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Research Article

Changes in Nutritional, Functional and Pasting Properties of Raw and Germinated Seeds of White Sesame (*Sesamum indicum* L.) Grown in Nigeria

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Abstract

Nigerian sesame (*Sesamum indicum*) seed is ideally suited for good health because it contains plethora of nutrients viz., lipid, protein, carbohydrate, minerals, antioxidants, lignans, tocopherols and other micronutrients. Germination could enhance improvement in its nutritional quality which provides further benefits in its use as an ingredient in food applications. The present study was carried out to evaluate the effect different time of germination on the chemical, mineral bioavailability, functional and pasting properties of sesame seeds. White sesame seeds were soaked in water (1: 5 w/v) for 4 h and germinated in wet jute bag for 0, 24, 48, 72 and 96 h respectively. After germination, sprouts were dried with air at 40oC for 18 h and analyzed for chemical, mineral bioavailability, functional and pasting properties. Germination process caused significant ($p \leq 0.05$) increases in moisture, protein, ash and fiber; however, oil content and carbohydrate values significantly decreased. Mineral concentrations of sprouts were higher than in raw seeds and anti-nutrient factors (phytate, oxalate and tannin) were lost during germination. Consequently, germination influenced the bioavailability of mineral elements. Swelling capacity, pH, gelation capacity, and water absorption capacity and oil absorption capacity values ranged between 1.54 to 1.84%, 6.27 to 6.60, 16.00 to 18.00%, 0.87 to 1.01 mL/g and 0.66 to 0.93 mL/g respectively for sesame flour samples. There were significant differences ($p \leq 0.05$) in peak, trough, breakdown, final and setback viscosities of samples. The samples had peak time in a range of 6.54 to 7.00 min with constant pasting temperature of 95oC. Nutritional, functional and pasting properties of germinated sesame flours indicated improved food quality and their suitability for various food formulations.

Keywords: Germination; Sesame; Nutrient; Anti Nutritional Factors; Functionality

Introduction

The growing concern about a healthier life style and healthy foods has necessitated the food industries to utilize indigenous food to create new products. In essence, various processing technologies have helped in transforming food ingredients into healthier products with maximum nutritional value to ensure nutrient security of the population in developing countries [1]. Such techniques include germination, a complex metabolic process during which the lipids, carbohydrates and storage proteins within the seeds are broken down in order to provide energy and amino acids necessary for the plant development [2]. The process has been reported to cause the most significant reduction in anti-nutrients possibly due to increase in enzymatic activity and bioactive compounds within the seeds [3]. Likewise, the metabolic changes that take place during the different stages of germination influence the bioaccessibility of essential nutrients. However, the germination time is a relevant factor and could interfere in germination process [4]. Although exist numerous studies about the nutritional characteristics of seeds germination, there is paucity of information on sesame seeds grown in Nigeria, where its consumption has been intensifying due to the high cost of animal protein.

Sesame (*Sesamum indicum* Linn) is an erect tropical flowering plant in the family *Pedaliaceae*. It is one of the most important oil

seed crops worldwide, and has been cultivated in Africa, Middle East, and Asia since ancient times [5]. Sesame seed production in Nigeria is ranked second in Africa and fifth in the world with an estimated production of 120 million tons annually as at 2013 [6]. The chemical composition of sesame shows that the seed is an important source of oil (44 - 58%), protein (18 - 25%), carbohydrate (~13.5%) and ash (~5%) as reported by Borchani., *et al.* [7]. Sesame contains important minerals and vitamins such as calcium, phosphorus, and iron, niacin and thiamine [8]. It has also some potential of nutraceutical compounds such as phenolic and tocopherols with antioxidant activity that have significant effect on reducing the blood pressure, lipid profile and degeneration of vessels and an impact in reducing chronic diseases [9]. On the other hand, sesame seed contains chemical components such as anti-nutritional factors such as phytate, trypsin, α-amylase inhibitors, lectin, and tannins which limit its utilization in the food systems.

Aside the improvement of nutritional quality of food materials as a result of germination; the process may alter their compositions and may therefore change the functional properties and pasting characteristics of the final product. Therefore, the objective of the study was to evaluate the effect of germination time on the nutritional, functional and pasting properties of Nigeria grown sesame seeds.

