Chemical, Physical and Sensory Properties on the Keeping Quality of Wheat-Groundnut Protein Concentrate Bread

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ABSTRACT

Background: *Bread is a staple food and is consumed in large quantities because it is affordable, is an excellent source of nutrients and is available in a "ready to eat" form.*

Objective: *This study investigated the effect of groundnut protein concentrate (GPC) inclusion on the keeping quality of baked bread.*

Methods: *The bread samples were produced using straight dough method from blends of wheat flour and groundnut protein concentrate (%, w/w) at ratios 100:0, 95:5, 90:10, 85:15, and 80:20, with 100% wheat flour serving as the control sample. Subsequently, free fatty acids, proximate composition, minerals, physical and sensory properties as well as its shelf stability were determined using established methods.*

Results: *There was an increase in free fatty acid (FFA) across all the blends at day 1, 2 and 5. Highest free fatty acid were recorded in blend with 20% groundnut protein concentrate 7.83, 10.10 and 13.46 for day 1, 2 and 5 respectively. Highest protein content of 28.61% was recorded in blend with 20% groundnut protein concentrate. Significantly (P<0.05), a decrease in the loaf height and volume was observed in the samples as storage time increases. An increase in the loaf weight was observed for sample 90:10 and 85:15 on the fifth day of storage.*

Conclusion: *Sample with 20% groundnut protein concentrate revealed to maintain its wholesomeness in terms of sensory and other parameters measured during storage.*

Keywords: wheat, bread, composite flour, groundnut, protein concentrate.

INTRODUCTION

Bread has become the second most widely consumed non-indigenous food products after rice in Nigeria (1, 2). This product is basically made from hard wheat flour, yeast, fat, sugar, salt and water. It is predominantly rich in carbohydrates and it is an appropriate vehicle for food fortification of essential macronutrients and micronutrients. Wheat is the choice cereal for manufacture of bread because it contains a large amount of gluten, which makes raised loaves (3). However, white bread is considered poor in nutrition owing to its deficiency of some essential amino acids such as lysine, threonine and tryptophan as well as dietary fiber (4, 5) and has also been implicated for the incidence of celiac disease (6).

Legume proteins are good sources of lysine, an essential amino acid and the critical criteria for use of any food material in food processing are its availability and cost. One of the main challenges faced by bakery industries in Nigeria is overdependence on importation of wheat to sustain it, since Nigeria's climate does not favour cultivation of wheat (3). Thus, any effort geared towards substituting part of wheat flour with readily available legume flours in bread making will be a welcome idea. The use of composite flours had a few advantages for developing countries such as Nigeria in terms of: i) the saving of hard currency; ii) promotion of high-yielding, native plant species; iii) a better supply of protein for human nutrition; and iv) better overall use of domestic agriculture production (7, 8).

Groundnut (*Arachis hypogae, L.*) is the fourth important legume in the world. Groundnuts after oil extraction leaves a lot of meal called as defatted groundnut flour which contains 50–55 % of high-quality protein (9). Groundnut protein concentrate (GPC) is extracted or prepared from groundnut through various methods such as isoelectric precipitation, aqueous precipitation, and alcoholic precipitation (10, 11, 12, 6). Fortification or enrichment of cereal based foods with other protein sources such as legumes has gained considerable attentions in the recent time among researchers and several institutions, including the Food and Agriculture Organization (FAO), (13, 14, 15, 3, 6). In countries such as Nigeria where malnutrition coupled with household food insecurity due to insurgency, herders/farmers and communal clashes pose a serious problem among the populace, composite flours which have better nutritional quality would be highly desirable (16). It has also been reported that composite flour can be made from legumes and nuts such as soybean, bambara nut, cowpea, african yam bean etc (17). Also Ocheme et al (6) reported that the protein concentrate in defatted groundnut flour was greater than 70%. Groundnut protein concentrate (GPC) can be successfully used in baked products to obtain a protein-enriched product with improved amino acid balance. The objective of this study was to determine the chemical, physical and sensory properties on the keeping quality of wheat-groundnut protein concentrate bread.

