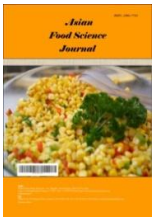

Asian Food Science Journal

20(8): 66-75, 2021; Article no.AFSJ.59469
ISSN: 2581-7752

In vitro Digestibility, Nutritional and Sensory Quality of Extruded Breakfast Cereal from Maize Grits, Partially Defatted Peanut and Beetroot Flour

T. M. Ukeyima[1], I. A. Akor[1,2,3*] , and B. Kyenge[2]

[1]Department of Food Science and Technology, Federal University of Agriculture, Makurdi, Nigeria.
[2]Department of Chemistry, Benue State University, Makurdi, Nigeria.
[3]Centre for Food Technology and Research, Benue State University, Makurdi, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2021/v20i830331
Editor(s):
(1) Dr. Ho Lee Hoon, Universiti Sultan Zainal Abidin (UniSZA), Malaysia.
Reviewers:
(1) Amir, Hosseinvand, Islamic Azad University of Shahr-e-Qods Branch, Iran.
(2) Md. Mostafa Kamal, Hajee Mohammad Danesh Science and Technology University, Bangladesh.
(3) Rekha Rani, SHUATS, India.
Complete Peer review History: https://www.sdiarticle4.com/review-history/59469

Original Research Article

Received 28 April 2021
Accepted 02 July 2021
Published 12 July 2021

ABSTRACT

In-vitro digestibility, nutritional and sensory quality of extruded breakfast cereals from maize grits, partially defatted peanut and beetroot flour blends was investigated. Composite flour blends was prepared from maize, peanut and beetroot flour in the following proportions: 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). The breakfast cereals were analyzed for proximate, vitamins, in-vitro protein digestibility and sensory properties. There was significant ($P<0.05$) difference in the proximate composition, the values ranged from; 4.46 to 6.82%, 3.22 - 7.32%, 0.98 to 1.23%, 3.32 – 4.55%, 3.7 – 4.34% and 75.7 – 83.96% for moisture, protein, fat, fibre, ash, and carbohydrate respectively while energy ranged from 343.31 to 357.54Kcal. Vitamins A, B1, B2, B6 and C values ranged from 1.60–1671.84 IU, 0.95 – 1.43, 0.95 – 1.50, 1.09 – 1.75 and 8.77 – 16.22 respectively. There was increase in in-vitro protein digestibility of the samples with addition of defatted peanut and beetroot. Sensory evaluation results showed that sample C had the highest acceptability on 9-point hedonic scale.

**Corresponding author: Email: isaacakor4@gmail.com;*

Keywords: Beetroot; peanut; maize; in-vitro digestibility; minerals; vitamins.

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]. Food extrusion (extrusion-cookers) belong to the family of high temperature short time (HTST) equipment, capable of performing cooking tasks under high pressure [9]. 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 [10].

Maize is deficient in some essential amino acids such as lysine and tryptophan [11]. Maize 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) [12], anti-inflammatory and anti-carcinogenic properties [13]. Red beetroot is also rich in phenol compounds, which have antioxidant properties with capabilities for protective effects against DNA damage and oxidative stress [14], hypertension, atherosclerosis, type 2 diabetes, hypertension, atherosclerosis, type 2 diabetes and dementia [15-16]. The high monounsaturated fat peanut has been reported to lower body cholesterol by 11% [17], reduction in the risk of coronary heart disease [18]. Peanuts contain all the 20 amino acids in variable proportions and is the biggest source of the protein called arginine [19]. Peanut meal amino acid profile shows that it can be an ingredient for protein fortification [20]. Therefore, the aim of this study was to investigate in-vitro protein digestibility, nutritional and sensory quality of extruded breakfast cereals produced from maize-partially defatted peanut and beetroot flour.

