.96±1.20
Length (cm)	10.20±0.10	9.80±0.02	11.20±0.20	10.40±0.20	13.98±1.30
Oven spring (cm)	0.74±0.01	0.72±0.10	0.70±0.01	0.78±0.10	0.88±0.26
Spread ratio	5.98±0.20	6.42±0.20	5.88±0.02	6.54±1.00	6.58±0.20
Specific Volume (%)	1.28±0.20	1.24±0.20	1.32±0.20	1.42±0.20	3.82±0.26
Break strength(kg)	1.13±0.01	1.12±0.01	1.10±0.01	1.10±0.01	1.12±0.01

*   Data are means of 3 replications.
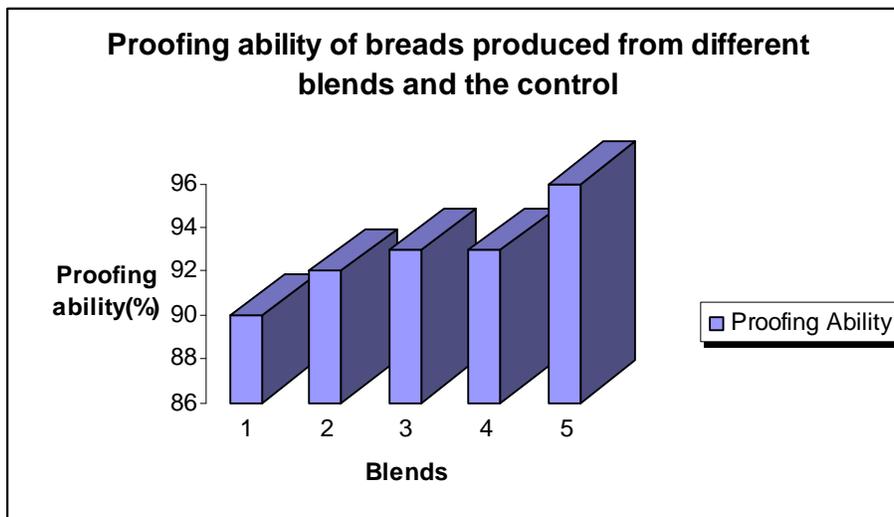
Figure 3: Proofing ability of breads produced from different blends and the control
Blend 1($W_{24}AYB_{24}WY_{24}$),Blend2($W_{24}CP_{24}WY_{24}$), Blend 3($W_{24}PP_{24}WY_{24}$), Blend 4($W_{24}CP_{24}CY_{24}PT_{24}$) and Blend 5(Control).

Table 5: Mean sensory evaluations of breads made from different composites and the control

Composites/ Ratios/ Parameters	$W_{24}AYB_{24}WY_{24}$ 70:25:5	$W_{24}CP_{24}WY_{24}$ 70:25:5	$W_{24}PP_{24}WY_{24}$ 70:25:5	$W_{24}CP_{24}CY_{24}PT_{24}$ 70:25:3:2	Whole wheat 100
Loaf shape	5.40±0.20[e]	7.60±1.20[c]	5.60±0.50[d]	8.40±0.20[a]	8.80±1.20[a]
Mouthfeel	5.86±0.26[e]	6.60±0.30[c]	6.40±0.20[d]	8.30±1.3±0[a]	8.60±0.30[a]
Taste	4.50±1.50[d]	7.40±0.80[b]	5.60±1.20[c]	8.20±0.26[a]	8.70±1.20[a]
Flavour	5.20±0.20[e]	7.20±0.10[c]	6.20±0.10[d]	7.80±1.20[b]	8.20±1.20[a]
Crust					
Colour	5.60±0.30[d]	7.46±0.30[b]	6.20±0.60[c]	8.00±1.20[a]	8.20±1.20[a]
Texture	5.40±0.36[c]	7.30±0.20[b]	5.60±0.20[c]	7.60±0.80[a]	7.80±2.00[a]
Crumb					
Colour	5.46±0.16[c]	7.10±0.36[b]	5.20±0.20[d]	8.20±1.20[a]	8.60±1.20[a]
Texture	5.60±0.20[c]	7.46±0.20[b]	4.60±0.40[d]	7.80±0.26[a]	7.98±0.20[a]
General					
Acceptability	5.50±0.26[d]	7.66±1.20[b]	5.66±1.00[c]	8.40±1.20[a]	8.60±1.00[a]

