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Research Article

Nutritional Evaluation, Glycemic Index and Sensory Property of Breakfast Cereals developed from Malted Amaranth and Roasted Sesame Blends -

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ABSTRACT

The aim of this study was to produce and assess breakfast meals produced from composite flour samples of processed malted amaranth and roasted sesame blends. The various biomaterials were processed separately. The resulting flour samples were blended at various ratios and processed to extruded breakfast meals. The extruded flaked meals were assessed for selected quality parameters (total dietary fibre, reducing/total sugar, sensory, amino acid and glycemic index/load) using standard methods. The results showed that there was increase in the amino acids, soluble, insoluble and total dietary fibre of sesame substituted samples. There was decrease in the reducing sugar and total sugar, glycemic index and load, total and reducing sugar of the samples containing sesame. The sample containing 50% sesame and 50% amaranth was the most acceptable in all the sensory parameters except in colour. The study concluded that high nutritional quality breakfast meal, also of low glycemic index/load could be produced from malted amaranth substituted with roasted sesame.

Keywords: Acceptability; Glycemic load; Amino acids; Reducing sugar; Soluble dietary fibre

INTRODUCTION

Breakfast cereals appeal to a wide demographic of varying ages, income level, cooking skill and are convenient, economical, nutritious, shelf stable, light weight, and easy to ship and store [1]. Having breakfast helps to stabilize blood sugar levels and this regulates appetite and energy. Breakfast is the nutritional foundation or the first meal of the day [2]. Skipping breakfast is associated with certain health condition such as obesity [3]. Breakfast cereal is a food made from processed grains such as wheat, corn, rice, oat, etc. some of these cereals have been implicated with low nutrients and celiac disease which occur in people with intolerance to gluten found in wheat [4].

The *Amaranthus* genotype species are cultivated as “pseudo cereals” which produce cereal-like grains. It is rich in carbohydrates, proteins, fibre and fats, comparable or even superior to cereals [5]. Bressani et al. [6] indicates that use of non-traditional cereal flours, such as amaranth, buckwheat or millet, may be used to reduce the glycemic index of breakfast cereals produced by extrusion. Amaranth is not genetically modified, it is rarely associated with any form of allergenic symptom because of the absence of gluten and could be used in foods designed to reduce allergies in sensitive individuals such as celiac disease patients [7]. Amaranth is a multi-purpose crop with rich nutritional quality grains and leafy vegetables for food and animal feed [8]. There is gradual appreciation of the usefulness of amaranth in the human food preparation.

Sesame seed (*Sesamum indicum* L.) is one of the unique healthy foods with multiple beneficial effects including anti-aging, anti-cancer, anti-oxidative activity, anti-hypertensive, modulation of lipid metabolism and lipid peroxidation, enhancement of liver function, immune-regulatory and anti-thrombosis properties [9]. Sankar et al. [10] reported that sesame oil lowered blood pressure and improved antioxidant status in hypertensive and diabetic-hypertensive patients. Sesame has been utilized in the production of various food items including complementary foods [11].

There is increased advocacy on the consumption of functional foods and a shift from over consumption of refined flour or white flour, also consideration must be given to other biomaterials that can be used as potential substitute to wheat and other conventional cereals. Going by the nutritional composition of amaranths [8] and the possibility of its utilisation in certain food product development coupled with the outstanding chemical composition of sesame; there is the need to exploit these raw materials for the benefit of consumers. There is information gap on the combination of these two biomaterials in the production of breakfast cereal. Therefore, this

study was designed to develop and produce extruded breakfast cereal based on the biomaterials and to assess selected quality parameters of the product.

MATERIALS AND METHODS

Materials

The materials used were amaranth grains (*Amaranthus virides*), sesame seeds (*Sesamum indicum*), experimental rats, digital glucometer (Accu-check), strips and chemical reagents. Amaranth grains were purchased from central market, Ondo, Ondo State, Nigeria while sesame seeds were purchased from Makurdi, Benue State, Nigeria. The seeds were identified at the Herbarium in Botany Department, Obafemi Awolowo University, Ile-Ife, Nigeria. The experimental animals, male rats were obtained from Faculty of Pharmacy, Obafemi Awolowo University, Ile-Ife, Nigeria. All chemicals used were of analytical grade.

Methods

Production of unmalted and malted amaranth flour samples:

The amaranth grains were cleaned and washed to remove dirt and stones. The grains were thereafter processed to unmalted and malted amaranth flour samples as described by Gamel et al. [12] and Ikujenlola et al. [13].

Production of roasted sesame flour: Sesame seeds were cleaned of extraneous materials and roasted at 150°C in locally fabricated roaster for 5 min with constant turning to prevent burning. The colour of the sesame seeds change to dark brown. The roasted seeds were cooled, milled, defatted, dried (to remove solvent) and packaged in high density polythene bag as reported by Ikujenlola et al. [13].

Sample formulation and production of extruded breakfast cereal:

The amaranth (unmalted and malted) and roasted sesame flour samples were blended at various ratios of 100:0; 90:10; 80:20; 70:30; and 50:50 respectively. The extruded breakfast cereal was produced step by step as reported by Ikujenlola et al. [13].

