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Cowpea seed nutrients: Impacts on nutritional quality and acceptability of bread

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Abstract

White bread is a fermented, energy-dense food with minimal protein and certain macro and micronutrients required for important living functions. In this study, bread was fortified with roasted cowpea flour (RCF) in varied amounts (0-20%). The chemical compositions and sensory properties of RCF-supplemented bread samples were evaluated using conventional procedures. Proximate analysis results demonstrated that RCF addition greatly raised the crude fiber (1.78-2.32%), ash (3.08-3.46%), fat (4.58-5.35%), and crude protein (13.81-16.82%) of the bread samples, while carbohydrate content (71.3-66.84%) reduced significantly. Supplementing bread with RCF increased the mineral content (calcium, iron, phosphorus, and magnesium) of the final bread samples. The sensory assessment score demonstrated differences in general acceptability between sample B (5% RCF with 95% wheat flour) and the other bread samples. Thus, supplementing white bread with RCF resulted in bread with improved nutritional content, particularly protein, magnesium, and phosphorous, which are required for good health.

Keywords: White bread; Roasted cowpea flour; Supplementation; Wheat flour; Micronutrients

Introduction

Bread, a baked wheat product, is a ready to eat food and widely consumed non-indigenous food in Nigeria (Shittu *et al.* 2007). It is a major staple food product which has gained wide acceptance for many years among consumers worldwide, including Nigeria (Badifu *et al*. 2005). It is a favourite of children and adults regardless of their socioeconomic class. Globally, bread is eaten in large quantity in different types and forms depending upon their cultural habits. It could be consumed as snack, or utilized as an ingredient for other culinary preparations. Bread is rich in carbohydrate but low in protein and other nutrients needed by the body to maintaining good health. Protein-Energy Malnutrition (PEM) is usually found among the children of low socioeconomic families, and in Nigeria, death of 22 to 40% of children below age five have been attributed to PEM (Ubesie and Ibeziakor, 2012), hence, the need for consumption of balance diets by these categories of people and adult in general.

Although, bread is a high energy food (Bolarinwa *et al*. 2017) due to its high carbohydrate and fat contents (Ameh *et al.* 2013), it could be deficient in some essential micronutrients (Young, 2001) that are needed for proper functioning of vital life activities. This is because bread is prepared basically from wheat flour that is limiting in lysine and contain low levels of some macro and micro nutrients, however it is still the preferred grain for bread production due to its high gluten content (Badifu and Aka, 2001). To enhance the nutritive value of wheat flour, it could be supplemented with other cereals or legumes flours.

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For instance, supplementation of bread as well as other cereal based foods with protein sources such as legumes has gained considerable attentions among Nigerian researchers (Olapade *et al.* 2011). Examples include production of bread from wheat, maize and orange fleshed sweet potato flour blends (Igbabul *et al.* 2014). Ameh *et al.* (2013) too produced bread from wheat flour and undefatted rice bran. In addition, bread was produced from wheat flour and tilapia fish (Adeleke and Odedeji, 2010), wheat, plantain and soybean flours (Olaoye *et al.* 2006), wheat and tiger-nut flours (Ade Omowaye *et al.* 2008), wheat flour and moringa seed powder (Bolarinwa *et al*. 2019), and wheat flour and pawpaw puree (Bolarinwa *et al*. 2019). All these aim at increasing the protein contents and reducing or solving micro-nutrients deficiency problems among the vulnerable groups in Nigeria.

Cowpea (*Vigna unguiculata* L. Walp) seeds are distributed globally, and a relatively cheap source of protein and energy. In Nigeria, cowpea, either white or red variety, is the main raw material for production of wide range of dishes and snacks (Asif *et al*. 2013) such as *akara, moinmoin, gbegiri* etc due to its appreciable nutritional quality and availability throughout the year. Like most seeds, it is rich in protein (21.70-24.70%) which has been shown to reduce low density lipoproteins that are implicated in heart disease (Phillips *et al.* 2003). Furthermore, cowpea is low in fat, rich in fibre, as well as other naturally occurring minerals and vitamins found in plants. In addition, because grain legume starch is digested at a slower rate than cereal and tuber starches, their consumption produces fewer abrupt changes in blood glucose levels following consumption (Phillips *et al*. 2003). Cowpea also contains appreciable quantities of minerals such as potassium, magnesium, zinc, iron, phosphorous and calcium (Braakhuis *et al*. 2016).

