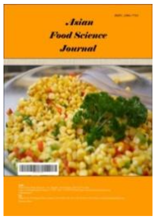

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Chemical and Antioxidant Quality of Breakfast Cereal Extruded from Maize Grits, Partially Defatted Peanut and Beetroot Flour Blend

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Authors' contributions

This work was carried out in collaboration among all authors. Author IAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TMU and BK managed the analyses of the study. Author PO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The mineral, essential and non essential amino acids contents and the antioxidant capacity of extruded breakfast cereal from maize grits, partially defatted peanut and beetroot flour blends was investigated. Composite flour blends were prepared from maize, peanuts and beetroot flour in the following proportion A= (100% Maize flour as control), B= (90:0:10), C= (90:10:0), D= (80:10:10), E= (70:20:10), F= (60:30:10), and G= (50:40:10). There was significant difference in the mineral composition of composite flour blends, the values ranged from 6.05-62.32 mg/g, 0.83-4.53 mg/g, 1.03-3.14 mg/g, 163.81-640.03 mg/g for calcium, iron, zinc, potassium respectively. The esstenial amino acids values of the four blends for isoleucine, leucine, lysine, methionine, alanine, threonine, tryptohan and valine ranged from 0.24-1.25, 0.04-1.08, 0.08-0.40, 0.13-0.49, 0.28-0.48, 0.22-0.44, 0.4-0.24 and 0.30-0.69 respectively. There was increase in antioxidant capacity of the sample with beetroot and peanut inclusion. The 2.2 diphenyl 1-1 picryl hydroxyl (DPPH) radical scavenging activity ranged from 4.03-16.83 while the ferric reducing antioxidant power ranged from 15.65-45.53 MgGAE/Mol with trolox equivalent antioxidant capacity was from 10.21-37.01 mmol trolox/Mol and the total phenohic sontent 5.01-22.01 MgGAE/g.

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Keywords: Antioxidant; beetroot; breakfast; maize; minerals; peanuts; total phenolic content.

1. INTRODUCTION

Breakfast cereal is defined as any food obtained by the swelling, roasting, grinding, rolling or flaking of any cereal. It is a grain food, usually pre-cooked or ready- to-eat that is customarily eaten with milk or cream for breakfast in the United States or elsewhere, often eaten with sugar, syrup or fruit [1]. Breakfast is the nutritional foundation or the first meal of the day [2]. Nutritional experts have referred to breakfast as the most important meal of the day, citing studies that found people who skip breakfast to be disproportionately likely to have problems with concentration, metabolism, and weight [3]. A study has clearly shown that 42% of 10-year-olds and 35% of young adults consumed cereal at non-breakfast occasions [4]. The diet of an average Nigerian consists of food that is mostly carbohydrate based. Consumers are also becoming increasingly aware of the need to consume foods with enhanced nutritive and health promoting properties [5].

Previous studies [6], indicated that all cereals are limited in some essential amino acids especially threonine and tryptophan. Consumption of proteins from plant sources (legumes) is encouraged [7], since combination of legumes and grains provide biologically high quality and cheaper protein that contains all essential amino acids in proper proportion and their amino acids complement each other [8]. Composite flours are a mixture of flours from tubers rich in starch (eg. cassava) and /or protein rich flours (eg peanut, soybean) and/or cereals (eg. Maize, rice), with or without wheat flour [9]. Shittu [10] also agreed with that as the composite flours used were either binary or ternary mixtures of flours from some other crops with or without wheat flour. Flour from these root and tuber crops have been used in the production of bread, cookies, doughnuts and noodles [11,12]. The use of composite flours in bread making has been reported by many researchers. Olaoye [13] investigated the use of supplementation of flours of soybean and plantain in wheat in the production of bread. Mepba [14], Giami [15] produced acceptable bread from composite flour. Minerals and vitamins are essential daily requirements for adolescent diets [16,17] Extrusion technology well-known in the plastics industry, has now become a widely used technology in the agri-food processing industry, where it is referred to as extrusion-cooking [18]. Food extruders (extrusion-cookers) belong to the family of high temperature short time (HTST) equipment, capable of performing cooking tasks under high pressure [19]. Exposure to high temperatures for only a short time will restrict unwanted denaturation effects on, for example, proteins, amino acids, vitamins, starches and enzymes.