Determination of soluble dietary fibre, insoluble dietary fibre and total dietary fibre:

Determination of soluble dietary fibre, insoluble dietary fibre, and total dietary fibre was carried out using enzymatic method [14,15] as follows: homogeneous dry samples with ratio 1: 2 (solute: solvent) were extracted using petroleum benzene at room temperature for 15 min if the sample fat content exceeded 6-8%. Fat extraction aims to maximize starch degradation. One gram of sample is inserted into Erlenmeyer. Then 25 mL of Sodium Phosphate buffer was added and made into a suspension. The addition of the buffer is intended to stabilize the thermal enzyme. Termamyl

(100 µL) was added, sealed and incubated at 100°C for 15 min, with occasional stirring. The purpose of thermal treatments was to break the starch. The mixture was then raised and cooled. Further, 20 mL of distilled water was added and pH was adjusted set to 1.5 by adding 4 M HCl. Then, 100 mg pepsin was added. A pH of 1.5 is intended to condition the maximum enzyme activity of pepsin incubated at 40°C and agitated for 60 min with 225 rpm. Distilled water (20 mL) was added and the pH was adjusted to 6.8 with 0.1N NaOH. Then, 100 mL of the pancreatic enzyme was added, and the mixture was incubated at 40°C for 60 min with agitation. The pH was then adjusted with 0.1N HCl to 4.5, filtered through a weighted weighing sintered crucible containing 0.5 g dried celite and washed twice with 10 mL distilled water. Insoluble Dietary Fibre (IDF) in the residue was washed twice with 10 mL 95% ethanol and 10 mL acetone. Then, dried for about 12 h, at a temperature of 105°C, to a fixed weight and weighed after cooling in a desiccator (D1). Furthermore, blanch in the 500°C furnace for at least 5 h, then weigh it after being cooled in the desiccator (I1). Then, the volume of the filtrate which contains the Soluble Dietary Fibre (SDF) was adjusted with water to 100 mL, and 400 mL of 95% warm ethanol at 60°C to precipitate for 1 hr. Thus, filtered with dry crucible (porosity 2) containing 0.5 dried celite and washed with 2 x 10 mL of 78% ethanol, and 2 x 10 mL of acetone. After cold, centrifuge the mixture at 822 x g for 10 min. The absorbance of the supernatant was measured at 532 nm. As a standard solution, TEP was used (tetra ethoxy propane).

Total sugar determination: Stock solution was prepared by dissolving 0.01 g of glucose in 100 ml of distilled water. Standard was prepared by dispensing 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0 ml into test tubes and was made up to 1ml with distilled water. One millilitre of ethanolic extract was added to 4 ml of anthrone reagent (50 mg of anthrone and 1 g of thiourea in 100 ml of 66% sulphuric acid) and then heated in a boiling water bath for 10 min and rapidly cooled. Optical Density (OD) of the solutions was read at 620 nm against a reference blank in spectrophotometer and the amount of sugar liberated was obtained from the standard curve based on known concentrations of glucose (10-100 mg/L) [16].

Reducing sugar determination: The reducing sugar concentrations were determined by the colorimetric estimation method with the reagent of 3,5-dinitrosalicylic acid (DNS). About, 10 g of sample was mixed well with 80 mL of distilled water. The sample was placed in a water bath maintained about 50°C with occasional shaking for 20 min. Next, the sample was centrifuged in a centrifuge (TGL-16B, Nanchang Jingmi Instrument, Nanchang, China) at 3000 rpm for 10 min. Then, 1 mL of the supernatant was mixed well with 1 mL of DNS. The absorption of the sample was read at 540 nm on an ultraviolet spectrophotometer (725, Nanchang Jingmi Instrument, Nanchang, China). The reducing sugar concentration was calculated using the standard curve [17].

Amino acid determination: The amino acid composition of the sample was determined according to the method of Spackman et al. [18] and reported by Abiose and Ikujenlola [19]. The amino acid analysis was determined at the Department of Zoology, University of Jos, using the High Performance Liquid Chromatography (HPLC) specifically the Technicon TSM (Technosequential Multisample) analyser for amino acid. The samples were dried to constant weight and defatted. A known weight of the defatted sample was hydrolysed under vacuum with 7 mL of 6 N HCl in a sealed pyrex tube at 105°C for 22 h. Immediately after cooling, it was filtered through non-absorbent cotton wool. The filtrate was dried at 40°C using rotary

evaporator. The amino acids in the flask were diluted with 5 mL of acetate buffer (pH 2.0) and 5 to 10 µL was loaded into the cartridge of Technicon Sequential Multisample Amino acid Analyzer (TSM). The absorbance of the mixture was monitored continuously in a colorimeter, the signals were magnified and traced on a two pen recorder using a linear chart to develop a chromatograph. The area under the peak was calculated as the concentration of each amino acid.