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

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

2.2 Sample Preparation

2.2.1 Preparation of maize grits

The modified method described by [21] was used. The flow diagram for the production of maize grits is shown in Fig. 1. Maize grains cleaning to remove dust, stones, metals, light particles, etc. was achieved using classifiers. The maize was degermed using attrition mill, Cleaning was carried out to obtain clean and uniform size maize grains. The clean maize grains were cooked, washed and cleaned by air classifiers. The grits were packaged in polythene bags. The grits were discharged in a woler, preheated air is blown to reduce the moisture content to the desired level of about 20%.

2.2.2 Production of partially defatted peanut flour

Cracked peanuts were toasted for four (4) minutes, followed by the seed coat separation which impacts with unwanted particles. The

cleaned seed were grounded using grinding machine followed by introduction of 100^{O}c water into the mass. The peanut mass was continually stirred which allowed for oil extraction by decantation. The size reduction of the partially defatted mass followed. The masses were exposed to heat to allow draining of the oil. The low moisture cake was cooled and milled into meal.

2.2.3 Production of beetroot flour

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

2.2.4 Product formulation

Composite flour was formulated by mixing maize grits, peanut and beetroot flours in the ratios as shown in Table 1. 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.

The broken maize pieces are mixed with peanut and beetroot and cooked in rotary steam cooker under pressure. It is subjected to steam and for 2 hours. Flavour syrup of sugar, salt and water are added during the process. The cooked material possess moisture which raises to about 36 - 37%. The grits are again washed and cleaned by air classifiers.

The grits carried to an agitator or lump breaker and then is discharged into a steamer where pre-heated air is blown to reduce the moisture content to the desired degree about 20%. The dried material is kept in de-moistening tank for few hours in order to provide the residual moisture to become equally distributed. The grits or cooked material are passed to heavy flaking machine, where the grits are converted into flakes by pressing the grits. The flakes are immediately transferred to the rotary of any other oven for roasting, followed by cooling.

2.3 Analysis

2.3.1 Proximate composition

The moisture content, crude fat and crude protein content, ash content, crude fibre, carbohydrate content were determined using method described by AOAC [25]. The energy value was determined using method described by Kanu [26].

2.3.2 Vitamin composition maize-partially defatted peanut and beetroot flakes

The vitamin A (retinol) was determined using Seongeung et al [27] method, while thiamine (B1), Riboflavin (B2), Pyridoxine (B6), Ascorbic Acid (C) were determined by AOAC [25].

2.3.3 In-vitro protein digestibility maize-partially defatted peanut and beetroot flakes

The in vitro protein digestibility of the samples was determined using the method described by Kanu [26].

2.3.4 Sensory evaluation maize-partially defatted peanut and beetroot flakes

The flakes were served to 15 panelists consisting of students of the Benue University Makurdi. The panelists were asked to score the samples on a 9-point hedonic scale where 1=dislike extremely and 9=like extremely). The samples were served with warm milk and assessed for appearance, consistency, flavour, taste, mouth feel, and overall acceptability. The sensory scores obtained were further subjected to a one-way Analysis of Variance (ANOVA). The Least Significant Difference (LSD) test was used to determine significant differences between means at $p<0.05$ using SPSS package version 17.0.

2.3.5 Statistical analysis

Data obtained was subjected to Analysis of Variance (ANOVA) followed by Duncan's new multiple range test (DNMRT) to compare treatment means. Statistical significance was accepted at ($p\leq0.05$).

3. RESULT AND DISCUSSION

3.1 Proximate Composition of Maize-Partially Defatted Peanut and Beetroot Flakes

Table 3 shows the proximate composition result of flakes produced from 100% maize and blend of maize, partially defatted peanut and beetroot flour. The moisture content of the flake samples differed significantly ($P<0.05$) and ranged between 4.46 to 6.82%. The crude protein and