Whole maize contains about 11% protein, 4% fat, 3% fibre, 65% of starch and other carbohydrates and 1.5% of minerals [20]. Maize is deficient in some essential amino acids such as lysine and tryptophan [21]. Corn contain vitamin B-complex such as B1 (thiamine), B2 (niacin), B3 (riboflavin), B5 (pantothenic acid) and B6 that makes it good for hair, skin, digestion, heart and brain. Red beetroot is a rich source of minerals (manganese, sodium, potassium, magnesium, iron, copper). Beetroot contains a lot of antioxidants, vitamins (A, C, B) [22], anti-inflammatory and anticarcinogenic properties [23]. Red beetroot is also rich in phenol compounds, which have antioxidant properties with capabilities for protective effects against DNA damage and oxidative stress [24], hypertension, atherosclerosis, type 2 diabetes, hypertension, atherosclerosis, type 2 diabetes and dementia [25,26].

The high monounsaturated fat peanut has been reported to lower body cholesterol by 11% [27], reduction in the risk of coronary heart disease [28]. Peanuts contains all the 20 amino acids in variable proportions and is the biggest source of the protein called arginine [29]. Peanut meal amino acid profile shows that it can be an ingredient for protein fortification [30].

This research aimed at producing and determining the chemical, functional and antioxidant properties of the flakes extruded from the composite flour blends.

2. MATERIALS AND METHODS

2.1 Materials

Maize grains were bought from Wurukum market Makurdi, Benue State. Beetroots were purchased from local sellers in Jos, Plateau State. Also, peanuts were purchased from Wadata, Makurdi Benue state.

2.2 Preparation of Maize Grits

The modified method described by [8] was used. The flow diagram for the production of maize grits is shown in Fig. 1.

2.2.1 Production of partially defatted peanut flour

Cracked peanuts were toasted for a few minutes, followed by removing the seed coat which impacts unwanted particles. The cleaned seed were grinded using grinding machine followed by introduction of boiling water into the mass. The peanut mass was continually mixed which allowed for oil extraction. The partially defatted mass was sliced into small masses and introduced into the same extracted oil which was heated to frying temperature. The masses were stirred to ensure uniform frying after which it was cooled and milled into flour.

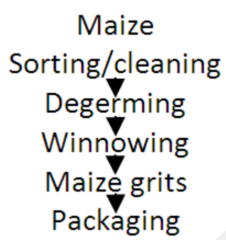

Fig. 1. Flowchart for production of maize grits (modified) [31]

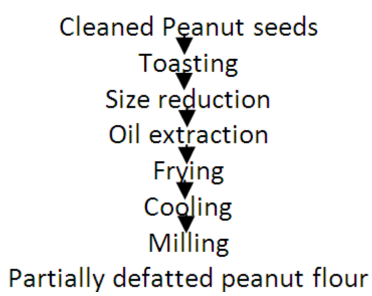

Fig. 2. Partially defatted peanut flour production [32]

2.2.2 Production of beetroot flour

The beetroots were sorted, clean and weighed. The roots were sliced and dried in a hot air oven (80°C for 8 hours). The dried chips were milled into flour and sieved using 0.5 m sieve size. The flour was packaged inside polyethylene. The flowchart for beetroot flour production is shown in Fig. 3.

2.2.3 Product formulation

Composite flour was formulated by mixing maize grits, peanut and beetroot flours in the ratios as shown in Table 2. Other ingredients such as sugar, salt and water were added to the composite flours as shown in Table 3. A control sample was produced from 100% maize grits.