Calculation of other protein quality parameters: Protein quality parameters were calculated as described by FAO/WHO [20]. Determination of the ratio of Total Essential Amino Acids (TEAA) to the Total Amino Acids (TAA), i.e. (TEAA/TAA), Total Sulphur Amino Acids (TSAA), percentage cysteine in TSAA (% Cys/TSAA), Total Aromatic Amino Acids (TArAA), Total Neutral Amino Acids (TNAA), Total Acidic Amino Acids (TAAA) and Total Basic Amino Acids (TBAA) were estimated from the results obtained for amino acids profiles.

Experimental animals study: Male matured Wistar strain albino rats of weight ranging between 65-75 g were used for this study to see the effect of the breakfast cereal on blood glucose level of the rats. The animals were housed in metabolic cages and acclimatized for four days on maize based animal feed while water was supplied *ad libitum*. On the fourth day of acclimatization the animals were reweighed and grouped into 8 groups of five rats per group. The average weight difference was maintained within ±2 g [21]. For the determination; the animals were fasted by withdrawing feed from the animal for 12 hours (overnight fasting). The animals were fed with 5 g of the samples and control within a period of 30 minutes. After the end of 30 minutes, samples were withdrawn from each group and blood sugar level were determined by drawing blood from the tail of the animals using Accu-chek[®] Advantage, Roche Diagnostic, Germany. The first drop of blood was laced onto the strip and reading was taken (within 5-10 seconds) and recorded. Further blood samples were obtained at 0, 15, 30, 60 and 90 mins intervals. The rat experiment/protocol was carried out following the approval of the Departmental Research Committee, Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria [22].

Measurement of blood glucose response: Blood glucose curves were constructed from blood glucose values of animals at time 0, after 15, 30, 60 and 90 min intervals after consumption of the formulated food samples and control. Glycemic Index (GI) for each sample was determined by calculation of Incremental Area Under one and half hours of blood glucose response or Curve (IAUC) for each diet and compared with the IAUC for glucose solution standard according to the method of Wolever et al. [23] using equation.

$$GI = \frac{\text{Incremental Area Under Blood Glucose Curve for test Food}}{\text{Incremental Area Under Blood Glucose Curve for Glucose}} \times 100$$

Calculation of glycemic load: The Glycemic Load (GL) was determined by the method of Wolever et al. [23]. The GL was calculated based on the quantity of the recipe per serving and the respective available carbohydrate content.

The following formula was used: Glycemic load =

$$\frac{\text{Available carbohydrates (g)} \times \text{GI}}{100}$$

Sensory evaluation of extruded breakfast cereal from amaranth and sesame: Sensory parameter evaluation of the extruded breakfast cereal was carried out using the method described by Agu et al.

[24]. A 9- point Hedonic scale was used and the quality parameters assessed were colour, texture, flavour, crispness, taste, and overall acceptability. Fifteen (15) semi trained panellists from the University community who were familiar with breakfast cereal and good consumers of similar products were selected. Each sample was coded and the score sheet was presented for scoring in well illuminated laboratory for this assessment. Water was given to each panellist for oral rinsing in between tasting of the samples. The questionnaire and other protocols followed the established ethics of the Departmental Research Committee, Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria.

Statistical analysis

All experiments were conducted in replicate. Data reported were the average of two determinations. Analysis of Variance (ANOVA) was performed on each of the variables and the Least Significant Difference (LSD) test at a significant level $p < 0.05$ was performed using SPSS/16 software to compare the differences between treatment means. Results were expressed as the means \pm standard deviation of three separate determinations.

RESULTS AND DISCUSSION

Proximate composition of the flour blends used for extruded breakfast cereal

The proximate composition of the flour blends of amaranth and sesame used for extruded breakfast cereal production has been reported elsewhere in previous work of Ikujenlola et al. [13]. The protein content of the flour blends ranged from 11.07 and 15.04%. The result showed that the addition of sesame increased the proximate composition parameters (protein, fat, ash, fibre), except for carbohydrate which decreased.

Dietary fibre of flour and extruded samples

Dietary fibre is food component that is chemically unchanged or resistant to digestion. Its presence is indispensable in the digestive process in the human body [15]. The tables 1 and 2 report the dietary fibre of the flour samples and the extruded breakfast cereal samples. The Soluble Dietary Fibre (SDF) component ranged from 1.46 to 2.59 g/100 g for flour blends, the extruded products had the values ranging from 1.87 to 2.28 g/100 g. It was observed that the more the level of sesame the higher the soluble fibre component in the both flour and extruded samples. The 50% substitution of sesame recorded higher soluble fibre than that of control sample (wheat). The insoluble component of the dietary fibre which resists digestion in the intestine ranged between 3.17-3.78 and 3.3-3.89 g/100 g for flour samples and extruded samples respectively. Breakfast made from these type of biomaterials could be classified as moderate dietary fibre containing food. The total dietary fibre ranged between 4.62 and 6.37 g/100 g. The malted samples had higher dietary fibre, this may be due formation of resistant starch according to Taraseviciene et al. [25] who reported that fibre content increased with increasing germination time. Food high in dietary fibre has many functions such as increasing the volume of faecal bulk, decreasing the time of intestinal transit, cholesterol and glycemic levels, trapping substances that can be dangerous for the human organism (mutagenic and carcinogenic agents), stimulating the proliferation of the intestinal flora, etc. [26]. However, food of high fibre should be consumed with appropriate amount of water in order to prevent difficulty during defecation [22]. The total dietary fibre reported in this study is higher than the values (2.73-3.89 g/100 g) reported by Saragih et al. [15] for different varieties of rice.