*   Means ± with different letter superscripts in the same horizontal line are significantly different (P<0.05). Abbreviations as already defined.
          Values were based on a 5 – point , Abbreviations as already defined.
          Hedonic scale (where 5 represented the highest and 1 the lowest)

The control had much higher carbohydrate (84.10%) than the rest. The test breads had appreciable high carbohydrate levels that ranged from 69.70 to 74.60%. The ash content of the CP_{24} C_{24} WY_{24} blend was the highest (5.80%) relative to the other test samples and the control.. The CP_{24} C_{24} CY_{24} PT_{24} blend had the second highest ash (5.26%). The $W_{24}AYB_{24}WY_{24}$ blend had the least value amongst the

test breads. The experimental breads had ash values that were significantly different from the control (2.96%) (P< 0.05). The control had the highest fat content (3.26%) compared with the test samples (P ≤ 0.05). The CP_{24} C_{24} WY_{24} blend had higher fat (2.40%) than the other test samples (P ≤ 0.05). The PP_{24} C_{24} WY_{24} and AYB_{24} C_{24} WY_{24} blends had comparable fat values (2.20 cf 2.20%, respectively). The control had the least fibre (1.16%) and the values for the test samples were appreciable and ranged from (5.56 to 6.96%). The energy content of the $W_{24}CP_{24}CY_{24}PT_{24}$ bread (383.80 kilocalories) was the highest amongst the test samples. The values of the test samples ranged from (358.74 to 383.80 kilocalories) (Table 2). On the other hand, the control had the overall highest energy value (406.54kilocalories) that was significantly different (P< 0.05) from the test samples.

Table 3 presents the mean mineral and vitamin composition of the breads. The mineral values of the test samples were higher than the control except the Cd that had comparable values with the control (P> 0.05) while the Cr values of the test breads were slightly lower than the control. However, the values for calcium, phosphorus, potassium, sodium and magnesium in both the test products and the control were markedly high. The iodine values of both the test products and the control were insignificant. The vitamins B_1 and B_2 and niacin levels of the test products were higher than the control.

The physical qualities of the breads are presented in Table 4. The weights of bread samples from $W_{24}AYB_{24}WY_{24}$, $W_{24}CP_{24}WY_{24}$, $W_{24}PP_{24}WY_{24}$ and $W_{24}CP_{24}CY_{24}$ PT_{24} blends and the control were 166.20, 167.30, 176.20, 170.30 and 134.30g, respectively. This indicated that $W_{24}PP_{24}WY_{24}$ bread had the highest weight followed by $W_{24}CP_{24}CY_{24}$ PT_{24} when compared with the other test breads and the control (Table4). The control on the other hand had the least (134.50g). The control had the highest width (5.20cm) relative to the test breads. The $W_{24}AYB_{24}WY_{24}$ and $W_{24}CP_{24}WY_{24}$ samples had 4.68 and 4.50 cm, respectively. The $W_{24}PP_{24}WY_{24}$ and $W_{24}CP_{24}CY_{24}PT_{24}$ had comparable values (4.90 cf 4.80cm). The $W_{24}CP_{24}CY_{24}$ PT_{24} bread had the highest height (4.30cm) compared to the other test samples. The $W_{24}CP_{24}WY_{24}$ sample was the second highest (4.26cm) among the test samples. The control (wheat flour bread) had the overall highest height (5.96cm) which differed markedly from the test breads (P<0.05).

