Food Research 6 (6) : 78 - 87 (December 2022)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Effects of roasted defatted sesame seed (*Sesamum indicum*) flour addition on the nutritional quality, dietary fibre, and glycaemic index of malted amaranth grain (*Amaranthus hybridus*) flour

[1]Ogundele, O.M., [2]Ojedokun, F.O., [1]Fasogbon, B.M. and [3,*]Bamidele, O.P.

[1]*Department of Biotechnology and Food Technology, University of Johannesburg, South Africa*
[2]*Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Nigeria*
[3]*Department of Food Science and Technology, University of Venda, South Africa*

Article history:
Received: 13 September 2021
Received in revised form: 18 October 2021
Accepted: 19 February 2022
Available Online: 19 November 2022

Keywords:
Amino acid profile,
Mineral content,
Composite flour,
Cereals,
Underutilized grains

DOI:
https://doi.org/10.26656/fr.2017.6(6).698

Abstract

This study determined the effects of the addition of roasted defatted sesame seed flour to malted amaranth flour at different ratios on the nutritional quality, dietary fibre, and glycaemic index of composite flour. The proximate composition of the composite flour increased with an increase in the percentage of roasted sesame seed flour added. Although the amino acid profile of the flour blends did not significantly change in the composite flour, the pasting properties were significantly reduced with the addition of roasted defatted sesame flour. The dietary fibre increased with the addition of roasted defatted sesame seed flour and the estimated glycaemic index was significantly reduced. The composite flour containing 50% malted amaranth flour and 50% roasted defatted sesame seed flour has the lowest glycaemic index. The addition of roasted defatted sesame flour to malted amaranth flour up to 50% may be good raw material in further processing of flour for complementary or breakfast foods.

1. Introduction

Consumers are increasingly aware of the relationships between diet, health, and well-being ensuring the choices of foods that are deemed healthier and extra nutritious (Motta *et al*., 2019). The search for lesser-known and underutilized crops, many of which are potentially valuable as human meals have been intensified to hold a balance between population growth and agricultural product. In tropical growing nations where the furnish of animal protein is insufficient to meet the fast populace growth, extreme research efforts are currently directed toward the identification and contrast of underexploited grains, which normally have sizable high protein content. Research into such underutilized vegetation may also help to improve their utilization thereby decreasing starvation and malnutrition amongst the prone team which consists of children and pregnant women. Generally, sesame seed and pseudo-cereals such as amaranth have been pronounced to have high nutritive value, due to the fact of their high protein content and a well-balanced essential amino acid (EAA) profile (Rodríguez *et al.*, 2020).

Sesame (*Sesamum indicum L*.) is cultivated in many countries of the world such as China, India, Sudan, and Burma (Myint *et al.,* 2020). The seed is imperative for the manufacturing of oil, paste, and food formulations (Abu-Jdayil *et al.,* 2002). Sesame seeds play an essential role in human nutrition and have been proven to contain antinutrients in seed hulls. These anti-nutritional elements decrease the bioavailability of minerals and digestibility of plant proteins thereby limiting their use as a food ingredient (Gilani *et al.*, 2012). Roasting of sesame seed has been reported to reduce the anti-nutritional content of the seed and enhance the dietary high quality of the seed flour (Myint *et al*., 2020). The sesame seed flour after the extraction of oil has been used as composite flour with wheat flour and maize flour (Zouari *et al*., 2016).

Amaranth is a multipurpose crop presenting high dietary quality grains and leafy vegetables as food for humans and animals respectively (Manyelo *et al*., 2020). Amaranth grain is high in protein with approximately 90% digestibility, and rich in lysine (limiting amino acid in grains). Amaranth grain is additionally a wealthy source of tryptophan and amino acids containing Sulphur which usually does not appear frequently ample in grains. Najdi Hejazi and Orsat, (2017) pronounced an 8% amplification in protein availability of malted

*Corresponding author.
Email: *Oluwaseun.bamidele@univen.ac.za*

eISSN: 2550-2166
Published by Rynnye Lyan Resources

amaranth for 48 hrs at 26°C. Amaranth grain is a high glycaemic meal (Capriles *et al.,* 2008), which may additionally lead to diabetes and other blood sugar-related diseases if consumed on its own.

However, these cereals need to be processed earlier than they can be integrated into the human diet. Different reviews point out that processing strategies such as roasting, fermentation, and malting enhance digestibility, the bioavailability of nutrients, and palatability, taste, texture, and flavour (van Boekel *et al.,* 2010). Malting of amaranth grain and roasting of sesame seeds may additionally enhance their dietary qualities and reduce their anti-nutritional activities. Moreover, apart from the treatments of raw materials with the above-mentioned processes, enrichment with substitute protein ingredients is another approach to improve the nutritional value. With the nutritional characteristics of amaranth grains, the grains as being used to substitute different cereals like maize, rice, millet, and wheat in the production of confectionaries (e.g., bread and biscuits) (Pretova and Petrov, 2020). To the first-class of our knowledge, data on compositing two pseudo-cereal flour is limited. This study, therefore, aimed at mixing malted amaranth grain flour and roasted defatted sesame seed flour in other to produce composite flour with a reduced glycaemic index and higher nutritional composition that can be used in the food industry. It was hypothesized that the addition of roasted defatted sesame seed flour to amaranth grain flour will minimize the glycaemic index and improve the nutritional qualities of the composite flour.

2. Materials and methods

2.1 Materials

Amaranth grains (*Amaranthus hybridus*) (50 kg) were purchased from the central market in Ondo, Nigeria while the Sesame seeds (*Sesamum indicum*) (50 kg) were purchased from Central market Makurdi, Nigeria. The seeds were taken to the herbarium for identification. All the chemicals used for this study were of analytical standard.

2.2 Production of malted amaranth flour and roasted sesame seed flour

Cleaned amaranth grain was steeped for 12 hrs, malted for 48 hrs at 30±2°C, washed, dried at 50°C, winnowed, milled using Hammer milled with 500-micron sieve size, and packaged in a polyethylene bag and stored at refrigeration temperature (4°C) for further usage. Sesame seeds were roasted at 150°C for 5 mins (Roastech, Bloemfontein, South Africa) at 240 rpm speed until the lightly browned colour was obtained for all the batches. All roasted samples were allowed to cool to room temperature. The roasted sesame seeds were then milled into flour (using Hammer milled with 500-micron sieve size). The flour was defatted using normal hexane and the defatting procedure was carried out three times. The fat content was determined (2.51%) after defatting. The roasted defatted sesame seed flour was packaged in a polyethylene bag and stored at refrigeration temperature (4°C) for further usage.