Recently, consumers are becoming conscious of what they eat. People are more interested in consuming nutritious and healthy foods. Therefore, food manufacturers must bear in mind the need for production of functional foods and nutraceuticals. Thus, the objective of this study is to determine the effects of supplementing wheat flour with roasted cowpea flour on the nutritional quality and acceptability of the bread.

Materials and methods

Sources of materials

Wheat flour, cowpea (Maiduguri variety), sugar, salt, yeast and margarine were bought from Oja-oba market, Ilorin, Kwara state, Nigeria.

Preparation of roasted cowpea flour (RCF)

Cowpea seeds were cleaned manually in order to remove sand and other foreign bodies. It was then soaked in water for

Raw cowpea seeds
↓
Cleaning
↓
Soaking and Dehulling
↓
Washing and draining
↓
Roasting (180ºC for 15 minutes)
↓
Cooling
↓
Dry milling
↓
Sieving and packaging
↓
Roasted cowpea flour

Fig. 1. Flow chart for production of roasted cowpea flour

5 mins, dehulled by rubbing it strongly between the two palms, washed several times with potable water, drained and roasted at 180°C for 15 minutes. It was then cooled, dry-milled into flour using hammer mill, sieved to remove coarse particles (20 µm) and packaged in air-tight container (Fig. 1).

Preparation of wheat- roasted cowpea flour bread samples

Wheat flour, margarine, sugar, yeast, salt and water were hand mixed together in a clean bowl. The dough was

Raw materials (wheat flour, margarine, sugar, salt, roasted cowpea flour)
↓
Addition of water containing yeast
↓
Mixing
↓
Kneading, scaling and moulding
↓
Oiling of pans
↓
Panning
↓
Proofing (55 min)
↓
Baking (220°C for 20 min)
↓
Cooling
↓
Packaging
↓
Wheat -roasted cowpea bread

Fig. 2. Flow chart for production of roasted cowpea flour supplemented bread

kneaded, weighed, moulded and placed in already oiled baking pans to proof (at room temperature for 55 mins). The fermented dough was baked in the oven at 220 to 230℃ (Bolarinwa *et al.* 2019) for 20 mins. The 100% white bread was cooled and packaged as control sample. For the wheat-roasted cowpea flour supplemented bread (Fig. 2), ingredients were prepared as described above, with the addition of varying proportion of the roasted cowpea flour (RCF) as indicated in Table I.

HNO_3-$HClO_4$ acid solution (2:1 volume) was added and digested. Colourless solution obtained was transferred into a 100 ml calibrated sample bottle and made up to mark with distilled water. Calcium (Ca), Magnesium (Mg), Iron (Fe), Potassium (K) and Sodium (Na) in the bread samples were determined using Flame Atomic Absorption Spectrophotometer (VARIAN model AA240FS, United States) (AOAC, 2012).

Table I. Formulation of wheat-roasted cowpea dough

Samples	Roasted cowpea flour (g)	Wheat flour (g)	Yeast (g)	Margarine (g)	Salt (g)	Sugar (g)	Water (ml)
A	0	1000	20	100	10	120	600
B	50	950	20	100	10	120	600
C	100	900	20	100	10	120	600
D	150	850	20	100	10	120	600
E	200	800	20	100	10	120	600

KEY

Samples A - bread from 100% wheat flour

Samples B - 5% roasted cowpea flour supplemented bread

Samples C - 10% roasted cowpea flour supplemented bread

Samples D - 15% roasted cowpea flour supplemented bread

Samples E - 20% roasted cowpea flour supplemented bread

Chemical analyses of wheat-roasted cowpea bread

Proximate Analyses

The ash, crude fibre, fat, and moisture contents were determined using AOAC (2012) method. Kjeldahl method was used to determine the crude protein content and carbohydrate contents were determined by difference as shown below:

%Carbohydrate = 100 – (%Ash + %Fiber + %Protein + %Fat + %Moisture)

Mineral analysis

Bread samples were oven- dried at 60°C, cooled, ground into powder and 1g of each of the bread sample was weighed into a 250 ml Kjeldahl distillation glass and 50 ml of

Sensory assessments of the bread samples

The wheat-roasted cowpea bread samples and 100% white bread (control sample) were coded and presented to twenty randomly selected untrained tasters that were familiar with bread. They were asked to score the control and RCF supplemented bread samples for texture, taste, flavour, mouth feel and overall acceptability, using a nine (9) point hedonic scale rating, where 1 to 9 represented dislike extremely and like extremely, respectively.

Statistical analysis

All results were analyzed statistically at 5% significance level, data generated were subjected to ANOVA using a statistical package for the social science (SPSS for windows software version 20.0) and means were separated using Duncan Multiple Range test.

Results and discussions

Proximate composition of the control and roasted cowpea flour (RCF) supplemented bread

Boiling and roasting of legumes, such as cowpeas, are significant unit procedures that eliminate anti-nutritional components, increase protein availability, improve protein digestibility, and enhance flavour through caramelization. Table II shows the proximate composition of wheat-roasted

Table II. Proximate composition of bread supplemented with roasted cowpea flour

Samples	Moisture %	Crude fibre %	Ash %	Crude fat %	Crude protein %	Carbohydrate %
A	4.84±0.01[e]	1.54±0.00[d]	1.73±0.01[b]	4.02±0.00[d]	9.70±0.01[e]	78.16±0.01[a]
B	5.55±0.01[d]	1.78±0.01[c]	3.25±0.00[a]	4.59±0.07[c]	13.81±0.00[d]	71.03±0.09[b]
C	6.36±0.01[a]	2.03±0.02[b]	3.28±0.00[a]	5.35±0.04[a]	15.05±0.05[c]	67.92±0.07[d]
D	5.64±0.01[c]	2.06±0.00[b]	3.08±0.01[a]	4.58±0.00[c]	15.34±0.03[b]	69.31±0.05[c]
E	6.23±0.01[b]	2.32±0.00[a]	3.46±0.01[a]	5.13±0.01[b]	16.02±0.00[a]	66.84±0.03[e]

Means with same superscripts are not significantly different (p>0.05)

Where A= 100% wheat flour, B =950 g wheat flour (WF); 50 g roasted cowpea flour (RCF), C = 900 g wheat flour (WF); 100 g roasted cowpea flour (RCF), D= 850 g wheat flour (WF); 150 g roasted cowpea flour (RCF), E= 800 g wheat flour (WF); 200 g roasted cowpea flour (RCF)

cowpea bread samples, and each bread sample differed significantly from the others. The moisture levels varied between 4.84 and 6.36%, with sample A (100% wheat flour) having the lowest value and sample C (900 g WF; 100 g RCF) having the highest value. Similarly, as the level of RCF in the bread samples increases, so does the moisture content, while it remains within an acceptable range for a stable shelf life, as described by Adeyanju *et al.* (2021). The degree of moisture in food samples is one of the most commonly utilized metrics for predicting shelf stability (Akinsanmi*,* 2015), as well as susceptibility to contamination and/or spoilage by microbes. Flours with lower moisture content offer improved shelf stability because spoilage is frequently triggered by microbial activities and related chemical reactions that require more moisture.

The crude fiber levels of the bread samples ranged from 1.54 to 2.32%, and they increased with the amount of roasted cowpea flour in the bread samples. Soluble fiber increases bowel movement while slowing glucose absorption (Chukwuma *et al.* 2010). Similarly, the ash contents increased with increase in roasted cowpea flour supplementation. Ash content in the bread samples ranged from 1.73 to 3.46%, and the highest value was observed in sample E (800 g WF; 200 g RCF) while sample A (100% wheat flour) had the lowest ash value. The ash and crude fibre contents of the RCF supplemented bread samples reported in this study were higher than 1.51-1.61% ash and 0.13-0.18% fibre contents respectively reported for defatted moringa seed flour fortified wheat bread (Ojotu eke *et al.* 2022).