2.3 Analysis

2.3.1 Determination of mineral content flakes from maze, partially defatted peanut and beetroot campsite flour

Mineral content of the samples was evaluated using the method described by Adedeye and Adewoke [35].

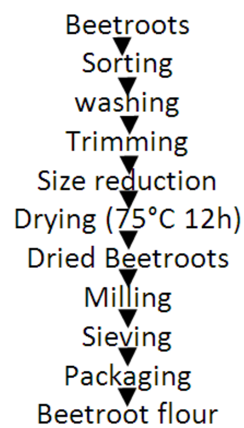

Fig. 3. Flowchart for production of beetroot flour [33]

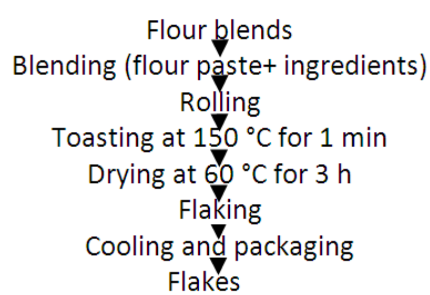

Fig. 4. Production of flakes [34]

2.3.2 Determination of essential and non-essential amino acids

The method used for the essential and non-essential amino acids was as described by Chen [36].

2.3.3 Determination of total phenol content

The total phenol content was determined according to the method of Singleton [37].

Table 1. Composite flour blend formulation for flakes from maize, defatted peanut and beetroot

Samples	Maize (%)	Peanut (%)	Beetroots (%)
A	100	-	-
B	90	0	10
C	90	10	0
D	80	10	10
E	70	20	10
F	60	30	10
G	50	40	10

Table 2. Ingredient mix for flakes

Sample	Quantity
Flour Blends	400 g
Sugar	40 g
Salt	4 g
Water	160 mL

Table 3. Composition of Ca, Fe, Z and K in studied samples

Sample	Ca	Fe	Z	K
A	6.05±0.04^{a}	0.83±0.04^{a}	1.03±0.05^{a}	163.81±0.01^{a}
B	8.71±0.01^{b}	1.62±0.06^{b}	1.55±0.06^{c}	188.96±0.04^{b}
C	19.46±0.05^{c}	2.25±0.06^{c}	1.45±0.02 ^{b}	276.39±0.06^{c}
D	22.17±0.05^{d}	3.06±0.08^{d}	1.92±0.03^{d}	301.62±0.09^{d}
E	35.55±0.05e	3.42±0.04^{e}	2.31±0.01e	414.09±0.12^{e}
F	48.88±0.05^{f}	3.45±0.06 ^{e}	2.74±0.04 ^{e}	426.76±0.04^{f}
G	62.32±0.01^{g}	4.53±0.02^{f}	3.14±0.04^{g}	640.03±0.04^{g}
LSD	13.47	1.11	0.45	213.31

Selected Mineral composition of flakes produced from Maize, Partially defatted Peanut and Beetroot flakes

2.3.4 Determination of antioxidant capacity

2,2 dipenyl-1-picryl hydroxyl (DPPH) Radical Scavenging Activity Assay was determined using the method described by Beta [38]. Ferric Reducing Antioxidant Power Assay (FRAP) was determined by the method described by Jayaprakash as modified by Olaleye [39]. The method of Campos and Lissi [40] was used to determine the Trolox Equivalent Antioxidant Capacity (TEAC).