2.3 Samples formulation

The malted amaranth flour and roasted defatted sesame seed flour were blended at different ratios (95% malted amaranth flour: 5% roasted defatted sesame seed flour, 85% malted amaranth flour: 15% roasted defatted sesame seed flour, 75% malted amaranth flour: 25% roasted defatted sesame seed flour, and 50% malted amaranth flour: 50% roasted defatted sesame seed flour). Unmalted amaranth flour served as the control sample.

2.4 Proximate composition and energy value

The samples were analysed for moisture content, crude fat, crude protein, ash content, crude fibre, and carbohydrate content based on the method of analysis of the Association of Official Analytical Chemists (AOAC, 2005a). The energy value was calculated using the formula

Energy = (Protein x 4 + Fat x 9+ Carbohydrate x 4) in kcal/100 g

2.5 Functional properties

2.5.1 Water absorption capacity

The water absorption capacity (WAC) of the flour blends was determined by the modified method of Bamidele *et al*. (2015). Exactly 2 g of the flour blend (W_1) was measured into a centrifuge tube and 30 mL of hot water was added at 70°C. The formed slurry was vortexed for 10 mins and allowed to rest for 10 mins. The suspension was centrifuged at 4100×*g* for 15 mins at 25°C. The supernatant was decanted and the tube containing the residue was weighed (W_2).

$$\text{Water absorption capacity (\%)} = \left(\frac{W_2\text{-}W_1}{\text{Weight of the samples}}\right)$$

2.5.2 Swelling capacity

The swelling capacity of the flour blend was determined by the modified method of Bamidele *et al.* (2015). Exactly 2 g of the flour blend was weighed into the centrifuge tube and 30 mL of water was added. The formed slurry was then heated at 70°C for 15 mins in a water bath (Orbita shaking water bath, Thomas scientific, South Africa). The cooled slurry was placed in a centrifuge at 4100×*g* for 15 mins (BOSCH L50) at 25° C. The supernatant was decanted and the centrifuge tube that contained the residue alone was dried in a hot air

oven (50°C) for 30 mins to remove any water present in the tube and weighed.

2.5.3 Bulk density

The bulk density (BD) of the flour blend was determined by the modified method of Bamidele *et al.* (2015). Exactly, 10 g of the sample was weighed into a 25 mL graduated cylinder, the cylinder was gently tapped on the laboratory bench until no change in volume. The final volume of the sample was recorded and the difference in the initial volume and the final volume was determined and expressed as the bulk density in g/mL.

2.5.4 Oil absorption capacity

The oil absorption capacity of the samples was determined by the method described by Beuchat (1977) with slight modifications. Approximately 1 g (W_1) of the sample was weighed into a previously weighed centrifuge tube (40 ml in volume) and 10 mL of Gino oil was added to the sample in the tube (W_2) in triplicate. The sample was vortexed and allowed to stand for 10 mins at room temperature, centrifuged at 30000 × *g* for 30 mins (BOSCH L50). The oil phase was carefully decanted, and the tube was allowed to drain at a 45° angle for 10 mins and then weighed (W_3). Oil absorption was expressed as a percentage of the weight of oil absorbed by the sample.

$$\text{Oil absorption capacity (\%)} = \left(\frac{W_3\text{-}W_2}{W_1}\right)$$

2.6 Pasting characteristics

Pasting characteristics of the samples were obtained according to the modified method described by Folasade Maria *et al*. (2018). The pasting profile was studied using a Rapid Visco Analyzer (RVA, Model 3D, Newport Scientific-Warriewood, Australia), the sample (3 g) was collected and 25 mL of distilled water was dispensed into a canister. A paddle is placed inside the canister and inserted into the RVA machine. A measurement cycle is initiated by pressing the motor tower of the instrument and 12 mins profile was used. The time-temperature regime was idle at 50°C for 1 min, heated 50-90°C for 3 mins, 45 s, and then held at 95°C for 2.5 mins. The sample was cooled to 50°C for 3 mins, 45 seconds followed by 2 mins where the temperature is maintained at 50°C. The pasting characteristics indicated the minimum temperature to cook a sample.

2.7 Soluble and insoluble dietary fibre determination

Dietary fibre was determined with Megazyme Kit (K -TDFR) according to AOAC 991.43 method (AOAC, 2005b). The flour sample (1 g) was dissolved in 40 mL of mes-tris (pH 8.2, 0.05 M) buffer solution containing thermostable α-amylase (*Bacillus licheniformis*) at 100° C. Protease (*Subtilisin A* from *B. licheniformis*) enzyme was used to solubilize protein. Amyloglucosidase (*Aspergillus niger*) enzyme was used to hydrolyse starch fragments to glucose. The flour sample and enzyme mixture were filtered, and the residue was washed with ethanol and acetone to obtain the insoluble dietary fibre (IDF) portion. Four volumes of ethanol were added to the filtrate at 60°C to precipitate the SDF and it was allowed to stand for 1 hr. after filtration. The soluble dietary fibre (SDF) residues were washed with ethanol at 78 and 95% (v/v) and then washed with acetone. The IDF and SDF residues were dried overnight at 100°C. The SDF and IDF residues were corrected for protein and ash for the final calculation of the SDF and IDF values.

2.8 Amino acid determination

The amino acid composition of the sample was determined according to the method described by Gbadamosi *et al.* (2012) Amino acid analyser S433 (SYKAM, Erasing, Germany) was used. The sample was lyophilized and hydrolysed with 6N HCl at 110°C for 24 hrs. After hydrolysis, the sample was frozen in sodium citrate buffer at pH 2.2. When ready for analysis, the 50 µL hydrolysate was injected directly into the analyser. Tryptophan was measured individually by hydrolysing the sample with sodium hydroxide. Sistine and methionine were measured after oxidizing the performic acid before being hydrolysed with 6N HCl and measured as cystic acid and methionine sulphate, respectively.

2.9 Estimated glycaemic index

The estimated glycaemic index was determined by the method of Goñi *et al.* (1997) after the kinetics of starch hydrolysis using the following equation below:

$$C = C\infty\,(1 - e^{-k1})$$

Where C = is the concentration of starch hydrolysed at time t. C∞ = percentage (%) starch hydrolysed after 180 min, and k = digestibility rate constant (min^{-1}) at time t.

The equation by Jaisut *et al*. (2008) was used to calculate the area under the curve (AUC).

$$AUC = C\infty\,(tf - t0) - \left(\frac{C\infty}{K}\right)(1 - \exp(-K\,(tf - t0)))$$

The glycaemic index was then estimated using the equation:

$$EGI = 39{:}71 + 0{:}549HI$$

Where EGI is the estimated glycaemic index and HI is the hydrolysis index.