On the other hand, the fat contents of the bread samples ranged from 4.02 to 5.35%. Sample A (control) had the lowest value while sample C (900 g WF; 100 g RCF) had the highest fat content. The fat contents of RCF supplemented bread samples in this study corroborates with the fat content of bread supplemented with buckwheat flour (4.88-5.85%) reported by Mohajan *et al.* (2019). The lower fat contents could contribute to a longer shelf-life as this may delay onset of rancidity (Adeyanju *et al*. 2021). Proteins are biopolymers and are of paramount importance for biological systems. In fact, all the major structural and functional aspects of the body are done by protein molecules (Vasudevan *et al.* 2011). In this study, the protein contents of the bread samples ranged from 9.70 to 16.82%. Since cowpea is rich in protein (21.70-24%), as its quantities in the bread samples increased, the crude protein contents of the bread samples also improved significantly (p<0.05). This is an indication that consumption of wheat-roasted cowpea bread will enhance the protein intake of the consumer public. For instance, sample E, 800 g WF: 200 g RCF had the highest protein content while sample A, 100% wheat flour, had the lowest protein content. Barber and Obinna-Echem (2016) in their study on cookies from wheat and walnut flours also reported highest protein (13%) content in samples with the highest level of walnut flour (80% wheat flour to 20% walnut flour). The crude protein contents of the roasted cowpea supplemented bread samples also corroborates with what Adeleke and Odedeji (2010) reported for tilapia fish flour fortified bread (9.08-18.01%), Shekarabi and Shahbazi (2022) reported for bread fortified with fish protein powder and similar to 10.11-16.23 % crude protein contents of buckwheat flour supplemented bread reported by Mohajan *et al*. (2019). However, the carbohydrate contents of the bread samples ranged from 66.84 to 78.16%. The control sample (Sample A), had the highest carbohydrate content and sample E, 800 g WF; 200 g RCF had the lowest value. Decrease in carbohydrate levels in the RCF supplemented bread samples could be due to increase in crude protein, moisture and ash contents in the RCF supplemented bread samples.

Mineral contents of roasted cowpea flour supplemented bread

The mineral contents of RCF supplemented bread are shown in Table III. Minerals are inorganic nutrients that are needed by the body in small quantities from less than 1 to 2500 mg/day depending on the type of mineral (Soetan *et al.* 2010). They are essential dietary requirement for building structural components of the body, and some mineral elements form an integral part of an enzyme or protein structure. They are also vital for normal growth, body maintenance, effective immune system and prevention of cell damage (Kassa and Hailay, 2014). In this study, the values obtained for mineral elements ranged from 261.34-275.52, 9.24-10.13, 17.41-19.93, 24.94-9.24 and 28.10 mg/100g for calcium, iron, phosphorus and magnesium respectively. The notable increase in essential mineral of RCF supplemented bread compared to the non-supplemented counterpart could be due to presence of these minerals in the roasted cowpea flour used to supplement the bread samples (Bolarinwa *et al*. 2019).

Table III. Mineral compositions of roasted cowpea flour supplemented white bread

Samples	Ca (mg/100g)	Fe (mg/100g)	P (mg/100g)	Mg (mg/100g)
A	255.02±0.00d	4.55±6.44a	13.97±0.00d	24.87±0.00e
B	261.34±0.00c	9.24±0.00b	17.41±0.00c	24.94±0.00d
C	268.07±0.00b	8.40±0.00c	18.24±0.00b	25.63±0.00c
D	270.41±0.00a	8.43±0.00c	19.11±0.00a	26.73±0.00b
E	275.52±0.00a	10.13±0.91a	19.93±0.00a	28.10±0.00a

Means with same letter are not significantly different ($p > 0.05$)

A= 100% wheat flour, B =950 g wheat flour (WF); 50 g roasted cowpea flour (RCF), C = 900 g wheat flour (WF); 100 g roasted cowpea flour (RCF), D= 850 g wheat flour (WF); 150 g roasted cowpea flour (RCF), E= 800 g wheat flour (WF); 200 g roasted cowpea flour (RCF).