The lengths of the test samples $W_{24}AYB_{24}WY_{24}$, $W_{24}CP_{24}WY_{24}$, $W_{24}PP_{24}WY_{24}$ and $W_{24}CP_{24}CY_{24}$ PT_{24} were 10.20, 9.80, 11.20 and 10.40cm, respectively which differed significantly (P<0.05) from the control (13.98cm). The oven spring of both the test breads and the control were comparable and ranged from (0.72 to 0.88cm). The spread ratio of both the control sample and the $W_{24}CP_{24}CY_{24}$ PT_{24} bread was comparable (6.54 vs 6.58) and were higher than other samples. The values for $W_{24}AYB_{24}WY_{24}$, $W_{24}CP_{24}WY_{24}$ and $W_{24}PP_{24}WY_{24}$ were 5.98, 6.42 and 5.88cm, respectively. The value of the specific volume for the control bread was the highest (3.82%) which was significantly different (P<0.05) from the test samples. The values for the test breads were 1.28, 1.24, 1.32 and 1.42% for $W_{24}AYB_{24}WY_{24}$, $W_{24}CP_{24}WY_{24}$, $W_{24}PP_{24}WY_{24}$ and $W_{24}CP_{24}CY_{24}$ PT_{24} samples, respectively. The break

strength of both the test breads and the control were not significantly different (P>0.05) from each other. The values ranged from (1.10 to 1.13kg). The proofing ability of both the test breads and the control is shown in Figure 3. The control sample exhibited the highest proofing ability followed by the $W_{24}PP_{24}WY_{24}$,$W_{24}CP_{24}CY_{24}$ PT_{24} , $W_{24}CP_{24}WY_{24}$ and $W_{24}AYB_{24}WY_{24}$ samples in that order, thus: control > $W_{24}PP_{24}WY_{24}$ > $W_{24}CP_{24}CY_{24}$ PT_{24} > $W_{24}CP_{24}WY_{24}$ > $W_{24}AYB_{24}WY_{24}$.

Table 5 presents the mean sensory evaluation scores of the breads produced from the various flour blends and the control. The observable trend was that the bread from $W_{24}CP_{24}CY_{24}$ PT_{24} had much higher organoleptic attributes (flavour, texture, crumb colour, crust colour, taste and general acceptability) than those from the other test samples. There was a significant difference (P ≤ 0.05) in crumb and crust colour among the test products (breads). The judges preferred the colour of the breads from $W_{24}CP_{24}CY_{24}$ PT_{24} blend to the other test samples (P ≤ 0.05) except for the control. Although the sensory attributes of the breads from the other test blends were lower than those of the control and the $W_{24}CP_{24}CY_{24}$ PT_{24} blend, they were, however, acceptable. There was a significance difference (P ≤ 0.05) in the degree of acceptance among the breads. The panelists neither liked nor disliked the breads produced from the $W_{24}AYB_{24}WY_{24}$ and $W_{24}PP_{24}WY_{24}$ blends.

DISCUSSION

The high protein values of the test breads were due to fermentation, type of supplements and mutual supplementation effects. It could as well be attributable to synthesis of new protein from hydrolyzed free amino acids during fermentation by microflora enzymes. It is known that when legumes supplement cereals and tubers they provided a protein quality comparable to or higher than that of animal protein (Impar et al., 1977; Hotz and Gibson, 2007; Obizoba and Okeke 1986). The higher protein for the CP_{24} C_{24} CY_{24} PT_{24} blend over the other blends showed that it was superior to other blends. The low lipid level is expected. Legumes, cereals, roots, tubers and plantain store energy in form of starch rather than lipids. The low lipid values are beneficial as it guarantees longer shelf life for the breads (Beuchat and Worthington, 1974). This is because it is a common knowledge that the higher the lipid content of a given food, the higher are the chances for rancidity.