2.10 Mineral analysis

The selected mineral elements were determined by the nuclear absorption spectrophotometry method (AOAC, 2005a). The flour sample (0.5 g) was weighed into a 75 mL digestion flask and 5 mL of the digestion mixture was added and left in a hood overnight. It was then digested at 150°C for 2 hrs, then left to cool for 10 mins. Add about 3 mL of 6 M hydrochloric acid and digest for another hour and a half. It was then cooled, and 30 mL of distilled water was added. The tube was rigidly stirred. The sample aliquot was transferred to a self-analyser (Technicon AAU model) at 420 nm for total mineralization analysis. Residual digestion was used to determine other elements (calcium, iron, lead, phosphorus, and magnesium) in a nuclear absorption spectrophotometer (Perkin Elmer, model 402), while sodium and potassium were determined by flame geometry.

2.11 Anti-nutritional composition

2.11.1 Determination of phytate

Phytate content in flour mixes was determined using the method described by Maga, (1982). Approximately 2 g of flour mixture was soaked in 20 mL 0.2 N HCL and filtered. After distillation, 0.5 mL of filtrate was mixed with 1 mL of ferrous and ammonium sulphate solution, boiled in a water bath for 30 min, cooled on ice for 15 mins, and centrifuged for 15 mins at 3000 rpm. The 1 mL supernatant was once mixed with 1.5 mL of 2,2-pyridine solution and the optical density was measured at 519 nm on a spectrophotometer. Phytic acid concentrations were obtained by extracting the standard curve.

2.11.2 Determination of oxalate

The method of AOAC (2005a) was used to determine the oxalate content of the flour samples. The flour sample (1 g) was once weighed into a hundred ml conical flask, 75 mL of 3M H_2SO_4 was added, and the solution was cautiously stirred intermittently with a magnetic stirrer for about 1 hr and then filtered with Whatman No. 1 filter paper. The sample filtrate (extract; 25 mL) was once amassed and titrated towards warm (80 -90°C) 0.1 N $KMnO_4$ solution to the point when a faint pink shade appeared that continued for at least 30 s. The oxalate content in each sample was once acquired from the calculation:

1 mL 0.1 permanganate = 0.006303 g oxalate

2.12 Statistical analysis

All analyses were performed in replicate. Analysis of variance (ANOVA) was performed on each of the results and the least significant difference (LSD) test at a significant level of $P < 0.05$ was performed using SPSS/16 software to compare the effects of the flour blends on various parameters.

3. Results and discussion

3.1 Proximate composition

The proximate analysis of the flour samples is shown in Table 1. The moisture content of all flour samples including the composite flours showed no significant difference and was about 8% moisture content indicating the flours are at a safe moisture level. The protein content significantly increased by 15% in malted amaranth flour, and this decreased with an increase in the percentage addition of roasted sesame seed flour. The crude fat and ash contents of the flour blends significantly ($p < 0.05$) increased in malted amaranth flour and with an increase in the addition of a percentage of roasted defatted sesame seed flour. Although the crude fibre content of the malted amaranth flour slightly increased with an increase in addition to the percentage of roasted sesame flour, the carbohydrate content showed a slight decrease upon the addition of the roasted sesame flour. However, the calorific values slightly increased with the addition of roasted sesame seed flour to the malted amaranth flour.

The increase reported in protein content was similar to the report of malted sorghum. Malting may offer a means by which to improve the quality and digestibility of protein in grains such as amaranth and sorghum due to the increases in the amylase activity and amount of free nitrogen (Limami *et al.,* 2002; Martínez-Villaluenga, Peñas and Hernández-Ledesma, 2020). The decrease in the crude protein of the samples upon addition of roasted sesame flour to the malted amaranth flour may be attributed to the percentage of substitution of roasted sesame seed flour into malted amaranth flour. In roasted sesame seed flour, the protein content may have decreased due to the reaction between free amino acids and the sugar aldehyde group forming an insoluble brown polymer called melanoidins (Pérez-Burillo *et al*., 2020). The increase in crude fat, ash, and crude fibre in the composite flour may also be due to the addition of roasted sesame seed flour which has been reported to be rich in fat, ash, and crude fibre (Abdualrahman and Ali, 2012).

3.2 Functional properties

Table 2 shows the functional properties of the flour blends. The water absorption capacity (WAC), oil absorption capacity (OAC), and swelling capacity (SC) increased with an increase in the percentage of roasted defatted sesame seed flour added to malted amaranth flour. In WAC, the control sample (untreated amaranth

Table 1. Proximate composition of amaranth and sesame flour blends (%) and energy value

Samples	Moisture	Crude Protein	Crude Fat	Ash	Crude Fibre	Carbohydrate	Energy (kcal/100 g)
100% Unmalted Amaranth	8.24±0.2^{a}	11.74±0.3^{a}	7.77±0.2^{a}	1.81±0.1^{a}	5.34±0.1^{a}	65.19±0.2^{e}	377.13±1.1^{c}
100% Malted Amaranth	8.35±0.1^{a}	13.55±0.1^{d}	8.67±0.2^{b}	3.32±0.2^{b}	5.54±0.1^{b}	60.57±0.7^{d}	374.43±1.1^{a}
95% MA: 5% RS	8.37±0.1^{a}	13.14±0.1^{c}	9.06±0.1^{c}	3.41±0.1^{b}	5.68±0.2^{b}	60.34±0.1^{c}	375.38±1.3^{b}
85% MA: 15% RS	8.46±0.1^{a}	12.94±0.1^{b}	9.15±0.1^{c}	3.50±0.1^{c}	5.97±0.1^{b}	59.98±0.1^{b}	373.99±1.4^{b}
75% MA: 25% RS	8.65±0.2^{a}	12.67±0.2^{b}	9.53±0.1^{d}	3.52±0.1^{c}	5.98±0.1^{b}	59.65±0.1^{b}	374.85±1.2^{a}
50% MA: 50% RS	8.76±0.1^{a}	12.44±0.1^{a}	9.86±0.1^{e}	3.70±0.1^{d}	6.06±0.2^{b}	59.18±0.5^{a}	375.10±1.3^{b}

Values with different superscript within the same column are significantly different ($p < 0.05$) using the least significant difference (LSD). MA: Malted amaranth, RS: Roasted sesame seed.