Table 1: Soluble, insoluble and total dietary fibre of amaranth and sesame flour blends (g/100g).

Sample	Soluble	Insoluble	Total
1	1.46 \pm 0.02 ^g	3.16 \pm 0.01 ^g	4.62 \pm 0.05 ^g
2	1.88 \pm 0.01 ^f	3.36 \pm 0.01 ^f	5.24 \pm 0.01 ^f
3	2.06 \pm 0.01 ^e	3.44 \pm 0.01 ^e	5.50 \pm 0.01 ^e
4	2.16 \pm 0.01 ^d	3.55 \pm 0.01 ^d	5.71 \pm 0.01 ^d
5	2.26 \pm 0.01 ^c	3.64 \pm 0.01 ^c	5.90 \pm 0.01 ^c
6	2.59 \pm 0.01 ^a	3.78 \pm 0.03 ^a	6.37 \pm 0.02 ^a
7	2.51 \pm 0.03 ^b	3.72 \pm 0.01 ^b	6.23 \pm 0.02 ^b

Values with different Superscript in the same column are significantly different at ($p < 0.05$).

Sample 1: 100% Unmalted Amaranth

Sample 2: 100% Malted Amaranth

Sample 3: 90% Malted Amaranth: 10% Roasted Sesame

Sample 4: 80% Malted Amaranth: 20% Roasted Sesame

Sample 5: 70% Malted Amaranth: 30% Roasted Sesame

Sample 6: 50% Malted Amaranth: 50% Roasted Sesame

Sample 7: 100% Whole Wheat Flour.

Table 2: Soluble, insoluble and total dietary fibre of breakfast cereal from amaranth and sesame flour blends.

Sample	Soluble	Insoluble	Total
1	1.87 \pm 0.01 ^g	3.37 \pm 0.01 ^g	5.24 \pm 0.01 ^g
2	2.05 \pm 0.01 ^f	3.47 \pm 0.01 ^f	5.52 \pm 0.01 ^f
3	2.16 \pm 0.01 ^e	3.58 \pm 0.01 ^e	5.74 \pm 0.01 ^e
4	2.26 \pm 0.02 ^d	3.63 \pm 0.02 ^d	5.89 \pm 0.02 ^d
5	2.30 \pm 0.20 ^b	3.71 \pm 0.20 ^c	6.01 \pm 0.20 ^c
6	2.34 \pm 0.25 ^a	3.89 \pm 0.15 ^a	6.23 \pm 0.10 ^a
7	2.28 \pm 0.01 ^c	3.76 \pm 0.01 ^b	6.04 \pm 0.01 ^b

Values with different Superscript in the same column are significantly different at ($p < 0.05$).

Sample 1: 100%Unmalted Amaranth

Sample 2: 100% Malted Amaranth

Sample 3: 90% Malted Amaranth: 10% Roasted Sesame

Sample 4: 80% Malted Amaranth: 20% Roasted Sesame

Sample 5: 70% Malted Amaranth: 30% Roasted Sesame

Sample 6: 50 % Malted Amaranth: 50% Roasted Sesame

Sample 7: 100% Whole Wheat Flour.

Amino acids composition of flour and extruded samples

Tables 3 and 4 show the Amino Acid (AA) composition for the flour and extruded samples produced from mixtures of amaranth and roasted sesame. It was observed that the unmalted amaranth sample had higher values of amino acids compared to malted sample. In addition, the substitution of sesame to amaranth showed an increase in some of the amino acids. The process of extrusion into which the samples were subjected to prior to production of breakfast showed an appreciable increase in some of the amino acids in the extruded samples. However, it was observed that lysine decreased with extrusion. This observation agrees with the reports of Bjorck et al. [27] and Lasekan et al. [28] on reduction of lysine in extruded wheat flour and in whole-grain maize flour extruded in a twin-screw extruder at 45 g/kg feed moisture/135°C temperature respectively. Nass et al. [29] and Mauron [30] have attributed the loss to maillard reaction which takes place at low moisture and high temperature that leads to starch degradation, thus providing reducing sugars that modifies protein structure, which favours browning reactions. Since

Table 3: Amino acid composition of the flour samples and extruded breakfast cereal from amaranth and sesame flour (g/100g protein).