Materials and Methods

Materials

Groundnuts (Arachis hypogeal) and wheat flour (Golden Penny) were obtained from Kure Central Market, Minna, Niger State.

Methods

Preparation of defatted groundnut flour

Defatted groundnut flour was produced based on the procedure described by Ocheme et al (6). The nuts were sorted to remove extraneous materials and then pretreated for 5 min with a mixture of 5.25% sodium hypochlorite and de-ionized water (1:10 v/v) to control microbial growth. Thereafter, the nuts were rinsed with de-ionized water (1:3 w/v) and oven-dried (NL9023A England) at 50°C for 24 hr. The nuts were then roasted at 140°C for 6 min, decoated manually and milled in a laboratory blender (Sa-1706, China). Subsequently, the milled groundnut paste was wrapped with filter paper and put inside a solvent extractor. N-hexane was filled into a fat free round bottom flask up to $^{2}/_{3}$ of the volume of the flask; the soxhlet apparatus was assembled and allowed to reflux for 6hours with heating mantle (KDM 1000) adjusted to 60-70°C. The filter paper was removed from the solvent extractor and spread for proper drying.

Preparation of GPC

Groundnut protein concentrate was produced using the procedure reported by Gayol et al (18). Defatted groundnut flour was mixed with water at ratio 1/10 (w/v). Then it was shaken at ambient temperature for an hour and the pH was modified to 4.5 with 4mol/L concentration HCL. The suspension was centrifuged at 959 x g for 20 min. The supernatant was discarded, and the precipitate was re-suspended in water at ratio 1/10 (w/v) and stirred at room temperature for 1hour so as to clear the acid. Thereafter, it was centrifuged at 3,500 rpm for 30minutes. The supernatant was discarded, and the precipitate was removed from the tube with a spatula, dried in an oven (Gallenkamp oven plus series) at 40°C, packaged, and stored at 4 ± 2°C until required for use.

Preparation of blends of wheat flour and GPC

Wheat flour and GPC were blended (%, w/w) at ratios 100:0, 95:5, 90:10, 85:15 and 80:20, with 100% wheat flour serving as the control sample. The samples were homogenized with the aid of a Kenwood Mixer to obtain homogenous samples.

Bread loaves Production

The straight dough method described by Ihekoronye and Ngoddy (19) was used with some modification to produce bread. The bread samples were produced in batches by mixing and kneading manually. The dough was allowed to rest for 15minutes before being kneaded back and then moulded into cylindrical shape after which the dough was then placed in baking pan smeared with vegetable oil and covered for the dough to ferment for 1hour at room temperature, resulting in gas production and gluten development. The dough was baked in a cabinet oven pre-heated and set at 180°C for 30minutes after which it was brought out in each case from the oven and immediately de-panned by knocking out. The bread samples were allowed to cool to room temperature and then packaged and stored in polyethylene bags for further analysis.

Proximate analysis
Protein, fat, ash, moisture, carbohydrate, fiber contents, and energy values were determined using standard methods (20). All experiments were performed in triplicate.

Determination of physical properties of the bread loaves
The method described by Onwuka (21) was used to determine the loaf volume of bread samples. After cooling for 1hour by using millet seed in place of rape-seed displacement, the weight of each of the bread samples was taking with the aid of a weighing balance and the volume of the container (1200ml beaker) used was recorded as V_1 (cm^3). The container was then filled with millet seed until the seeds started dropping from the container, a straight ruler was used to cut-off all seeds above container rim so that the seeds formed a Plateau with the rim of the container. The seeds were then poured out of the container, weighed and recorded.

Determination of Mineral Content
The mineral content of the bread samples was determined by the method described by AOAC (20) using the ash gotten from ash analysis by adding few drops of distilled water, 2ml of concentrated HCL and 10ml of 20% HNO_3 into the crucible which was allowed to evaporated on the hot plate. Whiteman filter paper was used to filter the samples into 100ml volumetric flask. Atomic absorbance spectrophotometer was then used to determine iron, magnesium and calcium. Potassium and sodium was determined by corning 400 flame photometers (22), while the method described by Nielsen (23) was used to determine the phosphorus in the filtrate using calorimetrically with jenway 6100 spectrophotometer.