Materials and Methods

Sample materials

The most frequently used sesame variety in Nigeria was selected for this study. White variety sesame seeds were purchased from an open market in Ibadan, Oyo State, Nigeria.

Preparation of germinated sesame seed

The mature, dry sesame seeds were sorted to remove infested seeds. The whole sesame seeds were dehulled by soaking in water (1:5 w/v) ratio for 4 h at temperature of 29 ± 2°C according to the method of Mohamed., *et al*. [10]. The ruptured seed coats were then removed by rubbing with palms and washing with water. The dehulled seeds were then soaked for 2 h to achieve hydration then rinsed, drained and spread thinly on jute and germinated at room temperatures (32 ± 2°C) for 0, 24, 48, 72 and 96 h according to Olagunju., *et al*. [11]. The germination process was closely monitored to prevent discontinuity of germination and mould growth which was achieved by constant wetting and intermittent uniform spreading of sprouts. The sprouts were thoroughly rinsed with water; drained, derooted, and dried in a hot air oven at 40°C to a constant weight. The dried samples were milled into flour using laboratory mill (Braun-KMM 30) and sieved using a 60 mm mesh. The flour obtained was packed in a glass container and stored in refrigerator maintained at 8°C prior to use.

Chemical analyses

Determination of proximate composition

Standard methods of AOAC [12] were used to determine moisture, fat, protein, ash and fiber. Carbohydrate content was determined by difference. The energy value was estimated (kJ/g) by multiplying the percentage crude protein, crude lipid and carbohydrate by the Atwater's conversion factors; 16.7 kJ/g for protein, 37.4 kJ/g for fat and 16.7 kJ/g for carbohydrate [13]. All analyses were carried out in triplicate.

Determination of mineral concentration

Ash was determined by combustion of the sample in a muffle furnace at 550°C for 12 h [12]. The residue was dissolved in HNO_3 with 50 g/L of LaCl3 and the mineral constituents (Ca, K, Mg, Fe and Zn) were analyzed separately, using an atomic absorption spectrophotometer (Hitachi Z6100, Tokyo, Japan). Phosphorus content (P) was determined by the Phosphomolybdate method [12].

Determination of anti- nutritional compounds

Phytate content

The phytate content of the flours was determined using method described by Oladele., *et al* [14]. Two grams of each finely ground floor sample was soaked in 20mL of 0.2N HCl and filtered. After filtration, 0.5 mL of the filtrate was mixed with 1 mL ferric ammonium sulphate solution in a test tube, boiled for 30 minutes in a water bath, cooled in ice for 15 minutes and centrifuged at 3000 rpm for 15 minutes. One millilitre of the supernatant was mixed with 1.5 mL of 2, 2-pyridine solution and the absorbance measured in a spectrophotometer at 519 nm. The concentration of phytic acid was obtained by extrapolation from a standard curve using standard phytic acid solution.

Oxalate content

The titration method described by Oladele., *et al*. [14] was used to determine the oxalate content. One gram of the sample was

weighed into 100 mL conical flask, 75 mL 3N H_2SO_4 was added and stirred intermittently with a magnetic stirrer for 1h. It was then filtered using Whatman No.1 filter paper. From the filtrate, 25 mL was taken and titrated while hot (80 - 90°C) against 0.1N $KMnO_4$ solution until a faint pink colour persisted for at least 30 sec.

Tannin content

Tannin content was determined by the method described by Mugaboa., *et al*. [15]. One gram of sample was dispersed in 10mL distilled water and agitated. This was left to stand for 30 min at room temperature (20 ± 2°C), after which it was centrifuged to get the extract. About 2.5 mL of the supernatant (extract) was pipetted into a 50 mL volumetric ask. Similarly, 2.5 mL of standard tannic acid solution was pipetted into a separate 50 mL flask. One millilitre of Folin-Denis reagent was measured into each flask, followed by 2.5 mL of saturated Na_2CO_3 solution. The mixture was made up to mark in a 50 mL flask and incubated for 90 minutes at room temperature. The absorbance was measured at 250 nm with a spectrophotometer (Genway model 6000).