Table 2. Functional properties of amaranth and sesame flour blends (mg/mL)

Samples	Water Absorption Capacity	Oil Absorption	Swelling Capacity	Bulk Density
100% Unmalted Amaranth	1.61±0.1^{a}	1.91±0.1^{b}	2.52±0.1^{a}	0.93±0.01^{b}
100% Malted Amaranth	1.97±0.1^{b}	2.12±0.3^{a}	2.75±0.1^{b}	0.90±0.01^{b}
95% MA: 5% RS	2.93±0.2^{c}	2.91±0.1^{b}	3.25±0.1^{c}	0.86±0.01^{b}
85% MA: 15% RS	3.79±0.1^{d}	3.02±0.2^{c}	4.12±0.1^{d}	0.84±0.01^{a}
75% MA: 25% RS	4.73±0.2^{e}	3.52±0.1^{d}	5.78±0.1^{e}	0.82±0.01^{a}
50% MA: 50% RS	5.54±0.2^{f}	3.75±0.1^{e}	6.54±0.1^{f}	0.79±0.01^{a}

Values with different superscript within the same column are significantly different ($p < 0.05$) using the least significant difference (LSD). MA: Malted amaranth, RS: Roasted sesame seed.

flour) had the least value (1.61 mg/mL), followed by 100% malted amaranth flour (1.97 mg/mL) and the WAC significantly ($p < 0.05$) increased with an increase in the addition of roasted sesame flour to the malted amaranth flour Malted amaranth (50%) and sesame seed flour (50%) blends had the highest WAC (5.54 mg/mL). The oil absorption capacity and swelling capacity also showed a significant ($p < 0.05$) increase in values with an increase in the addition of roasted defatted sesame seed flour to the malted amaranth flour. The composite flour had an increase of about 37 to 78% in OAC and 18 to 137% in SC with increased addition of roasted defatted sesame flour. The bulk density showed a slight reduction with an increase in the addition of roasted defatted sesame seed flour to the malted amaranth flour.

The increase in values of WAC, OAC, and SC may be attributed to the modification of malting and roasting on the components such as starch, protein, and fibres in the flour blend. As earlier mentioned, the malting of amaranth seed increases the protein content by the metabolism of nitrogenous compounds from the reserved carbohydrates, this may help in water absorption of the flour (Limami *et al.,* 2002). Fibre may also contribute to an increase in water absorption capacity, oil absorption capacity, and swelling capacity of processed and raw flour by absorbing water and oil (Elleuch *et al.,* 2007). Fibres (dietary fibre) are known for their bulkiness and low digestibility which may help in water and oil retention (Adams *et al.*, 2018). The slight decrease in the bulk density may be due to the particle size of the flour blend.

3.3 Pasting properties of the flour blend

The pasting properties of the flour blends are shown in Table 3. The first peak viscosity of the unmalted amaranth flour was the highest at 5.63 mins (112.67 RVU) while malted amaranth had 102.25 RVU, the peak viscosity significantly ($p < 0.05$) decreased with the addition of roasted sesame flour in the flour blend and the 50% roasted defatted sesame seed flour had the least value (50.83 RVU) at 6.35 mins. Similarly, the trough and the breakdown viscosity value of all the flour blends significantly ($p < 0.05$) decreased with an increase in the addition of roasted defatted sesame seed flour added to malted amaranth flour. The final viscosity, setback viscosity, and peak time increased with an increase in the addition of roasted defatted sesame flour to malted amaranth flour.

The decrease in the first peak viscosity of the flour blend may be due to differences in size, shape, and amylose content of the starch granules of the flour. Amaranth flour has been reported to have smaller size starch granules and low amylose content (Xia *et al.,* 2015). The highest value for the first peak viscosity observed in the unmalted amaranth flour may be attributed to total carbohydrate in the same which helps in quick water absorption during pasting. The level of carbohydrate content in the samples influences the pasting profile positively.

The addition of roasted defatted sesame seed flour to malted amaranth grain flour reduced the trough and the breakdown viscosity of the flour blend and increased the final viscosity of the flour blends. The decrease in the trough and breakdown viscosity may be attributed to the

Table 3. Pasting properties of processed amaranth and sesame flour blends

Samples	Peak viscosity (RVU)	Through (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak Time (mins)	Pasting Temp. (°C)
100% Unmalted Amaranth	112.67±0.7^{f}	62.83±0.3^{e}	49.84±0.1^{c}	226.72±0.7^{e}	163.92±0.4^{c}	5.65±0.2^{a}	92.15±0.7^{c}
100% Malted Amaranth	102.25±0.6^{e}	43.42±0.5^{f}	58.83±0.1^{d}	118.41±0.8^{a}	75.00±0.3^{a}	5.56±0.1^{a}	90.58±0.5^{b}
95% MA: 5% RS	96.08±0.5^{d}	37.42±0.4^{d}	58.66±0.2^{d}	183.30±0.6^{b}	145.91±0.5^{b}	6.15±0.3^{b}	90.76±0.6^{b}
85% MA: 15% RS	74.42±0.3^{c}	30.50±0.6^{c}	43.92±0.2^{b}	193.59±0.7^{c}	163.08±0.6^{c}	6.28±0.3^{b}	90.65±0.7^{a}
75% MA: 25% RS	62.56±0.4^{b}	28.75±0.5^{b}	33.81±0.2^{b}	222.74±0.8^{d}	194.00±0.8^{d}	6.32±0.2^{b}	90.45±0.6^{a}
50% MA: 50% RS	50.83±0.5^{a}	27.25±0.7^{a}	23.58±0.1^{a}	252.19±0.7^{f}	224.92±0.8^{e}	6.45±0.1^{c}	90.37±0.7^{a}

Values with different superscript within the same column are significantly different ($p < 0.05$) using the least significant difference (LSD). MA: Malted amaranth, RS: Roasted sesame seed.

formation of complexes between the leached-out amylose and endogenous lipids in the flour and the increase in the final viscosity may be due to retrogradation of the starch that occurred by the rearrangement of the amylose molecule (da Silva Costa *et al.,* 2020).

3.4 Dietary fibre and glycaemic index of the flour blend

Dietary fibre has an important therapeutic utility in preventing constipation, colon-rectal diseases, diabetes, and obesity and offers protective health benefits (Soliman, 2019). The dietary fibre of the flour blends increases with an increase in the addition of roasted defatted sesame seed flour to malted amaranth flour (Table 4). The addition of the roasted defatted sesame seed flour to malted amaranth flour increased the dietary fibre of the flour blend. The soluble dietary fibre value of the samples increased by about 26 to 123% (1.46 g/100 g to 4.19 g/100 g) and the insoluble dietary fibre value increased by about 36 to 131% with the addition of roasted defatted sesame flour (3.16 g/100 g to 7.78 g/100 g). The increase in the dietary fibre of the flour blends may be due to the addition of roasting of the sesame seed which improves the insoluble dietary fibre such as Uronic acid and Klason lignin. Elleuch *et al.* (2011) reported that processed sesame seeds contain high dietary fibre which can help in combating diet-related non-communicable diseases.