crude fat content of the flake varied between 3.22 - 7.32% and 0.98 to 1.23% respectively. There was significant (P<0.05) difference in both the crude protein and crude fat content of the samples. There was significant (P<0.05) difference in the crude fibre, ash and carbohydrate content of the samples. The crude fibre, ash and carbohydrate content of the samples ranged between 3.32 – 4.55%, 3.7 – 4.34% and 75.7 – 83.96% respectively. The energy value of the flakes ranged between 343.31 to 357.54kcal and significantly (P<0.05) differed from each other. The carbohydrate content of the flakes decreased with increase in the peanut substitution. This agrees with Otunola [27] who observed decreased in carbohydrate of kokoro with partially defatted peanut flour. The decreased carbohydrate content of the flakes with substitution of peanut would be of great use to people that need low carbohydrate foods. There has been reports on decrease in the carbohydrate content of breakfast meals when peanut was blended with maize [27]. The low-fat content of the flakes could be linked to the defatting of the peanut. The fat content was lower than the result of Sibt-e-Abbas [28]. This implies longer shelf life as fat is a determinant of keeping qualities, and as such high fat content could be undesirable in extruded food products. The results of the present investigation are comparable to the findings reported by Atasie [29]. The moisture content levels of the samples were below 10% which is recommended for better keeping. This would prolong the flakes shelf life. The results are similar to work by [28] and Sibt-e-Abbas [30]. The energy values of the samples decreased with increased peanut inclusion. This could be as a result of the defatting. The calculated energy values were within the recommended levels by [31], which specify energy requirements as 185-345 kcal/kg/day for adults and 44.1-82.4 kcal/kg/day for children.

Fig. 1.Flowchart for production of maize grits (modified) [21]

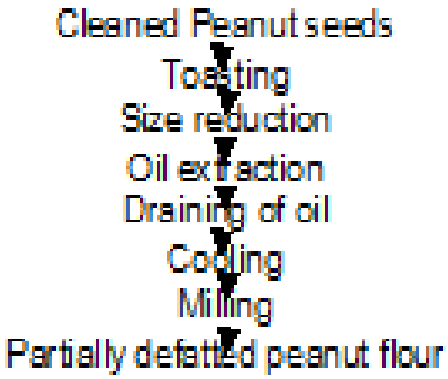

Fig. 2. Partially defatted peanut flour production [22]

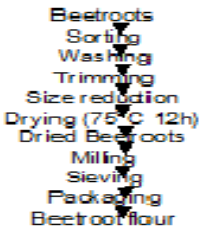

Fig. 3. Flowchart for production of beetroot flour [23]

Table1. Composite flour blend formulation for flakes from maize, defatted peanut and beetroot

Samples	Maize(%)	Peanut (%)	Beetroots (%)
A	100	0	0
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

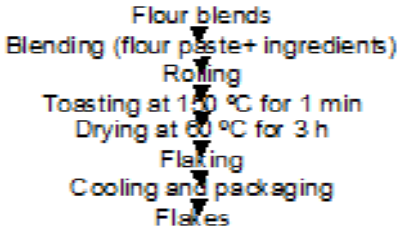

Fig 4. Production of flakes [24]

3.2 Vitamins Composition of Maize-Partially Defatted Peanut and Beetroot Flakes

Table 4 presents selected vitamin composition of flakes produced from maize, partially defatted peanut and beetroot. There was significant ($P<0.05$) difference in vitamin A content of the samples. Vitamin A content ranged between 1.60–1671.84 IU. Vitamin B_1 and B_2 content of the samples ranged between 0.95 – 1.43 and 0.95 – 1.50 IU respectively. There was significant ($P<0.05$) difference among the samples for vitamin B_1 and B_2. Vitamin B_6 and vitamin C varied between 1.09 – 1.75 and 8.77 – 16.22. There was significant ($P<0.05$) difference among the samples. The vitamin A content increased with beetroot addition. This may be as a result of the high vitamin A content in beetroots. The low values in samples A and C is attributed to the fact that both peanut and maize contain very low amounts of the vitamins. The vitamin B_1 (Thiamine) content decreased with peanut and beetroot powder addition which are both reported to be low in thiamine content. This agrees with the findings of [32] who observed poor thiamine content in peanuts. There was also decline in the niacin content in the samples with beetroot and peanut addition.