Mineral bioavailability determination

Bioavailability of mineral element was calculated as reported by Woldegiorgis., *et al.* [16]. The molar ratio between anti-nutrient and mineral was obtained after dividing the mole of anti-nutrient with the mole of mineral. The mole of phytic acid was calculated as measured value of phytic acid divided by molecular weight of phytic acid (660) whereas, the mole of mineral (Ca, Mg, K, Fe or Zn) was calculated as measured value of the mineral divided by individual mineral molecular weight (Fe: 55.85, Zn: 65.38, Ca: 40.08, Mg: 24.31, K: 39.10).

Determination of functional properties

The pH of the sample was determined by method described by Onwuka [17]. The loose and packed densities were determined using the method of Ikpeme., *et al.* [18]. The swelling capacity was determined by the method described by Akpada and Miachi [19]. Water and oil absorption properties of the cashew flour were determined following methods of Adebayo., *et al.* [20] with slight modifications. Flour sample (1g) was mixed with 10 mL distilled water for water absorption and 10mL of oil for oil absorption in a blender at high speed for 30 sec. Samples were allowed to stand for 30 minutes at room temperature then centrifuged (Uniscope, England) at 2000 rpm for 30 minutes. The volume of supernatant in a graduated cylinder was noted. Density of water was taken to be 1 g/mL and that of oil was determined to be 0.993 g/mL. Least gelation capacity was determined by the method of Coffman and Gracia [21].

Determination of pasting properties

The pasting properties of sesame samples were analyzed on a Rapid Visco Analyzer instrument (Model: RVA-4, Newport Scientific Pty. Ltd., Sydney, Australia, 1995) and Thermocline for windows software was used to evaluate the pasting properties. Parameters recorded were peak viscosity (PV), trough viscosity (TV), final viscosity (FV: viscosity at 50°C), break down viscosity (PV–TV), and setback viscosity (FV–TV).

Statistical analysis

The results were expressed as mean and standard deviation of triplicate determinations. Data were analysed with SPSS software for window release 16.00; SPSS Inc., Chicago IL, USA. The data were analysed by one-way analysis of variance (ANOVA). Duncan's multiple range test was used to separate means. Significance was accepted at $p \leq 0.05$.

Results and Discussion

Effect of germination on chemical composition

The gross chemical composition of germinated sesame samples is presented in table 1. Germination significantly ($p \leq 0.05$) increased moisture, protein, fiber and ash content while fat content and carbohydrate values of the flour samples showed a decrease. The water content of sesame seeds increased gradually with germination time. After 24, 48 and 96 h of germination, water content in germinated seeds reached 5.01, 5.43 and 5.78%, respectively, and were higher than the corresponding values in raw seed (4.93%). The increase in moisture content corroborates the work of Kordylas [22] which reported that during the process of germination, the cells are liberated, and the seeds absorb water and swell. Also, the water sprinkled on the seeds during sample preparation must have increased the availability of moisture for absorption by cells of the seeds, thus leading to higher moisture content after germination.

In relation to protein content, the time of germination caused a significant interference ($p \leq 0.05$) in values; the protein level increase with a higher germination time. The significant increase in protein content seen in germinated samples compared to raw seed is attributed to increased water activity as a result of hormonal or compositional change following the degradation of other constituents [23]. In earlier studies, Lee and Karunanithy [24] observed

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)	Energy (kJ/g)
GSS_0	4.93a ± 0.01	25.47a ± 0.14	49.32e ± 0.07	3.74a ± 0.03	3.42a ± 0.01	13.12e ± 0.05	219.10
GSS_{24}	5.01b ± 0.01	46.37b ± 0.07	31.60d ± 0.05	3.98b ± 0.01	3.50b ± 0.01	9.54d ± 0.03	159.32
GSS_{48}	5.43c ± 0.02	49.01c ± 0.05	30.01c ± 0.05	4.07c ± 0.02	3.62c ± 0.03	7.87c ± 0.02	131.43
GSS_{72}	5.47d ± 0.01	50.75d ± 0.02	29.20b ± 0.04	4.16d ± 0.11	3.87d ± 0.01	6.35b ± 0.01	106.05
GSS_{96}	5.78e ± 0.01	52.62e ± 0.13	27.90a ± 0.02	4.32e ± 0.05	3.95e ± 0.01	5.43a ± 0.01	90.68

Table 1: Proximate Composition of Sesame Seeds at Different Germination Time.