The glycaemic index defines carbohydrates present in different foods based on the postprandial level of blood glucose (Gbenga-Fabusiwa *et al.,* 2019). The estimated glycaemic index of the flour blends was significantly reduced with an increase in the addition of roasted defatted sesame seed flour to malted amaranth grain flour (Table 4). The control sample had the highest value (97.48%) followed by malted amaranth flour (96.56%). The two values (Unmalted and malted amaranth flour) were higher than the value of the white bread (94.67%). The addition of roasted defatted sesame seed flour reduced the estimated glycaemic index from 96.56% (malted amaranth flour) to 47.89% (flour blend with 50% malted amaranth grain flour and 50% roasted defatted sesame seed flour). The reduction could also be attributed to a decrease in the total carbohydrates in the flour (malted amaranth and roasted defatted sesame seed flour) blends.

The high value of the glycaemic index in amaranth grain as being attributed to low resistances starch (0.65%), low amylose, and smaller starch granules which may completely lose their crystallinity in a short period during heating (González *et al.,* 2007). On the contrary, whole sesame seed has been reported to have high dietary fibre which increases when roasted (Elleuch *et al.,* 2011).

3.5 Amino acid profile of the flour blends

Table 5 shows the amino acid profile of the flour blends. The essential amino acid profile of malted amaranth flour was higher than the unmalted amaranth flour and the amino acid profile of the flour blends showed no significant changes, a slight decrease when compared to malted amaranth flour. This may be due to

Table 4. Soluble, insoluble, and glycaemic index of Amaranth and Sesame flour blends (%)

Samples	Soluble Dietary Fibre	Insoluble Dietary Fibre	Glycaemic Index
100% Unmalted Amaranth	1.46±0.02^{a}	3.16±0.01^{a}	97.48±0.7^{b}
100% Malted Amaranth	1.88±0.01^{b}	3.36±0.01^{a}	96.56±0.3^{b}
95% MA: 5% RS	2.36±0.01^{c}	4.44±0.01^{b}	74.56±0.5^{b}
85% MA: 15% RS	2.86±0.01^{d}	5.55±0.01^{c}	55.46±0.4^{b}
75% MA: 25% RS	3.26±0.01^{e}	6.64±0.01^{d}	50.55±0.5^{b}
50% MA: 50% RS	4.19±0.01^{f}	7.78±0.03^{f}	47.89±0.5^{b}

Values with different superscript within the same column are significantly different ($p < 0.05$) using the least significant difference (LSD). MA: Malted amaranth, RS: Roasted sesame seed.

Table 5. Amino acid composition of the composited flour from amaranth grain and sesame seed (mg/100 g)

Amino acid	100% Unmalted Amaranth flour	100% malted Amaranth flour	95% MA: 5% RS	85% MA: 15% RS	75% MA: 25% RS	50% MA: 50 RS	FAO/WHO[#]
Essential Amino Acid							
Histidine	2.77±0.1^{a}	4.70±0.1^{d}	4.40±0.1^{c}	4.32±0.3^{c}	4.21±0.2^{b}	4.14±0.1^{b}	1.50
Lysine	3.45±0.2^{a}	5.59±0.2^{c}	5.22±0.1^{b}	5.15±0.2^{b}	5.04±0.2^{b}	4.96±0.3^{b}	4.50
Tryptophan	5.32±0.2^{c}	5.63±0.2^{d}	5.10±0.2^{b}	5.07±0.1^{b}	4.97±0.2^{a}	4.64±0.4^{a}	1.20
Methionine	1.28±0.1^{a}	3.22±0.1^{b}	3.19±0.1^{b}	3.12±0.1^{b}	3.08±0.2^{b}	2.98±0.1^{b}	2.20
Valine	4.69±0.2^{a}	6.87±0.1^{d}	6.55±0.2^{d}	6.21±0.2^{c}	6.08±0.3^{c}	5.79±0.2^{b}	3.90
Threonine	3.71±0.2^{a}	5.29±0.1^{e}	5.06±0.1^{e}	4.86±0.2^{d}	4.46±0.2^{c}	4.28±0.2^{b}	2.30
Isoleucine	3.62±0.2^{a}	4.95±0.1^{e}	4.46±0.2^{d}	4.27±0.2^{c}	4.09±0.3^{b}	3.89±0.1^{a}	3.00
Leucine	7.54±0.1^{a}	9.65±0.3^{d}	9.24±0.1^{c}	9.20±0.1^{c}	9.01±0.2^{c}	8.79±0.3^{b}	5.90
Phenylalanine	4.59±0.1^{a}	6.55±0.2^{c}	6.30±0.2^{b}	6.23±0.2^{b}	6.14±0.3^{b}	6.02±0.2^{b}	3.80
Total EAA	36.97±0.8^{a}	52.45±0.7^{f}	49.52±0.7^{e}	48.43±0.8^{d}	47.08±0.8^{c}	45.49±0.5^{b}	28.30
Non-essential Amino Acids							
Serine	4.68±0.1^{a}	6.95±0.2^{e}	6.76±0.2^{d}	6.36±0.2^{c}	6.22±0.2^{c}	5.93±0.2^{b}	8.00
Glutamate	18.43±0.3^{a}	20.76±0.5^{d}	19.86±0.6^{c}	19.56±0.5^{c}	19.39±0.4^{b}	19.08±0.5^{b}	15.00
Aspartate	9.28±0.3^{a}	12.29±0.1^{d}	12.02±0.2^{d}	11.82±0.4^{e}	11.56±0.4^{c}	11.33±0.2^{b}	8.00
Alanine	4.33±0.2^{a}	6.27±0.2^{d}	6.14±0.1^{d}	6.04±0.2^{d}	5.47±0.3^{c}	5.17±0.3^{b}	6.10
Arginine	8.54±0.3^{a}	10.60±0.2^{c}	10.43±0.2^{c}	10.27±0.2^{b}	10.15±0.3^{b}	10.04±0.2^{b}	5.20
Tyrosine	3.52±0.2^{a}	7.22±0.1^{d}	7.08±0.3^{d}	7.03±0.2^{d}	6.89±0.1^{c}	6.23±0.2^{b}	3.10
Proline	4.72±0.1^{a}	7.05±0.2^{d}	6.96±0.1^{d}	6.79±0.3^{d}	6.59±0.2^{c}	6.13±0.3^{b}	8.00
Cystine	2.22±0.2^{a}	4.13±0.2^{e}	4.01±0.1^{e}	3.77±0.2^{d}	3.47±0.1^{c}	3.10±0.2^{b}	2.20
Total NEAA	55.72±0.6^{a}	75.27±1.8^{f}	73.26±1.7^{e}	71.64±0.6^{d}	69.74±0.5^{c}	69.01±0.9^{b}	55.60

Values with different superscript within the same column are significantly different ($p < 0.05$) using the least significant difference (LSD). MA: Malted amaranth, RS: Roasted sesame seed, EAA: Essential amino acids, NEAA: Non-essential amino acids.