3. RESULTS AND DISCUSSION

3.1 Mineral Composition of Flakes Produced from Maize, Partially Defatted Peanut and Beetroot

Selected mineral composition of flakes produced from maize, partially defatted peanut and beetroot is presented in Table 4. There were significant ($P<0.05$) differences in the calcium and iron content of flakes. The calcium and iron ranged between 6.05 – 62.32 and 0.83 – 4.53 mg/g. the zinc and potassium content of the flakes varied between 1.03 – 3.14 and 163.81 – 640.03 mg/g respectively. There was significant difference in the zinc and potassium content of the samples ($P<0.05$). The calcium content of the flakes increased significantly from the lowest value in control sample A and was highest in sample G ($p<0.05$). Pinki [41] reported that calcium content increased in cakes from 32.0 to 52.0 (mg/100 g) with increased level of beetroot powder by 25 percent. The iron content of cookies was found increased from 0.3 to 4.53 mg/100 g. Pinki and Awasthi [41] reported that the iron content of cakes increased from 0.14 to 2.70 (mg/100 g) with increased level of beetroot powder from 0 to 25 per cent. The potassium content of flakes increased significantly from 163.81 – 640.03 (mg/100 g) as the quantity of beetroot powder increased in the samples ($p<0.05$). The zinc content of flakes was found to decrease from 3.14 – 1.03 (mg/100 g). Uma [42] reported that zinc contents of nutraceutical enriched cookies were decreased by 17.94 per cent, in control cookies and by 38.06 in barnyard millet cookies. The inclusion of beetroot powder in the composite flour resulted in increased mineral content in flakes agrees with the findings of Uthumporn [43-45].

3.2 Essential Amino Acid Content of Flakes Produced from Maize, Partially Defatted Peanut and Beetroot

Result of the essential amino acid content of flakes produced from maize, partially defatted peanut and beetroot is presented in Table 5. There was significant difference in the isoleucine, leucine, lysine and methionine ($P<0.05$). Isoleucine ranged between 0.24 – 1.25, leucine 0.04 - 1.08 while lysine and methionine content ranged between 0.08 – 0.40 and 0.13 – 0.49 respectively. The phenylalanine, threonine, tryptophan and valine differed significantly across the samples ($P<0.05$). Phenylalanine ranged between 0.28 – 0.48, threonine 0.22 – 0.44 while tryptophan ranged between 0.4 - 0.24 and valine 0.30 – 0.69 respectively. The nonessential amino acids varied significantly among alanine, proline, tyrosine, glutamic and glycine significantly differed among the samples. Alanine ranged between 0.543 – 0.74, proline 0.45 – 0.59, tyrosine 0.07 – 0.49, glutamic 0.25 – 1.94 and glycine 0.14 – 1.44 respectively ($P<0.05$). The arginine, aspartic, cysteine and glycine did not vary significantly varied among the samples ($P>0.05$). Arginine ranged between 0.11 – 0.96, aspartic 0.37 – 1.16, cystein 0.13 - 0.39 and glycine 0.14 – 1.44 respectively. The result of the amino acids showed that the flake samples contained the amino acids in varying proportions. There was increase in the amino acids of the samples with increased levels of partially defatted peanut flour. This agrees with [46] who reported increase in amino acid content of maize tuwo-cirinaForda flour blends. The values obtained for the amino acids content of the samples are comparable to their corresponding protein content [47]. The lysine content of sample A was lowest as compared to samples B, C, D, E, F and G. This is due to lysine deficiency cereal-based foods [48]. Sample G had the highest levels of amino acids, which is due to the defatted peanut supplementation.

Amino acids are the building block of proteins and are needed for growth and maintenance of body process as deficiency in any essential amino acid will cause protein malnutrition [49]. The addition of peanut to maize thus complemented the limiting amino acids in both cereals and legumes.

3.3 Antioxidant Capacity of the Flakes Produced From 100% Maize and the Flour Blends of Maize, Partially Defatted Peanut and Beetroot Flours

The antioxidant capacity of the flakes produced from 100% maize and the flour blends of maize, partially defatted peanut and beetroot flours served with warm milk is as presented in the Table 4. The DPPH values ranged from 9.02 in sample A (100:0:0 maize, partially defatted peanut and beetroot flours) to 46.02 in sample G (50:40:10 maize, partially defatted peanut and beetroot flours). There were significant variations cross the sample. The FRAP content varied across all the samples. Sample A had the least value of 28.37 while the highest value of 66.02 was recorded in sample G (50:40:10 maize, partially defatted peanut and beetroot flours). The TEAC content varies significantly across the samples. Sample A (100:0:0 maize, partially defatted peanut and beetroot flours) had the least value of 15.53, with 75.03 in sample G (50:40:10 maize, partially defatted peanut and beetroot flours).