Amino acid	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	FAO/ WHO*
Glycine	4.11	3.07	4.39	3.94	4.33	5.38	3.98	3.95	2.20
Alanine	4.30	4.27	4.47	3.44	4.27	3.71	4.15	4.71	6.10
Serine	4.78	4.95	5.32	5.30	5.22	5.33	5.70	5.50	8.00
Proline	4.69	5.05	4.46	4.59	4.79	4.83	4.82	5.38	11.00
Valine	4.64	4.87	5.05	4.80	4.88	3.29	4.21	5.01	4.00
Threonine	3.62	3.29	3.06	2.70	2.96	2.98	2.43	3.38	3.40
Isoleucine	3.59	2.95	3.46	3.40	3.89	3.09	2.77	2.57	3.00
Leucine	7.44	7.65	6.94	6.48	7.38	6.79	5.07	6.66	7.00
Aspartic acid	9.38	10.29	9.82	9.82	9.56	8.43	9.61	9.41	8.00
Lysine	3.30	3.59	3.83	3.48	3.64	3.66	3.63	3.60	5.80
Methionine	1.26	1.22	1.09	1.16	1.38	1.20	1.15	1.14	3.00
Glutamic acid	18.23	18.76	18.36	18.66	18.09	18.08	17.01	17.67	15.00
Phenylalanine	4.52	4.55	4.50	4.83	5.14	5.22	4.76	4.43	6.30
Histidine	2.74	2.70	2.30	2.32	2.30	1.94	2.18	2.09	2.50
Arginine	8.52	8.60	8.73	9.77	7.35	7.74	10.08	8.85	5.20
Tyrosine	3.38	3.22	3.58	4.03	3.29	3.23	3.16	2.99	3.10
Tryptophan	5.38	5.63	6.80	6.07	6.97	7.24	4.36	5.23	5.80
Cysteine	2.02	2.13	2.14	2.47	1.87	2.10	2.13	1.84	1.10
Total AA	96.90	96.16	98.30	97.26	97.31	93.12	90.63	94.44	94.70

Sample 1: 100% Unmalted Amaranth Bfc
Sample 2: 100% malted Amaranth Bfc
Sample 3: 90% Malted Amaranth: 10% Roasted Sesame Bfc
Sample 4: 80% Malted Amaranth: 20% Roasted Sesame Bfc
Sample 5: 70% Malted Amaranth: 30% Roasted Sesame Bfc
Sample 6: 50% Malted Amaranth: 50% Roasted Sesame Bfc
Sample 7: 100% Unmalted Amaranth Flour
Sample 8: 100% Malted Amaranth Flour
*FAO/WHO (1993)

the lysine α -amino group has been referred to as a major reactant in the maillard reaction, this might explain the extrusion effect on this particular amino acid.

From the listed amino acids, it was observed that the FAO/WHO [31] recommendation in terms of lysine, methionine and phenylalanine were not met. However, the values of the other essential amino acids for adults met the recommended values of FAO/WHO [31]. Essential amino acids in the right quantity is important for good growth and healthy living especially for children. Arising from the result, the essential amino acids composition for children are not met. However, for adults that require protein for maintenance and not for growth and development the extruded meal will be okay. However, if children will benefit maximally from the extruded meals there is the need to supplement for those essential amino acids in order to forestall malnutrition as a result of protein quality deficiency. Average of 50% substitution of sesame gave the best values in terms of amino acids. Glutamic and aspartic acids recorded the highest values of all the amino acids while lysine and methionine recorded the lowest values among the amino acids. For healthy living, food should contain all the essential amino acids at the right proportion.

Amino acids are important components that play key roles in many healing processes; amino acid deficiencies will hinder many recovery processes. It is also the building block of protein, synthesize neurotransmitters, and protect cardiovascular health [32].

Total Amino Acids (TAA) (Table 4) value ranged from 90.63-93.12 g/100 g protein for flour and 93.12-98.30 g/100 g protein for extruded samples. The total amino acids increased with increased level of substitution of sesame. Essential Amino Acids (EAA) and Non-Essential Amino Acids (NEAA) accounted for 27.81-32.05 g/100 g protein (flour) and 32.92-36.24 g/100 g protein for extruded samples respectively while TNEAA of flour ranged from 62.39-62.82 g/100 g protein and that of extruded samples ranged from 59.77-64.34 g/100 g protein.

Glycemic Index and glycemic load of Breakfast Cereal

Glycemic Index (GI) is a characteristics of starchy food, which describes the rate of blood glucose absorption after consumption [33,34]. Glycemic index is a physiological classification widely accepted for carbohydrate foods, with implications on health and disease [15]. The results presented in figure 1 shows the range of glycemic index (100.00-69.89) and glycemic load (78.19-41.65) of the assessed breakfast meals. It showed significant differences ($p < 0.05$) between amaranth based breakfast meals containing sesame and those not having sesame. It was observed that the addition of sesame at varied proportions to amaranth reduced glycemic index and load respectively. This observation agrees with the report of Kaur, et al. [35]. The glycemic index and glycemic load followed similar trend. The result also showed that the glycemic index of the white bread had the highest value compared to other samples. The whole wheat had values higher than any amaranth based meals. The glycemic index ranking can be classified as either high or medium or low GI food. The consumption of these breakfast cereals could be beneficial, since the consumption of a low GI foods has been shown to have positive health benefits in a variety of chronic diseases including insulin resistance, diabetes, cardiovascular disease, obesity and cancers [36]. Any food with GI value of 70 or more is a high GI food, moderate GI foods ranged from 56 to 69 and low GI foods have scores from 0 to 55 [35]. Based on this classification of World Health Organization (WHO) reported by Kaur et al. [35], the meal with sesame can be classified as moderate GI food while the unmalted amaranth, whole wheat and white bread can be classified as high GI food. Increase in certain nutrients such as crude fibre and protein and decrease in carbohydrates may account for the decrease in the glycemic value of the developed products.