Table 3. Proximate composition of Maize-partially defatted Peanut and Beetroot flakes

Sample	Moisture	Protein	Fat	Fibre	Ash	COH	Energy Value (Kcal)
A	4.64±0.17^{a}	3.22±0.00^{a}	0.98±0.04^{d}	3.32±0.02^{a}	4.06±0.09^{b}	83.96±0.03^{b}	357.54±0.05^{a}
B	5.31±0.14^{c}	3.61±0.03^{b}	1.04±0.01^{cd}	3.59±0.05^{b}	3.87±0.03^{a}	82.58±0.01^{a}	354.12±0.02^{b}
C	5.19±0.04^{b}	4.16±0.01^{c}	1.08±0.02^{c}	3.55±0.00^{b}	4.11±0.04^{bc}	81.91±0.06^{bc}	354.00±0.04^{c}
D	5.61±0.01^{d}	4.54±0.02^{d}	1.18±0.03^{cd}	3.82±0.03^{c}	4.07±0.09^{b}	80.78±0.17^{b}	351.90±0.03^{d}
E	6.05±0.04^{e}	5.46±0.03^{e}	1.16±0.00^{b}	4.09±0.05$_{d}$	4.14±0.05^{c}	79.10±0.07^{c}	348.68±0.01^{e}
F	6.44±0.01^{f}	6.39±0.02^{f}	1.21±0.03^{b}	4.33±0.04^{e}	4.27±0.02^{d}	77.36±0.11^{d}	345.89±0.04^{f}
G	6.82±0.02^{g}	7.32±0.02^{g}	1.23±0.03^{a}	4.55±0.00^{f}	4.34±0.02^{e}	75.74±0.04^{e}	343.31±0.03^{g}
LSD	0.55	0.93	0.10	0.27	0.19	107	3.13

Values are mean ± standard deviation of triplicate determination. Values down the columns with the same alphabets are the same while those with different alphabets are different at p≤0.05

Key

Sample A = 100% maize flour, B = 90%maize flour, 0%Peanut flour, 10%beetroots flour, C = 90%maize flour, 10% Peanut flour, 10%beetroots flour, D = 80%maize flour, 10% Peanut flour, 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

Table 4. Vitamin composition of Maize-partially defatted peanut and beetroot flakes

Sample	Vitamin A	Vitamin B1	Vitamin B2	Vitamin B6	Vitamin Vit C
A	1.78±0.00 [b]	1.31±0.00 [d]	1.50±0.02 [g]	1.75±0.03 [f]	16.22±0.01 [g]
B	1672.22±0.03 [e]	1.30±0.01 [cd]	1.36±0.03 [e]	1.59±0.03 [d]	15.25±0.03 [f]
C	1.60±0.01 [a]	1.25±0.00 [c]	1.40±0.03 [f]	1.62±0.02 [e]	14.63±0.04 [e]
D	1672.04±0.03 [d]	1.43±0.00 [e]	1.26±0.02 [d]	3.17±0.01 [g]	13.67±0.03 [d]
E	1671.84±0.01 [c]	1.06±0.02 [b]	1.15±0.03 [c]	1.34±0.02 [c]	12.03±0.00 [c]
F	1671.67±0.01 [b]	1.00±0.01 [ab]	1.05±0.01 [b]	1.22±0.02 [b]	10.40±0.00 [b]
G	1671.43±0.04 [b]	0.95±0.00 [a]	0.95±0.02 [a]	1.09±0.03 [a]	8.77±0.02 [a]
LSD	15.15	0.22	0.14	0.14	1.67

Values are mean ± standard deviation of triplicate determination. Values down the columns with the same alphabets are the same while those with different alphabets are different at p≤0.05

Key

Sample A = 100% maize flour, B = 90% maize flour, 0% Peanut flour, 10% beetroots flour, C = 90% maize flour, 10% Peanut flour, 10% beetroots flour, D = 80% maize flour, 10% Peanut flour, 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

Table5. In-vitro protein digestibility (%) of flakes produced from maize-partially defatted peanut and beetroot