Total phenolic content of the flake samples ranged between 5.01 – 22.01 (mgGAE/g) and increased significantly with increased beetroot ($p<0.05$). The total phenolic content of sample A was 5.01 (mgGAE/G). The increase in total phenolic content of the samples may be due to the amount of beetroot added. Beetroot s reported to be rich in phenolic compounds and its addition to the composite flour would have increased the phenolic content of the flakes. Increased consumption of phenolic compounds has been associated with the reduced risk of cardiovascular diseases and certain cancers [50-53].

The 1,2-diphenyl-2-picrylhydrazil (DPPH) ranged from 4.03 to 16.83. There was significant ($p<0.05$) increase in the reducing capacity of the samples with increase in beetroot. The ferric reducing antioxidant power (FRAP) of the flakes increased significantly from 15.65 to 45.54 mgGAE/ml with increase in beetroot ($p<0.05$). A similar trend was observed in Trolox equivalent antioxidant capacity for flake samples which ranged between 10.21 to 37.01 µmoltrolox/ml.

Table 4. Amino acid profile of flakes produced from maize-partially defatted peanut and beetroot

Essential amino acid of flakes produced from maize-partially defatted peanut and beetroot								
Sample	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**LSD**
Isoleucine	1.25±0.04	0.24±0.02^{a}	0.31±0.03^{ab}	0.29±0.05^{a}	0.35±0.03^{b}	0.41±0.02^{c}	0.46±0.02^{c}	0.14
Leucine	0.04±0.03^{a}	0.95±0.00^{b}	1.08±0.02^{c}	0.99±0.03^{b}	1.02±0.03^{b}	1.05±0.02^{bc}	1.08±0.04^{c}	0.98
Lysine	0.08±0.02^{a}	0.08±0.03^{a}	0.16±0.03^{b}	0.17±0.04^{b}	0.24±0.04^{c}	0.32±0.03^{d}	0.40±0.02^{e}	0.12
Methionine	0.13±0.02^{a}	0.13±0.02^{a}	0.49±0.02^{d}	0.18±0.03^{a}	0.24±0.01^{c}	0.27±0.04^{bc}	0.32±0.03^{c}	0.09
Phenylalanine	0.28±0.01^{a}	0.35±0.0^{b}	0.42±0.01^{c}	0.39±0.02^{bc}	0.41±0.03^{c}	0.45±0.02^{bc}	0.48±0.02^{d}	0.10
Threonine	0.23±0.00^{ab}	0-22±0.02^{a}	0.29±0.03^{bc}	0.28±0.02^{b}	0.33±0.03^{c}	0.39±0.02^{d}	0.44±0.04^{d}	0.13
Tryptophan	0.04±0.01^{a}	0.05±0.03^{a}	0.09±0.02^{ab}	0.09±0.04^{ab}	0.13±0.03^{b}	0.18±0.01^{bc}	0.24±0.04^{c}	0.0
Valine	0.30±0.03^{a}	0.38±0.01^{b}	0.39±0.03^{b}	0.46±0.03^{c}	0.54±0.0^{d}	0.62±0.01^{e}	0.69±0.01^{f}	0.11