Blood glucose response of breakfast cereal

Figure 2 presents the blood glucose response of the amaranth

Table 4: Amino acid distribution in the flour blends and extruded breakfast cereal from amaranth and sesame flour (g/100g protein).

Parameters	Samples							
	1	2	3	4	5	6	7	8
Total Amino Acid (TAA)	96.90	96.16	98.3	97.26	97.31	93.31	93.12	90.63
Total Non-Essential Amino Acid (TNEAA)	63.41	62.41	64.41	65.41	66.41	67.41	68.41	69.41
Total Essential Amino Acid (TEAA) with Histidine	37.43	36.43	38.43	39.43	40.43	41.43	42.43	43.43
Total Essential Amino Acid (TEAA) without Histidine	35.36	34.36	36.36	37.36	38.36	39.36	40.36	41.36
Total Neutral Amino Acid (TNAA)	40.26	39.26	41.26	42.26	43.26	44.26	45.26	46.26
Total Acidic Amino Acid (TAAA)	27.61	29.05	28.18	28.48	27.65	26.51	26.62	27.08
Total Basic Amino Acid (TBAA)	14.56	14.26	14.86	15.57	13.29	13.24	15.32	14.57
Total Sulphur Amino Acid (TSAA)	3.28	3.35	3.23	3.63	3.48	3.25	3.28	2.98
Total Aromatic (TArAA)	16.02	15.47	17.18	17.25	17.70	17.63	14.46	14.74
% with histidine	37.66	37.88	37.67	36.23	39.61	38.16	32.17	35.36
% without histidine	34.83	35.73	35.33	33.83	37.24	36.08	29.86	35.36
% Total Neutral Amino Acid (TNAA)	40.55	40.83	41.87	33.14	44.22	43.67	37.40	43.12
% Total Basic Amino Acid (TBAA)	15.03	14.83	15.12	16.01	13.66	14.19	16.45	16.08
% Total Acidic Amino Acid (TAAA)	28.49	30.21	28.67	29.28	28.41	28.42	28.59	29.88
% Total Sulphur Amino Acid (TSAA)	33.85	34.84	32.86	37.32	35.76	34.83	35.22	32.88
% Total Aromatic TArAA	16.53	16.09	17.48	17.74	18.19	18.89	15.53	16.26

Sample 1: 100% Unmalted Amaranth Bfc
 Sample 3: 90% Malted Amaranth: 10% Roasted Sesame Bfc
 Sample 5: 70% Malted Amaranth: 30% Roasted Sesame Bfc
 Sample 7: Unmalted Amaranth Flour

Sample 2: 100% Malted Amaranth Bfc
 Sample 4: 80% Malted Amaranth: 20% Roasted Sesame Bfc
 Sample 6: 50% Malted Amaranth: 50% Roasted Sesame Bfc
 Sample 8: Malted Amaranth Flour

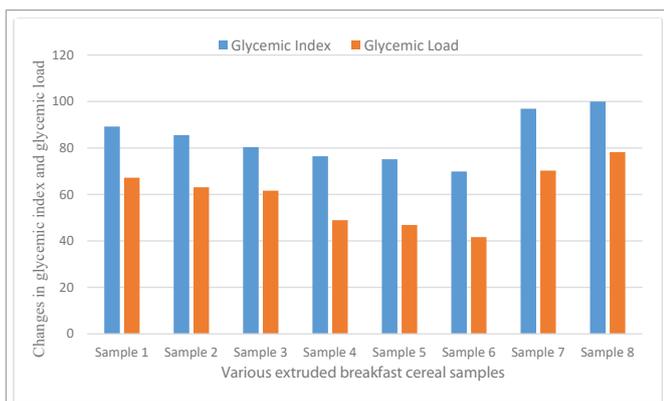


Figure 1: Glycemic index and glycemic loads of extruded breakfast cereal from amaranth and sesame flour blends.

Key: Sample 1: 100% Unmalted Amaranth Bfc; Sample 2: 100% Malted Amaranth Bfc; Sample 3: 90% Malted Amaranth: 10% Roasted Sesame Bfc; Sample 4: 80% Malted Amaranth: 20% Roasted Sesame Bfc; Sample 5: 70% Malted Amaranth: 30% Roasted Sesame Bfc; Sample 6: 50% Malted Amaranth: 50% Roasted Sesame Bfc; Sample 7: 100% Whole Wheat Flour; Sample 8- White bread.