Samples	Digestibility at 1hr	Digestibility at 6hr
A	72.52±0.02 [a]	74.02±0.02 [a]
B	75.03±0.04 [a]	76.91±0.01 [a]
C	73.81±0.01 [a]	75.31±0.01 [a]
D	77.21±0.01 [a]	79.93±0.04 [a]
E	86.21±0.01 [a]	83.02±0.03 [a]
F	89.53±0.04 [a]	87.82±0.03 [a]
G	92.91±0.01 [a]	89.72±0.03 [a]
LSD	1.31±0.01 [a]	1.30±0.01 [a]

Values are mean ± standard deviation of triplicate determination. Values down the columns with the same alphabets are the same while those with different alphabets are different at p≤0.05

Key

Sample A = 100% maize flour, B = 90%maize flour, 0%Peanut flour, 10%beetroots flour, C = 90%maize flour, 10% Peanut flour, 10%beetroots flour, D = 80%maize flour, 10% Peanut flour, 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

Table 6. Sensory properties of Maize-Partially defatted peanut and beetroot flakes

Samples	Appearance	flavor	taste	mouth feel	overall Acceptability
A	8.13±0.74 [bc]	6.40±1.55 [ab]	6.47±0.92 [ab]	6.00±1.51 [a]	7.47±0.74 [c]
B	7.33±0.72 [b]	6.53±1.92 [ab]	6.87±2.53 [b]	6.47±1.51 [ab]	7.13±1.69 [c]
C	8.40±0.63 [c]	7.87±1.25 [b]	8.07±1.03 [c]	7.47±1.30 [b]	8.40±0.83 [d]
D	6.40±1.24 [a]	6.20±1.57 [ab]	5.93±1.62 [ab]	6.33±1.63 [ab]	6.80±1.01 [b]
E	6.00±1.56 [a]	6.27±1.53 [ab]	6.40±1.50 [ab]	5.93±1.58 [a]	6.47±1.25 [b]
F	6.00±1.77 [a]	5.07±1.58 [a]	5.20±169 [a]	5.60±1.72 [a]	5.60±2.09 [a]
G	5.93±1.44 [a]	5.87±1.64 [a]	5.67±1.59 [ab]	5.40±2.03 [a]	6.00±1.56 [ab]
LSD	1.09	2.03	1.69	1.03	1.60

Values are mean ± standard deviation of triplicate determination. Values down the columns with the same alphabets are the same while those with different alphabets are different at p≤0.05

Key

Sample A = 100% maize flour, B = 90%maize flour, 0%Peanut flour, 10%beetroots flour, C = 90%maize flour, 10% Peanut flour, 10%beetroots flour, D = 80%maize flour, 10% Peanut flour, 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.

3.3 In-Vitro Protein Digestibility (%) of Flakes Produced from Maize-Partially Defatted Peanut and Beetroot

The IVPD of the control sample and the composite flours is shown in table 5 below. Supplementation was found to cause a significant ($p \leq 0.05$) improvement in IVPD for all the samples. The increase was from 72.50 to 92.90 at 1hr and 74.02 to 89.72% at 2hrs of digestion respectively. There was increase in in-vitro protein digestibility of the samples with addition of defatted peanut and beetroot. Ethag [33] also observed that the in-vitro protein digestibility increased with supplementation with soybean. A similar trend was observed by [34] who reported that the protein digestibility of sorghum was 49.3% and after supplementation with 15%, 20% and 25% groundnut flour, significantly ($P \leq 0.05$) increased to 56.8%, 60.1% and 62.5% respectively. Heat processing is reported to improve the digestibility of seed protein by destroying protein inhibitors and opening the protein structure through denaturation [35]. The IVPD of the samples generally increased with beetroot and partially defatted peanut substitution. The increase could be due to the replacement of maize with beetroot and peanut with has higher digestible protein.