Table 4. continued…

Nonessential amino acid of flakes produced from maize-partially defatted peanut and beetroot								
Sample	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**LSD**
Alanine	0.592±0.01^{ab}	0.543±0.02^{a}	0.64±0.01^{b}	0.59±0.01^{ab}	0.62±0.03^{b}	0.69±0.00^{bc}	0.74±0.01^{c}	0.09
Arginine	0.11±0.01^{a}	0.11±0.00^{a}	0.32±0.00^{b}	0.34±0.00^{b}	0.53±0.01^{c}	0.75±0.01^{d}	0.96±0.00^{e}	0.23
Aspartic	0.39±0.00^{a}	0.37±0.00^{a}	0.59±0.00^{b}	0.57±0.00^{b}	0.77±0.00^{d}	0.97±0.00^{c}	1.16±0.00^{d}	0.39
Cystein	0.14±0.00^{b}	0.13±0.00^{a}	0.19±0.00^{a}	0.18±0.00^{a}	0.23±0.00^{ab}	0.29±0.00^{b}	0.35±0.00^{c}	0.16
Glutamic	1.36±0.00^{a}	0.25±0.00^{a}	1.55±0.00^{d}	0.49±0.00$^{a\backslash c}$	1.64±0.00^{e}	1.79±0.00^{f}	1.94±0.00^{g}	1.09
Glycine	0.19±0.00^{a}	0.18±0.0^{a}	0.14±0.02^{a}	0.28±0.03^{b}	0.37±0.03^{c}	0.47±0.03^{e}	1.44±0.03^{d}	0.12
Histidine	0.17±0.02^{a}	0.15±0.01^{a}	0.19±0.01^{a}	0.17±0.04^{a}	0.18±0.01^{a}	0.20±0.04^{a}	0.22±0.03^{a}	0.05
Proline	0.51±0.03^{b}	0.57±0.02^{cd}	0.59±0.02^{d}	0.54±0.03^{c}	0.50±0.05^{b}	0.47±0.01^{dc}	0.45±0.03^{a}	0.08
Serine	0.24±0.04^{a}	0.32±0.01^{b}	0.37±0.00^{c}	0.34±0.04^{bc}	0.36±0.02^{bc}	0.39±0.03^{c}	0.41±0.01^{c}	0.11
Tyrosine	0.08±0.03^{a}	0.07±0.02^{a}	0.18±0.02^{b}	0.18±0.02^{b}	0.28±0.01^{c}	0.39±0.02^{d}	0.49±0.02^{e}	0.14

Table 5. Total phenolic content and antioxidant capacity of flakes produced from maize-partially defatted peanut and beetroot

Samples	TPC mg GAE.g–1	DPPH IC50%INH	FRAP mg GAE/ml	TEAC (μmol Trolox/mL)
A	5.01±0.01 [e]	4.03±0.04 [c]	15.65±0.06[a]	10.21±0.01 [c]
B	10.83±0.04 [b]	8.23±0.04 [c]	24.25±0.04[b]	16.40±0.00 [d]
C	7.49±0.01 [d]	6.70±0.08 [a]	17.53±0.04 [b]	9.34±0.05 [a]
D	14.04±0.05 [a]	10.04±0.06 [b]	28.36±0.04 [b]	21.02±0.03 [b]
E	16.02±0.03 [c]	12.02±0.03 [d]	35.22±0.01[d]	25.61±0.01
F	20.03±0.04 [b]	15.02±0.02 [e]	40.03±0.04 [b]	30.12±0.03 [b]
G	22.01±0.01 [e]	16.83±0.04 [c]	45.53±0.03[c]	37.01±0.01 [c]
LSD	4.03	3.03	6.89	6.92

Values are mean ± standard deviation of triplicate determination.
Values with the same superscript down the column are not significantly (p≤0.05) different
Key Sample A = 100% maize flour, B = 90%maize flour, 0%Peanut flour, 10%beetroots flour, C = 90%maize flour, 10% Peanut flour, 0%beetroots flour, D = 80%maize flour, 10% Peanutflour, 10% beetroots flour, E = 70% maize flour, 20% Peanut flour, 10% beetroots flour, F = 60%maize flour, 30% Peanut flour, 10% beetroots flour, G = 50% maize flour 40%Peanut flour, 10%beetroots flour

4. CONCLUSION

The increase in antioxidant capacity of the samples could be attributed to the addition of beetroot powder to the samples. Beetroot is reported to contain various compounds such as betalain which confer antioxidant effects on beetroot. The increase in antioxidant assays among the samples with increase in beetroot suggests the antioxidant effect of beetroot.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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