Sensory analysis
Using a 9 point hedonic scale (19), ranging from 1(disliked extremely) to 9(liked extremely) was employed to evaluate the product for flavour, taste, texture, colour (crumb, crust) and the overall acceptability. A-20 semi-trained panel of judges were from randomly selected from students and staff of the Department, Food Science and Technology, Federal University of Technology, Minna Nigeria, participated in the tasting sessions. Loaf samples were sliced evenly without removing the crust. Samples were placed on white plates and identified with random three-digit numbers. Each panelist was presented with a glass of water after each tasting session to rinse the mouth in order to prevent a carry-over effect.

Storage of bread loaves
The bread samples were stored under ambient temperature and observed for 5 days. Physical properties were analysed on a daily basis while the free fatty acids (FFA) was determined on the first, third and fifth day of storage using the method of Ibitoye (24).

Data analysis
Data obtained were subjected to one-way analysis of variance while Duncan's multiple range test was conducted to separate the means. These were achieved using the Statistical Package for Service Solution (SPSS) version 23.0.

Table 1 Free fatty acid of bread blends for day one, three and five

SAMPLE (mg/g/KOH)	DAYS		
	1	3	5
100:0	$5.59 \pm 0.01^{c, b}$	$7.92 \pm 0.03^{b; c}$	$10.10 \pm 0.00^{a; c}$
95:5	$4.47 \pm 0.01^{c; a}$	$5.59 \pm 0.01^{b; a}$	$8.97 \pm 0.00^{a; b}$
90:10	$6.72 \pm 0.01^{b; c}$	$6.73 \pm 0.00^{b; c}$	$7.8 \pm 0.00^{a; a}$
85:15	$6.73 \pm 0.00^{c; c}$	$8.97 \pm 0.00^{b; d}$	$11.22 \pm 0.00^{a; d}$
80:20	$7.83 \pm 0.01^{c; d}$	$10.10 \pm 0.00^{b; e}$	$13.46 \pm 0.00^{a; e}$

Values are means of duplicate determination. Means on the same row with different first superscript are significantly different ($p<0.05$). Means on the same column with different superscript are significantly different ($p<0.05$).

Results and Discussion

Free fatty acid (FFA) of GPC bread loaves

Free fatty acid (FFA) result of bread is presented in Table 1. The free fatty acid of bread samples increased with increase in storage time at ambient temperature, (25). There was a significant ($P<0.05$) difference between the days for 80:20, 85:15 with day 5 recording the highest values and day 1 having lowest value. Similar trend was also observed in 95:5, but 90:10 shows no significant ($P>0.05$) difference for day 1 and 3 but significantly ($P<0.05$) difference from day 5.

Proximate composition of GPC bread loaves

Proximate composition of bread loaves is presented in Table 2. Moisture content of the samples ranged from 18.31 to 29.30% with 100% wheat flour having the least value across the storage days. Significant ($p<0.05$) increase in protein content of wheat flour was recorded with increasing GPC. Highest protein content of 28.61% was recorded in blend with 20% groundnut protein concentrate. Sample 20% GPC was also seen to be significantly ($P<0.05$) high in crude fibre as well as ash content after the fifth day of storage. The increasing crude fiber with increasing GPC substitution in the blends could also be viewed as a nutritional advantage considering the effect of fiber in digestion of food. The increase may be due to the combination effect between wheat flour and groundnut protein concentrate. On the contrary, carbohydrate and fat content decreases significantly ($p<0.05$) with increasing GPC as the storage period proceeds. The increase in protein on the one hand and the decrease in carbohydrate on the other hand, was a direct consequence of increasing and decreasing GPC and wheat flour, respectively (26, 6). Moisture is a very important factor in the keeping of bread and high moisture can have an adverse effect on shelf stability (27). The bread samples with the highest moisture content may therefore have a reduced shelf life compared to the other samples with lower moisture content.