3.4 Sensory Properties of Maize-Partially Defatted Peanut and Beetroot Flakes

Result of the sensory attributes of flakes made from maize, partially defatted peanut and beetroot flour blend is presented in table 6. The score for the appearance of the flake samples ranged from 5.93 – 8. 40 and significantly ($P<0.05$) differ from one another. There was significant ($P<0.05$) differences in the flavor and taste of the samples. The score for the flavor and taste ranged from 5.07 – 7.87 and 5.20 – 8.07 respectively. The mouth feel and overall acceptability scores of the flake samples ranged from 5.40 – 7.47 and 5.60 – 7.47 respectively. Although the level of acceptability of the flakes decreased as the level of addition of peanut/beetroot flour increases the samples obtained good sensory scores. This could be as the result of characteristic appearance and flavor of beetroot.

4. CONCLUSION

The partial substation of breakfast cereals from maize with partially peanut and beetroot flour has great impact on the nutrition, In-vitro protein digestibility and sensory properties. There was significant increased in moisture, protein, fat, fibre and ash content than the control while carbohydrate decreased. Also, there was significant difference in the vitamin content of the breakfast cereals. There was increase in in-vitro protein digestibility of the samples with addition of defatted peanut and beetroot. Sensory evaluation results showed that sample C had the highest acceptability on 9-point hedonic scale. Addition of peanut and beetroot is recommended to increase the quality of maize-based breakfast cereals.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sharma JL, Caralli S. A dictionary of food and nutrition. CBS Pub. New Delhi; 2004.
2. Kowtaluk H. Food for today (9th ed). Tata McGraw hill publishing company. New Delhi. 2001;227.
3. Mayo Clinic. "Why is breakfast the most important meal of the day? 2010. Available:"http://www.mayoclinic.com/health/food-and-nutrition/AN01119, 2009
4. Haines P, Guilkey D, Popkin B. Trends in breakfast consumption of US adults between 1965 and 1991. J. Am. Dietetic Ass. 1996;96:464- 470.
5. Okafor GI, Usman OG. Production and evaluation of breakfast cereal from blends of Africa yam bean (*Sphenostylis stenocarpa*), maize (*zea may*) and defatted coconut (*cocos nuccifera*). JFPP; 2013.
6. Onweluzo JC, Nnamuchi OM. Production and evaluation of porridge-type breakfast product from *Treculia africana* and *Sorghum bicolor* flours. 652-661. Pak. J. Nutr. 2009;8:731-736.
7. Ofuya ZM, Akhidue V. The role of pulses in human nutrition: A review. J. Applied Sci and Env Mgt. 2005;9(3):99-104.
8. Okaka JC. Handling, storage and processing of plant foods. OJC academic publishers, Enugu; 2005.
9. Valentina Obradović, Jurislav Babić, Drago Šubarić, Đurđica Ačkar, Antun Jozinović. Improvement of nutritional and functional properties of extruded food products. Journal of Food and Nutrition Research. 2014;53(3):189–206.