based meal. The result showed that between 15-30 min of consuming the meal by the subjects (experimental rats) there was sharp increase in the level of the blood glucose of all the tested samples. However, the increase was at varying rates. The subjects fed with white bread, whole wheat and 100% amaranths recorded higher values while the least was observed in the animals fed with sample containing 50% amaranth and 50% sesame blends. These observations are deeply connected with the level of glycemic index/load of each sample. The result gives an indication of what happens to meal shortly after consumption that it raises the level of blood glucose. The result equally showed that the blood glucose started reducing between 30 and 60 min after consumption at varying proportions for all the samples. The reduction started from the peak point at 30 min after consumption, it begins to reduce until the last reading was taken at 90 min after consumption. This trend may be as a result of the utilisation of the

glucose for other metabolic purposes. The body system of healthy animals (man inclusive) through the hormone insulin mops excess blood glucose and converts to stored animal starch (glycogen), which can be used as source of glucose with the help of glucagon which converts glycogen to glucose during starvation. Excess blood glucose can be a very serious health issue especially when there is anomaly with respect to secretion of insulin in the body this is the case with diabetic patient. The reduction of glycemic index can be attributed to the addition of sesame an oil-seed which is likely to contain more protein and fibre which are more resistant to digestion and release of glucose [35]. Postprandial glucose responses of starch can be changed by processing factors such as disruption of the cell wall, gelatinization and structure of the granule of starch [37,15]. The results of Gilbertson et al. [38] showed that food with low IG can improve metabolic control in adult type 2 Diabetes Mellitus (DM).

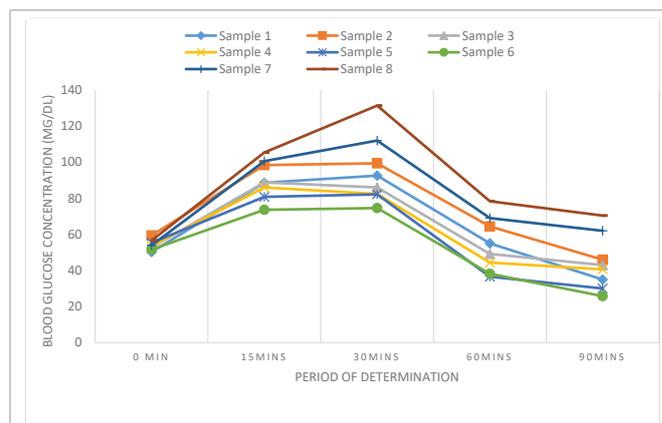


Figure 2: Blood glucose concentration of extruded breakfast.

Key: Sample 1: 100%Unmalted Amaranth Bfc; Sample 2: 100% Malted Amaranth Bfc; Sample 3: 90% Malted Amaranth: 10% Roasted Sesame Bfc; Sample 4: 80% Malted Amaranth: 20% Roasted Sesame Bfc; Sample 5: 70% Malted Amaranth: 30% Roasted Sesame Bfc; Sample 6: 50% Malted Amaranth: 50% Roasted Sesame Bfc; Sample 7: 100% Whole Wheat Flour; Sample 8: White bread.



Total and reducing sugar of flour and extruded breakfast meal from amaranth and sesame blends

The total sugar present in both the flour and extruded breakfast samples are presented in figure 3. The total sugar ranged from 9.18 to 13.05 mg/mL for flour samples and 10.21 to 15.53 mg/mL for extruded breakfast samples. It was observed that the total sugar in the extruded samples was higher than those of flour samples, this may be due to added sugar during the production of the breakfast meal. It was also observed that the level of total sugar reduced with increased level of sesame. This may be as a result of high level of fibre in sesame compared to amaranth. Meanwhile, the values of reducing sugar as presented in figure 4 show that the flour samples (9.18-13.05 mg/mL) and breakfast meal samples (10.21-15.53 mg/mL) followed similar trend with total sugar. The values reported in this study were lower than the reported values (21.20-26.26 mg/ml) by Jisha et al. [39] for similar samples.

Sensory characteristics of extruded breakfast cereals

The results of the sensory properties of the extruded amaranth based breakfast cereal is presented in Table 5. The overall acceptability of the meal which is the summary of all the constituents' parameters assessed and it showed that there was no significant difference ($p < 0.05$) between the control and the sample 6 containing 50% amaranth and 50% sesame. The result showed that the control was the most acceptable in terms of colour, texture and crispness. The amaranth based meals were acceptable to the panellists in terms of the all the assessed attributes. However, the colour was not very acceptable as the level of sesame increases. It was observed that addition of sesame increased the dark brown color and reduced the surface smoothness of the products. This might be attributed to a form of browning reaction that developed during extrusion process which darkens the color of the products. In all the best product is the sample containing 50% amaranth and 50% sesame based on all the parameters. The observation in this report agrees with the submission of Edima-Nyah et al. [40] on the sensory attributes of breakfast meal from composite flour.