[#]Source: Joint FAO/WHO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition (2007).

malting which helps to release bond protein by the metabolism of nitrogenous compounds in the food samples. Leucine, phenylalanine, lysine, and tryptophan were among the essential amino acid with high value in the flour blends, and glutamate, aspartate, and arginine were among the non-essential amino acid with high value. Also, the occurrence of the Maillard reaction may lower the amino acid content of the flour due to the interaction with reducing sugar to form brown colour.

The total essential amino acid profile of the flour blends was still higher (52.45, 49.52, 48.43, 47.08) than the daily recommended allowance (RDA) reported by the Food and Agriculture Organization (Joint FAO/ WHO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition, 2007). Also, the total of the non-essential amino acid profile of the flour blends was higher (75.27, 73.26, 71.64, 69.74, and 69.01) than the RDA by FAO. The higher value of the amnio acid profile in this study may be attributed to the cereals which have been reported to be a good source of protein and amino acids (Mota *et al.,* 2016). The amino acid profile of the flour blend is higher than the amino acid of roasted sesame seed flour reported by Makinde and Akinoso, (2014) and lower than the amino acid profile of malted amaranth grain flour reported by Motta *et al.* (2019). The amino acid profile of the flour blends showed that the flour blends may serve as raw materials for making breakfast cereals and other nutrient-dense snacks.

3.6 Mineral content of the flour blends

The mineral composition of the control sample (unmalted amaranth grain flour) was the least among the mineral content of all the flour samples (Table 6). The major elements (Calcium. Potassium, Magnesium, Sodium, and Phosphorous) in the flour blends increase with an increase in the amount of roasted defatted sesame seed flour added to malted amaranth grain flour. Among the major elements determined in the flour blends, Potassium has the highest value (388.86, 392.05, 402.03, 413.11, and 422.24 mg/100 g), followed by Calcium (263.64, 273.73, 294.06, 304.12, and 334.23 mg/100 g). Sodium has the least value (37.45, 46.36, 48.86, 51.13, 53.24, and 54.13 mg/100 g) among the major element determined in the flour blends while Iron (minor element) as the least value (0.29, 0.35, 0.35, 0.36, 0.37 and 0.38 mg/100 g). The increase in the mineral content of the flour blends may be attributed to the processing of the two pseudo-cereal flour (malting and roasting) which may reduce the anti-nutritional factors

Table 6. Mineral Composition (mg/100 g) of Amaranth and Sesame flour blends

Samples	Ca	Fe	Mg	K	Na	P
100% Unmalted Amaranth	242.97±0.1^{a}	0.31±0.00^{a}	224.48±0.5^{g}	345.76±1.3^{a}	39.45±0.4^{a}	119.74±1.3^{a}
100% Malted Amaranth	263.64±0.4^{b}	0.45±0.00^{b}	226.36±0.4^{f}	389.86±1.4^{b}	48.36±0.5^{b}	133.74±1.4^{b}
95% MA: 5% RS	273.73±0.1^{b}	0.45±0.08^{b}	228.06±0.3^{e}	394.05±1.1^{c}	49.86±0.5^{c}	135.59±1.6^{c}
85% MA: 15% RS	294.06±0.5^{c}	0.46±0.00^{b}	230.13±0.3^{c}	415.03±1.6^{d}	53.13±0.3^{d}	139.97±1.5^{d}
75% MA: 25% RS	304.12±0.1^{c}	0.47±0.00^{b}	231.86±0.6^{b}	425.11±1.2^{e}	55.24±0.3^{e}	140.06±1.5^{e}
50% MA: 50% RS	334.23±0.2^{c}	0.48±0.01^{b}	232.56±0.3^{a}	442.24±1.4^{f}	57.13±0.5^{f}	146.24±1.1^{f}

Values with different superscript within the same column are significantly different ($p < 0.05$) using the least significant difference (LSD). MA: Malted amaranth, RS: Roasted sesame seed.

(Phytate, oxalate, and trypsin inhibitor) that could chelate important minerals in the flour blends.

Cereals like amaranth grain and sesame seed are rich in minerals (Alencar and de Carvalho Oliveira, 2019). Processing (malting and roasting) of the raw amaranth and sesame seed before milling will be of great importance to the mineral content of the flour blends. The mineral content obtained in this study is lower than the report of Makinde and Akinoso (2014) on roasted sesame seed, and the reason may be due to roasting conditions and the defatting of the sesame seed flour used in this study. The mineral content of the flour blends is lower than the mineral content of the flour blend (Corn and Amaranth flour) reported by Gebreil *et al.* (2020). The reason may be due to corn grain composited with amaranth grain flour which is higher than sesame seed flour in minerals.

3.7 Anti-nutritional factor of the flour blends

Figure 1 shows the anti-nutritional factor of the flour blends. The phytate and oxalate contents of the unmalted amaranth grain flour were the highest (1580.2 mg/100 g and 258.6 mg/100 g). The phytate and oxalate content of the malted amaranth grain flour was reduced by 63% and 58% respectively. This reduction may be attributed to the effect of malting on the amaranth grains. Malting of grain has been reported to help activate the phytase enzyme which hydrolysed phytate resulting in dephosphorylation of inositol phosphate (Luo *et al.,* 2014) leading to a reduction in phytate content of the malted grain. The oxalate oxidase can also be activated during malting which hydrolysed oxalate to carbon dioxide and hydrogen peroxide (Davoine *et al.,* 2001).

The anti-nutritional factor of the flour blends was reduced with an increase in the percentage of roasted defatted sesame seed flour added to the malted amaranth grain flour. The reduction may be due to the addition of roasted defatted sesame seed flour which contained a lower quantity of phytate and oxalate (Makinde and Akinoso, 2014) when compared with amaranth grain flour. Also, the roasting of the sesame seed before milling reduced the anti-nutritional factor (phytate and oxalate) of the sesame seed (Makinde and Akinoso, 2014). The decrease in the anti-nutritional factor of the flour blend showed that flour can be used as a raw material in making food products.