Sensory scores of GPC bread loaves

Table 3, shows the sensory score of the various bread samples. Colour is an important physical and sensory property of concern to consumers. The crust colour of the bread samples 80:20, 85:15 and 95:5 were highly accepted than 100:0 and 90:10. However, sample 85:15 scored highest (8.17) acceptance, while 90:10 recorded the least score (7.61). This could be as a result of the inclusion of GPC. Crumb colour of sample 85:15 and 100:0 was highly accepted compared to the rest of the samples with sample 85:15 recording the highest (8.28) and 90:10 recorded the lowest. The acceptability for texture in sample 100:0 was higher than the rest of the samples with sample 80:20 and 90:10 the least score of (7.69) and (7.67) respectively. Sample 100:0 and 85:15 recorded the highest number of preference in terms of flavour than the rest samples, this could be due to the effect of fermentation on groundnut. While 90:10 was less accepted. Sample 100:0 was better accepted than the rest samples in term of taste. Samples 100:0 and 90:10 have the highest values for overall acceptability, while sample 80:20 recorded the lowest. However, sample 80:20 revealed to maintain its wholesomeness in terms of the parameters measured during storage and as such can be conveniently stored for the duration of five days.

In conclusion, bread loaves produced with groundnut protein concentrate (GPC) inclusion up to 20%, were nutritionally superior to that of the whole wheat flour. The effects of inclusion of wheat flour with groundnut protein concentrate (GPC) flour on the physical properties of bread do not have a uniform trend. However, consumer perception and preference agrees that it is quite possible to produce acceptable bread from groundnut protein concentrate (GPC) wheat composite flour that would compare favourably well with 100% whole wheat formulation. Bread loaves produced with groundnut protein concentrate (GPC) flour were more shelf stable than other bread produced from lower level of inclusion.

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Table 2 Proximate composition of GPC bread loaves DAY 1

Parameter (%)	100:0	95:5	90:10	85:15	80:20	100:0	95:5	90:10	85:15	80:20
Moisture content	$21.87^{d}\pm01$	$29.30^{a}\pm0.1$	$20.69^{e}\pm0.1$	$27.23^{b}\pm0.1$	$25.60^{c}\pm0.0$	$18.31^{e}\pm0.1$	$25.00^{a}\pm1.5$	$18.89^{d}\pm0.1$	$24.87^{b}\pm0.1$	$21.75^{c}\pm0.3$
Crude protein	$18.97^{e}\pm0.1$	$20.23^{d}\pm0.1$	$23.48^{c}\pm1.01$	$25.74^{b}\pm0.1$	$28.61^{a}\pm0.0$	$15.36^{e}\pm0.1$	$18.32^{d}\pm0.1$	$20.44^{c}\pm0.1$	$21.60^{b}\pm0.1$	$22.33^{a}\pm0.1$
Crude fibre	$1.03^{c}\pm0.01$	$1.30^{b}\pm0.12$	$1.04^{c}\pm0.01$	$1.34^{b}\pm0.01$	$1.56^{a}\pm0.01$	$0.30^{d}\pm0.12$	$0.71^{b}\pm0.14$	$0.37^{c}\pm0.09$	$0.71^{b}\pm0.14$	$1.52^{a}\pm0.01$
Ash content										
	$2.30^{b}\pm0.12$	$1.34^{e}\pm0.01$	$1.84^{b}\pm0.01$	$2.03^{c}\pm0.01$	$2.49^{a}\pm0.01$	$2.00^{c}\pm0.58$	$1.48^{d}\pm0.01$	$2.48^{b}\pm0.01$	$1.48^{d}\pm0.01$	$2.98^{a}\pm0.01$
Fat content										
CHO	$10.28^{a}\pm0.1$	$6.87^{d}\pm0.14$	$8.21^{b}\pm0.01$	$7.28^{c}\pm0.01$	$7.23^{c}\pm0.01$	$7.48^{a}\pm0.01$	$4.48^{b}\pm0.01$	$4.48^{b}\pm0.01$	$2.37^{d}\pm0.01$	$2.98^{c}\pm0.01$
	$45.55^{c}\pm0.1$	$42.30^{c}\pm0.1$	$44.74^{b}\pm0.01$	$36.38^{d}\pm0.01$	$34.51^{e}\pm0.01^{e}$	$56.55^{a}\pm0.01$	$50.01^{c}\pm0.01$	$53.34^{b}\pm0.01$	$48.97^{d}\pm0.01$	$48.44^{e}\pm0.01$

Values are means of duplicate determination. Means on the same row with different superscript are significantly different ($p<0.05$).