CONCLUSION

This study established the possibility of producing breakfast cereal of high quality from amaranth and sesame blends. Enrichment of amaranth with roasted sesame led to increase in the total amino acid content of the extruded breakfast cereal samples. The addition of sesame reduced the glycemic index/load, reducing and total sugar of the products. The sample containing 50% malted amaranth and 50%

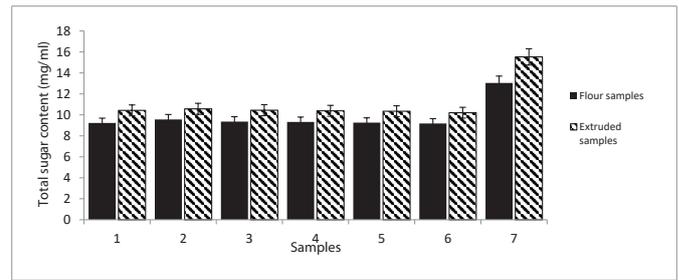


Figure 3: Total sugar content of the amaranth and sesame flour blends and breakfast cereal from amaranth and sesame

Sample 1: 100% Unmalted Amaranth; Sample 2: 100% Malted Amaranth; Sample 3: 90% Malted Amaranth: 10% Roasted Sesame; Sample 4: 80% Malted Amaranth: 20% Roasted Sesame; Sample 5: 70% Malted Amaranth: 30% Roasted Sesame; Sample 6: 50% Malted Amaranth: 50% Roasted Sesame; Sample 7: 100% Whole Wheat Flour.

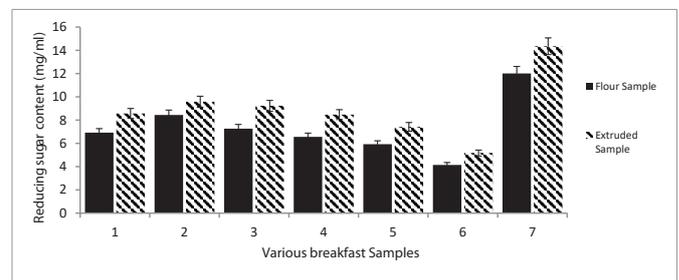


Figure 4: Reducing sugar content of flour blends and extruded breakfast cereal from amaranth and sesame.

Sample 1: 100% Unmalted Amaranth; Sample 2: 100% Malted Amaranth; Sample 3: 90% Malted Amaranth: 10% Roasted Sesame; Sample 4: 80% Malted Amaranth: 20% Roasted Sesame; Sample 5: 70% Malted Amaranth: 30% Roasted Sesame; Sample 6: 50% Malted Amaranth: 50% Roasted Sesame; Sample 7: 100% Whole Wheat Flour.

roasted sesame was ranked best among the amaranth based breakfast meals.

AUTHORS' CONTRIBUTIONS

Ikujenlola, A.V. conceived and designed the study, supervised the experimental protocols, analysed the data, wrote the final draft and submitted to the journal.

Ojedokun, F.O. carried out the experiment and wrote the first draft of the paper

Table 5: Sensory characteristics of extruded breakfast cereal from amaranth and sesame flour blends.

Samples	Colour	Texture	Flavour	Crispiness	Taste	Over Acceptability
1	4.20 ± 2.41 ^{cd}	5.40 ± 2.52 ^{bc}	3.90 ± 2.14 ^b	6.55 ± 1.95 ^a	3.10 ± 2.38 ^d	3.45 ± 1.93 ^d
2	3.65 ± 1.98 ^d	3.70 ± 2.02 ^{cd}	5.40 ± 2.52 ^a	5.85 ± 2.30 ^b	3.55 ± 2.13 ^d	3.50 ± 1.73 ^d
3	5.60 ± 2.01 ^b	5.10 ± 1.75 ^{bc}	4.75 ± 2.12 ^b	3.40 ± 1.88 ^d	5.05 ± 2.37 ^b	5.20 ± 2.03 ^b
4	5.40 ± 2.13 ^{bc}	3.75 ± 2.59 ^{de}	4.50 ± 2.48 ^b	4.10 ± 2.35 ^c	3.90 ± 1.86 ^d	4.50 ± 2.54 ^{bc}
5	4.40 ± 1.60 ^{cd}	5.65 ± 1.46 ^b	4.55 ± 1.53 ^b	5.80 ± 1.60 ^b	4.15 ± 1.75 ^{bc}	4.35 ± 1.84 ^{bc}
6	3.85 ± 1.84 ^d	5.35 ± 1.83 ^{bc}	4.15 ± 2.08 ^b	5.90 ± 2.19 ^b	5.70 ± 2.31 ^a	5.40 ± 1.73 ^a
7	7.90 ± 1.29 ^a	7.15 ± 1.56 ^a	4.30 ± 2.22 ^c	6.40 ± 2.08 ^a	4.60 ± 2.25 ^c	5.47 ± 2.26 ^a

Values with different Superscript in the same column are significantly different at ($p < 0.05$).

Key: Sample 1:100%Unmalted Amaranth

Sample 2:100% Malted Amaranth

Sample 3: 90% Malted Amaranth: 10% Roasted Sesame

Sample 4: 80% Malted Amaranth: 20% Roasted Sesame

Sample 5: 70% Malted Amaranth: 30% Roasted Sesame

Sample 6: 50% Malted Amaranth: 50% Roasted Sesame Sample 7: 100% Whole Wheat Flour.

Abiose, S.H. designed the study, supervised the study and vetted the draft.

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