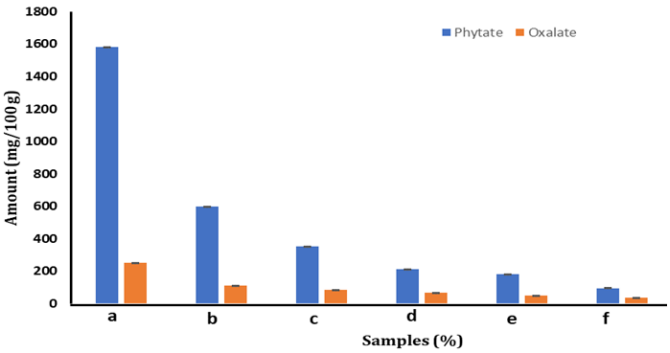

Figure 1. Effect of roasted defatted sesame seed flour on anti-nutritional factors of malted amaranth grain flour. a is 100% Unmalted amaranth flour, b is 100% malted amaranth, c is 95% malted amaranth + 5% roasted sesame seed flour, d is 85% malted amaranth + 15% roasted sesame seed flour, e is 75% and f is 50% malted amaranth + 50% roasted sesame seed flour.

4. Conclusion

Malting and roasting of pseudo cereal amaranth and sesame seeds importantly enhance the nutrition and functionality of the flour blends. The addition of roasted defatted sesame seed flour to malted amaranth flour improved the protein quality and digestibility of starch and non-polysaccharides (fibre) of the flour blends. Also, modified flour blends exhibited higher water and oil absorption and swelling power but lower peak viscosity. The improvement in the dietary fibre low glycaemic index and anti-nutritional factor indicates the flour blends are good ingredients to combat the problem of hunger and protein-energy malnutrition.

Conflict of interest

The authors declared that there is no conflict of interest in the manuscript.

Acknowledgements

The authors would like to appreciate all the people that contributed to the success of this study.

References

Abdualrahman, M.A.Y. and Ali, A.O. (2012). Effect of full and partial substitution of sesame seeds with bambara groundnuts and peanuts on the quality of sudanese traditional food (Khemiss-tweria). *America Journal of Food Technology*, 18(1),32-40. https://doi.org/10.3923/ajft.2012.398.408

Abu-Jdayil, B., Al-Malah, K. and Asoud, H. (2002). Rheological characterization of milled sesame (tehineh). *Food Hydrocolloid*, 16(1), 55-61. https://doi.org/10.1016/S0268-005X(01)00040-6

Adams, S., Sello, C.T., Qin, G.X., Che, D. and Han, R. (2018). Does dietary fiber affect the levels of nutritional components after feed formulation? *Fibers*, 6(2),29. https://doi.org/10.3390/fib6020029

Alencar, N.M.M. and de Carvalho Oliveira, L. (2019). Advances in Pseudocereals: Crop Cultivation, Food Application, and Consumer Perception. In Mérillon, J.M. and Ramawat, K. (eds,) Bioactive Molecules in Food, p. 1695-1713. Reference Series in Phytochemistry. Cham, Netherlands: Springer. https://doi.org/10.1007/978-3-319-78030-6-63

AOAC (Association of Official Analytical Chemistry). (2005a). Official methods of Analysis. 16th ed. Virginia, Arlington, USA: Association of Official Analysis Chemists International.

AOAC (Association of Official Analytical Chemistry). (2005b). Official Methods of Analysis of AOAC International. Virginia, Arlington, USA: Association of Official Analysis Chemists International.

Bamidele, O.P., Fasogbon, M.B., Oladiran, D.A. and Akande, E.O. (2015). Nutritional composition of fufu analog flour produced from Cassava root (*Manihot esculenta*) and Cocoyam (*Colocasia esculenta*) tuber. *Food Science and Nutrition*, 3(6), 597–603. https://doi.org/10.1002/fsn3.250

Beuchat, L.R. (1977). Functional and Electrophoretic Characteristics of Succinylated Peanut Flour Protein. *Journal of Agriculture and Food Chemistry*, 25(2), 258-261. https://doi.org/10.1021/jf60210a044

Capriles, V.D. Coelho, K.D. Guerra-Matias, A.C. and Arêas, J.A.G. (2008). Effects of processing methods on amaranth starch digestibility and predicted glycemic index. *Journal of Food Science,* 73(7), H160-H164. https://doi.org/10.1111/j.1750-3841.2008.00869.x

da Silva Costa, R.A., Bonomo, R.C.F., Rodrigues, L.B., Santos, L.S. and Veloso, C.M. (2020). Improvement of texture properties and syneresis of arrowroot (*Maranta arundinacea*) starch gels by using hydrocolloids (guar gum and xanthan gum). *Journal of the Science of Food and Agriculture,* 100(7), 3204-3211. https://doi.org/10.1002/jsfa.10356

Davoine, C., Le Deunff, E., Ledger, N., Avice, J.C., Billard, J.P., Dumas, B. and Huault, C. (2001). Specific and constitutive expression of oxalate oxidase during the ageing of leaf sheaths of ryegrass stubble. *Plant, Cell Environment*, 24(10), 1033-1043. https://doi.org/10.1046/j.1365-3040.2001.00757.x

Elleuch, M., Bedigian, D. and Zitoun, A. (2011). Sesame (*Sesamum indicum L.*) Seeds in Food, Nutrition, and Health. In Preedy, V.R., Watson, R.R. and Patel, V.B. (Eds.) Nuts and Seeds in Health and Disease Prevention, p. 1029-1036. USA: Academic Press. https://doi.org/10.1016/B978-0-12-375688-6.10122-7

Elleuch, M., Besbes, S., Roiseux, O. Blecker, C. and Attia, H. (2007). Quality characteristics of sesame seeds and by-products. *Food Chemistry,* 103(2), 641-650. https://doi.org/10.1016/j.foodchem.2006.09.008

Folasade Maria, M., Tolulope Victoria, A., Author, C. and Maria, F. (2018). Changes in Nutritional, Functional and Pasting Properties of Raw and Germinated Seeds of White Sesame (*Sesamum indicum L.*) Grown in Nigeria. *Acta Scientific Nutritional Health,* 2(11), 7-15

Gbadamosi, S.O., Abiose, S.H. and Aluko, R.E. (2012). Amino acid profile, protein digestibility, thermal and functional properties of Conophor nut (*Tetracarpidium conophorum*) defatted flour, protein concentrate and isolates. *International Journal of Food Science and Technology,* 47(4), 731-739. https://doi.org/10.1111/j.1365-2621.2011.02901.x