Calcium is necessary for supporting bone formation and growth; it also helps in the maintenance of healthy teeth, skeletal and soft tissue, mucous membranes and skin (Chidinma *et al.* 2010). Sample E (800 g WF; 200 g RCF) had the highest calcium content (275.52 mg/100g) followed by sample D (850 g WF; 150 g RCF) (270.41 mg/100 g) while the non-supplemented sample A (100% wheat flour) had the lowest calcium content (255.02 mg/100g). Sample E (800g WF; 200g RCF) had the highest iron, phosphorous and magnesium contents while sample A which was not supplemented had the least values. Generally, mineral contents of RCF supplemented bread samples were higher than those recorded for the non-supplemented counterpart. This could be due to high protein, fibre, and mineral contents of cowpea. In addition, many studies have reported that inclusion of legumes such as cowpea, soybeans etc in beverages (Udeozor, 2012; Bolarinwa *et al*. 2019), snacks (Bolarinwa *et al*. 2016a) or complimentary foods (Bolarinwa *et al*. 2016b; Tufa *et al*. 2016; Abeshu *et al*. 2016) could significantly increase nutrients such as protein, fat and mineral contents in the final products.

Sensory evaluation of roasted cowpea flour supplemented bread

The mean sensory results for all the evaluated quality attributes are shown in Table IV. A significant increase in appearance was observed with little supplementation of white wheat flour with roasted cowpea flour. The control sample (100% white bread) was the least acceptable with respect to appearance while sample B (950 g wheat flour (WF); 50 g roasted cowpea flour) had the highest appearance score and was significantly different from all other bread samples. The golden brown colour of RCF impact positively in the appearance of sample B, hence, the highest score recorded for it by the panelists. Taste is an important sensory parameter that determines whether a food product will be

Table IV. Sensory evaluation of roasted cowpea flour supplemented bread

Samples	Appearance	Taste	Aroma	Overall acceptability
A (control)	6.40±1.57c	7.95±0.94a	7.95±0.89a	8.10±0.85b
B	8.35±0.88a	8.20±1.01a	8.25±0.79a	8.70±0.47a
C	7.50±0.83b	7.25±0.97b	7.05±1.10b	7.60±0.94b
D	7.80±1.15ab	8.35±0.67a	7.95±0.69a	7.95±0.94b
E	7.80±1.11ab	6.75±1.21b	6.75±1.29b	7.60±1.31b

Means with same letter are not significantly different ($p > 0.05$)

Where A= 100% wheat flour, B =950 g wheat flour (WF); 50 g roasted cowpea flour (RCF), C = 900 g wheat flour (WF); 100 g roasted cowpea flour (RCF), D= 850 g wheat flour (WF); 150 g roasted cowpea flour (RCF), E= 800 g wheat flour (WF); 200 g roasted cowpea flour

accepted or not. Sample D (850 g wheat flour (WF); 150 g roasted cowpea flour) had better scores for taste than other samples followed by sample B (950 g WF; 50 g RCF) while sample E (800 g WF; 200 g RCF) had the least taste score. Aroma is another crucial attribute that influences the acceptability of baked food products even before they are consumed. Significant difference (p<0.05) also existed between the aroma scores for sample E and 100% white bread (control sample). This could be due to presence of roasted cowpea flour with desirable characteristic aroma in the supplemented bread samples. This is in line with that reported that roasting produces characteristic aroma that alters the sensory properties and improves palatability of foods. With respect to overall acceptability of bread samples, sample B had better acceptance than both the control sample and other roasted cowpea flour supplemented bread samples.

Conclusion

In this work, bread samples with increased protein and mineral contents were made by supplementing wheat flour with roasted cowpea flour. Sample B (bread made with 5% roasted cowpea flour and 95% wheat flour) received the highest sensory evaluations. Significant increases in protein and vital mineral content of wheat-roasted cowpea bread should provide significant nutritional benefits to Nigerians and other developing countries where animal protein meals are prohibitively expensive. Further research may look into the amino acid profile of wheat-roasted cowpea bread samples. The flour mixture proportions and processing conditions for bread making could also be improved.

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