10. Sivasankar B. Food processing and preservation. Prentice Hall of India, New Delhi; 2002.
11. Tom Clifford 1, Glyn Howatson 1, 2, Daniel J. West 1, Emma J. Stevenson. The potential benefits of red beetroot supplementation in health and disease. Journal Nutrients. 2015;7:2801-2822. DOI:10.3390/nu7042801. // www.mdpi.com/journal/nutrients
12. Straus S, Bavec F, Turinek M, Slatnar A, Rozman C, Bavec M. Nutritional value and economic feasibility of red beetroot (*Beta vulgaris L. ssp. vulgaris Rote Kugel*) from different production systems. African Journal of Agricultural Research. 2012;7(42):5653-5660.
13. Bonaccorsi P, Caristi C, Gargiulli C, Leuzzi U. Flavonol glucoside profile of southern Italian red onion (*Allium cepa L.*). Journal of Agriculture and Food Chemistry. 2005;53:2733-2740.
14. Vulić JJ, Ćebović TN, Čanadanović-Brunet JM, Ćetković GS, Čanadanović VM, Djilas SM, Tumbas Šaponjac VT. In vivo and in vitro antioxidant effects of beetroot pomace extracts. Journal of Functional Foods. 2014;6:168–175.
15. Gilchrist M, Winyard PG, Fulford J, Anning C, Shore AC, Benjamin N. Dietarynitrate supplementation improves reaction time in type 2 diabetes: Development and application of a novel nitrate-depleted beetroot juice placebo. Nitric Oxide. 2014;40:67–74.
16. Ninfali P, Angelino D. Nutritional and functional potential of *Beta vulgaris cicla*and *rubra*. Fitoterapia. 2013;89:188–199.
17. Pelkman CL. Effects of moderate fat (from mono unsaturated fat) and low-fat weight loss diets on the serum lipid profile in overweight and obese men and women. Am J Chin Nutr. 2004, 79 (2); 204-212
18. MaltilskyDK,Nekta M, Manarymj, supplementary feeding with fortified spread results in higher recovery rates than with a corn/soy blend in moderately wasted children. J Nutr. 2009;139(4):773-8.
19. United states department of agriculture (USDA); 2014.
20. Yu MJ, Ahmedna M, Goktepe I, Dai J. Peanut skin procyandin: Compostion and autoxidant activities as affected by processing. J Food Compos Anal. 2016;19:364-371.
21. Standard for degermed Maize (Corn) meal And Maize (Corn) Grits codex standard. 1985;155.
22. Yetunde zinwanyi, et al. Utilization of Barbara nut flour blends in bread production. J. Food Technol. 2009;7(4):111-114.
23. Burcu Guldiken, et al. Home-processed red beetroot (*Beta vulgaris* L.) Products: Changes in antioxidant properties and bio accessibility. Int. J. Mol. Sci. 2016;17:858.
24. Tribelhorn RE. "Breakfast cereal'' handbook of cereal science and technology, marcel dekker, inc; 1991.
25. AOAC. Official methods of analysis, 18th Ed. Association of official analytical chemists, Washington D.C, USA; 2006.
26. Kanu JK, Sandy EH, Kandeh BAJ. Production and evaluation of of breakfast cereal-based porridges mixed with sesame and pigeon peas for adults. Pak. J. Nutr. 2009;8(9):1335-1343.
27. Seongeung L, et al. Effect of different cooking methods on the content of vitamins and true retention in selected vegetables. Food Sci Biotechnol. 2018;27(2):333-342.
28. Otunola ET, Sunny-Roberts EO, Adejuyitan JA, Famakinwa AO. Effects of addition of partially defatted groundnut paste on some properties of 'Kokoro' (a popular snack made from maize paste). Agric. Biol. J. N. Am. 2012;3(7):280-286.
29. Makumba C. Temba, Patrick Njobel, Eugenie Kayitesi. Storage stability of maize-groundnut composite flours and assessment of Aflatoxin B_1 and Ochratoxin A contamination in flours and porridges. Journal of Food Control. 2017;71:178-186
30. Kraithong S, Lee S, Rawdkuen S. Physicochemical and functional properties of Thai organic rice flour. Journal of Cereal Science. 2018;79:259-266.
31. Food and agriculture organisation: World Health Organisation. United Nations report of a joint FAO/WHO expert consultation. Folate and folic acid. Human vitamin and mineral requirement. Rome; Italy; FAO/WHO; 2004.
32. Yashwant Kumar. Beetroot: A super food. International Journal of Engineering Studies and Technical Approach. 2015;1(3):20-26.
33. Ethag ME. Protein quality and acceptability of sorghum flour supplemented with defatted groundnut flour as influenced by trachtorial processing, PhD Thesis, faculty

of Agriculture University of Khartoum, Sudan; 2009.

34. Liu RH. J potential synergy of phyto chemicals in cancer prevention: Mechanism of action. Nutr. 2004;134:3479–3485.

35. Azhari A, Mohammed Nour, et al. Effect of supplement and cooking on In-vitro protein digestibility and anti-nutrients of pearl millet flour. American Journal of Food Science and Health. 2015;3:66-75.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/59469