Gbenga-Fabusiwa, F.J., Oladele, E.P., Oboh, G., Adefegha, S.A., Fabusiwa, O.F., Osho, P.O., Enikuomehin, A. and Oshodi, A.A. (2019). Glycemic Response in Diabetic Subjects to Biscuits Produced from Blends of Pigeon Pea and Wheat Flour. *Plant Foods and Human Nutrition,* 74(4), 553-559. https://doi.org/10.1007/s11130-019-00758-2

Gebreil, S.Y., Ali, M.I.K. and Mousa, E.A.M. (2020). Utilization of Amaranth Flour in Preparation of High Nutritional Value Bakery Products. *Food Nutrition Sciences*, 11, 336-354. https://doi.org/10.4236/fns.2020.115025

Gilani, G.S., Xiao, C.W. and Cockell, K.A. (2012). Impact of anti-nutritionalfactors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. *British Journal of Nutrition*, 108(S2), S315-S332. https://

doi.org/10.1017/S0007114512002371

Goñi, I., Garcia-Alonso, A. and Saura-Calixto, F. (1997). A starch hydrolysis procedure to estimate glycemic index. *Nutrition Research,* 17(3), 427-437. https://doi.org/10.1016/S0271-5317(97)00010-9

González, R., Tosi, E., Ré, E., Añón, M.C., Pilosof, A.M.R. and Martinez, K. (2007). Amaranth starch-rich fraction properties modified by high-temperature heating. *Food Chemistry,* 103(3), 927-934. https://doi.org/10.1016/j.foodchem.2006.09.046

Jaisut, D., Prachayawarakorn, S., Varanyanond, W., Tungtrakul, P. and Soponronnarit, S. (2008). Effects of drying temperature and tempering time on starch digestibility of brown fragrant rice. *Journal of Food Engineering,* 86(2), 251-258. https://doi.org/10.1016/j.jfoodeng.2007.10.002

Joint FAO/WHO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition, Food and Agriculture Organization of the United Nations, World Health Organization and United Nations University. (2007). Protein and amino acid requirements in human nutrition : report of a joint FAO/WHO/UNU expert consultation. Geneva, Switzerland: World Health Organization. https://apps.who.int/iris/handle/10665/43411

Limami, A.M., Rouillon, C., Glevarec, G., Gallais, A. and Hirel, B. (2002). Genetic and physiological analysis of germination efficiency in maize in relation to nitrogen metabolism reveals the importance of cytosolic glutamine synthetase. *Plant Physiology,* 130(4), 1860-1870. https://doi.org/10.1104/pp.009647

Maga, J.A. (1982). Phytate: Its Chemistry, Occurrence, Food Interactions, Nutritional Significance, and Methods of Analysis. *Journal of Agricultural and Food Chemistry,* 30(1), 1-9. https://doi.org/10.1021/jf00109a001

Makinde, F.M. and Akinoso, R. (2014). Comparison between the nutritional quality of flour obtained from raw, roasted and fermented sesame (*Sesamum Indicum L.*) seed grown in Nigeria. *Acta Scientiarum Polonorum, Technologia Alimentaria*, 13(3), 309-319. https://doi.org/10.17306/J.AFS.2014.3.9

Manyelo, T.G., Sebola, N.A., van Rensburg, E.J. and Mabelebele, M. (2020). The Probable Use of Genus amaranthus as Feed Material for Monogastric *Animals. Animals*, 10(9), 1504. https://doi.org/10.3390/ani10091504

Mota, C., Santos, M., Mauro, R., Samman, N., Matos, A.S., Torres, D. and Castanheira, I. (2016). Protein content and amino acids profile of pseudocereals. *Food Chemistry*, 193, 55-61. https://doi.org/10.1016/j.foodchem.2014.11.043

Motta, C., Castanheira, I., Gonzales, G.B., Delgado, I., Torres, D., Santos, M. and Matos, A.S. (2019). Impact of cooking methods and malting on amino acids content in amaranth, buckwheat and quinoa. *Journal of Food Composition and Analysis*, 76, 58-65. https://doi.org/10.1016/j.jfca.2018.10.001

Myint, D., Gilani, S.A., Kawase, M. and Watanabe, K.N. (2020). Sustainable sesame (*Sesamum indicum L.*) production through improved technology: An overview of production, challenges, and opportunities in Myanmar. *Sustain,* 12(9), 3515. https://doi.org/10.3390/SU12093515

Najdi Hejazi, S. and Orsat, V. (2017). Optimization of the malting process for nutritional improvement of finger millet and amaranth flours in the infant weaning food industry. *International Journal Food Science and Nutrition*, 68(4), 429-441. https://doi.org/10.1080/09637486.2016.1261085.

Pérez-Burillo, S., Rajakaruna, S., Pastoriza, S., Paliy, O. and Rufián-Henares, J.Á. (2020). Bioactivity of food melanoidins is mediated by gut microbiota. *Food Chemistry*, 316, 126309. https://doi.org/ 10.1016/j.foodchem.2020.126309.

Rodríguez, J.P., Rahman, H., Thushar, S. and Singh, R.K. (2020). Healthy and Resilient Cereals and Pseudo-Cereals for Marginal Agriculture: Molecular Advances for Improving Nutrient Bioavailability. *Frontiers in Genetics,* 11, 49. https://doi.org/10.3389/fgene.2020.00049

Soliman, G.A. (2019). Dietary fiber, atherosclerosis, and cardiovascular disease. *Nutrients*, 11(5), 1155. https://doi.org/10.3390/nu11051155

van Boekel, M., Fogliano, V., Pellegrini, N., Stanton, C., Scholz, G., Lalljie, S., Somoza, V., Knorr, D., Jasti, P.R. and Eisenbrand, G. (2010). A review on the beneficial aspects of food processing. *Molecular Nutrition and Food Research,* 54(9), 1215-1247. https://doi.org/10.1002/mnfr.200900608

Xia, X., Li, G., Liao, F., Zhang, F., Zheng, J. and Kan, J. (2015). Granular structure and physicochemical properties of starches from amaranth grain. *International Journal of Food Properties*, 18(5), 1029-1037. https://doi.org/10.1080/10942912.2013.860168

Zouari, R., Besbes, S., Ellouze-Chaabouni, S. and Ghribi -Aydi, D. (2016). Cookies from composite wheat-sesame peels flours: Dough quality and effect of Bacillus subtilis SPB1 biosurfactant addition. *Food Chemistry,* 194, 758-769. https://doi.org/10.1016/j.foodchem.2015.08.064