Table 3 Sensory Scores of GPC bread loaves

Parameter %	100:0	95:5	90:10	85:15	80:20
Crust colour	$7.94^d \pm 0.17$	$8.00^c \pm 0.14$	$7.61^e \pm 0.20$	$8.17^a \pm 0.22$	$8.06^b \pm 0.19$
Crumb colour	$8.06^b \pm 0.19$	$7.94^d \pm 0.17$	$7.78^e \pm 0.25$	$8.28^a \pm 0.25$	$7.97^c \pm 0.91$
Texture	$8.17^a \pm 0.19$	$7.94^b \pm 0.19$	$7.67^d \pm 0.23$	$7.78^c \pm 0.15$	$7.69^d \pm 0.19$
Flavour	$8.00^a \pm 0.18$	$7.83^b \pm 0.19$	$7.56^d \pm 0.20$	$8.00^a \pm 0.19$	$7.81^c \pm 0.19$
Taste	$8.11^a \pm 0.16$	$7.89^b \pm 0.18$	$7.72^d \pm 0.18$	$7.83^c \pm 0.17$	$7.81^c \pm 0.28$
Overall acceptability	$8.50^a \pm 0.29$	$8.00^c \pm 0.58$	$8.50^a \pm 0.50$	$8.25^b \pm 0.25$	$7.75^d \pm 0.48$

Values are means of duplicate determination. Means in the same row with different superscript are significantly different ($p<0.05$).

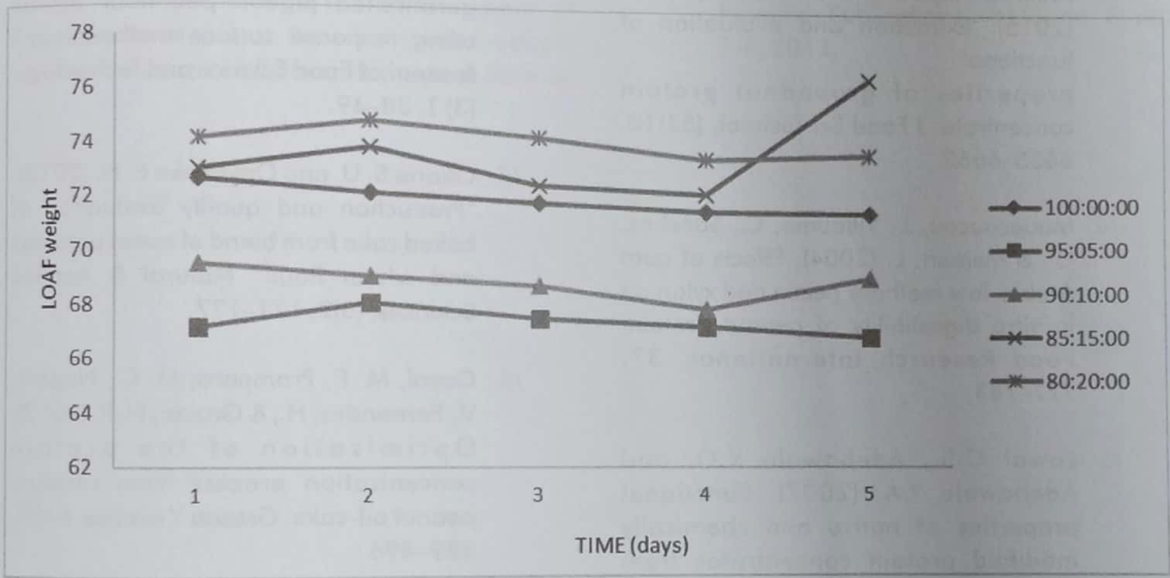

Fig 1 Loaf weight of GPC bread samples under storage

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