The high ash content for the CP_{24} C_{24} CY_{24} PT_{24} bread and the control when compared to the other test samples was an indication that the products are good sources of mineral (Reebe et al., 2000). The high carbohydrate levels for the breads might be ascribed to either individual food materials or microflora enzyme hydrolysis that led to the synthesis of complex carbohydrates from other nutrients carbon skeletons. The slightly lower values of carbohydrate for some blends could be attributed to its use as source of energy by the fermenting microflora or that the carbohydrate provided the required carbon skeleton for synthesis of other new nutrients particularly, protein (Hotz and Gibson, 2007; Obizoba, 1998; Odunfa, 1985) .

The copper values of the test breads relative to the control suggest their superiority over the control. The variations in values observed in the test breads could be due to source of supplementation. The levels of iron

were a function of treatment and food sources. It is known that iron complexes with tannin and phytate. During fermentation these complexes are broken down by the hydrolyzing enzymes to increase iron levels (Reebe et al., 2000; Hotz and Gibson, 2007). The increase in phosphorus might be due to release of phosphorus from its organic complex by the microflora enzymes (Reebe et al., 2000). The higher calcium for the CP_{24} C_{24} CY_{24} PT_{24} sample as compared to others might be that the optimum fermentation conditions were met to release free calcium from its bound form by enzyme hydrolysis (Nnam, 1995, 2003).

Fermentation influenced the physical characteristics of the test breads produced. The width and length of the test samples had comparable values. They were however, lower than their controls. This is because the spread of bread was affected by the competition of the ingredients for the available water. Flour which absorbs water during mixing will tend to reduce it (Raidi and Klevin, 1983; Singh et al., 1991). The wheat flour used in producing control bread might have absorbed more water than the test blends.

The low level of gluten in the composite flour would no doubt affect the weight, the height, the proofing ability, the specific volume, the oven spring and the shear stress of the sample products as less carbon IV oxide (CO_2) would be retained by the dough. Moreover during fermentation fat, protein and carbohydrate are hydrolyzed (diluted) and would influence the products and result in the above observations. The present findings were in agreement with those for bambara groundnut – maize flour blend (Akpapunam, 1994), fermented wheat – cowpea blend (Akubor, 2008), fermented composite flour blend (Onoja and Obizoba, 2007), African yam-bean – wheat blend (Onyechi and Nwachi, 2008), chickpea-broadbean-isolated soy protein flour blend (Taha et al., 2006). Fermentation improved the proofing ability, the oven spring as well as the specific volume of the test products except for the AYB_{24} C_{24} WY_{24} and PP_{24} C_{24} WY_{24} breads.

The sensory evaluation of the bread samples are presented in Table 5. The preference of crumb and crust colour, texture, flavour and taste of bread from CP_{24} C_{24} CY_{24} PT_{24} blend to other test samples could be due to synergistic effects of food supplementation. The lower colour and flavour scores for the AYB_{24} C_{24} WY_{24} and PP_{24} C_{24} WY_{24} blends could be due to type of supplement. The general acceptability of the products was a function of colour, flavour, texture and taste. The breads from the control and CP_{24} C_{24} CY_{24} PT_{24} that had better flavour, taste and colour than others were much more acceptable. This phenomenon is not surprise. This is because it is known that appearance of food evokes the initial response. However, the flavour determines the ultimate final acceptance or rejection by the consumer (Ratapol and Hooker, 2006). This high acceptability of the CP_{24} C_{24} CY_{24} PT_{24} blend could be due to mutual supplementation effect. Mbithi -Mwikya et al. (2002); Hamad and Fields (1979), equally reported higher acceptability of corn chips, rice chips and bakery products from fermented flour.

CONCLUSION

Fermentation and supplementation increased nutrient density and organoleptic attributes of the products. Fermentation of the cereals, legumes, tubers and plantain to produce breads increased acceptability. The high fibre contents make the products good for diabetics. The selected blends could be incorporated into the traditional dishes of those who prefer natural enhancement of nutrients to enrichment. The blends and their products have greater promise for increased use of other under-utilized food crops in Nigeria ecosystem.

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