Values are mean of thee determinations. Values with different superscript within the same row are significantly different from each other ($p \leq 0.05$). Where GSS_0 = 0h germinated sesame; GSS_{24}=24h germinated sesame; GSS_{48}= 48h germinated sesame; GSS_{72}= 72h germinated sesame; GSS_{96}= 96h germinated sesame.

also an increase in total crude protein content of more than 21% in germinated soybean compared to raw seeds. Another major chemical component of sesame is lipid. The high lipid content (49.3%) in the cotyledon of dry seeds confirms it is an oil seed; however, there was significant reduction of this reserve after 24 h till 96 h germination. Similarly, the lipids in the dry seeds of *Euphorbia heterophylla* (60%) were reduced by 70% during seed germination [25]. These reductions in oil content may be attributed to the increased activity of lipolytic enzymes during germination, which hydrolyzed the fats into fatty acid and glycerol.

Sesame seeds germinated for 96 h showed the highest percentage of the ash (4.32%) in comparison with the control 3.74%. In relation to ash content, it was possible to observe an increase with increase in germination time. The increase may be due to endogenous enzyme hydrolysis of complex organic compounds to release more nutrients leaving the anti-nutrients to leach into the germination medium [26]. From the results, it could be inferred that sesame seeds contain appreciable quantity of dietary fibre. The fibre content at 24h of germination (3.50%) showed significant difference with the control (3.42%) and with the germinated sesame at 96h. Similar effect of germination on dietary fibre has also been studied in black sesame seeds grown in South Sudan [27]. Changes in fiber content may attribute to the fact that part of the seed fiber may be solubilized enzymatically during seed germination [28].

The carbohydrate content in sprouts decreased continuously with germination time, from 13.1 to 9.6% at 24 h of germination compared to 5.4% at 96 h. This observation could be due to the utilization of fat and carbohydrate for biochemical activities of the germinating seeds. It is also interesting to note that germination process had significant effect ($p \leq 0.05$) on the energy value of the sesame samples. The value ranged from 90.86 to 219.10 kJ/g. The calorie content decreased continuously with germination time which corroborates the reported utilization of fat and carbohydrate for biochemical activities by the germinating sprouts.

Effect of germination on mineral composition

The concentration of mineral elements found in sesame flour, both raw and after germination at different time intervals is presented in table 2. The results indicated that they were rich sources of magnesium, calcium, phosphorus and potassium but contain low concentrations of zinc and iron. At 96 h of germination, the concentration of calcium and phosphorus in germinated sesame samples were about 157 and 178% of that in raw seed, respectively. Potassium and magnesium had similar pattern as both increased at 24h of germination till 96h of germination making them significantly different from the control ($p \leq 0.05$). Likewise, zinc and iron contents steadily increase in sprouts during germination. Generally, the data revealed that germination time led to significant increase in mineral levels. The enhancement of mineral concentration may be as a result of anti-nutrient decomposition, thus releasing the bound nutrients. Earlier research had reported association of germination with increase in the bioavailability of trace elements and minerals [29].

Sample	Calcium	Magnesium	Potassium	Phosphorus	Iron	Zink
GSS_0	4.72a ± 0.02	18.66a ± 0.11	25.66a ± 0.05	4.45a ± 0.01	0.47a ± 0.02	0.46a ± 0.01
GSS_{24}	5.39b ± 0.02	23.25b ± 0.07	28.58b ± 0.21	4.60b ± 0.01	0.53b ± 0.03	0.48ab ± 0.01
GSS_{48}	5.92c ± 0.01	23.86c ± 0.05	30.14c ± 0.13	6.90c ± 0.02	0.76c ± 0.01	0.56c ± 0.01
GSS_{72}	7.03d ± 0.03	24.13d ± 0.03	31.19d ± 0.09	7.10d ± 0.01	0.83de ± 0.04	0.57c ± 0.02
GSS_{96}	7.39e ± 0.05	33.62e ± 0.03	35.20e ± 0.05	7.90e ± 0.01	0.87e ± 0.01	0.59cd ± 0.01

Table 2: Mineral Composition of Sesame Seed at Different Germination Time (mg/kg).

Values are mean of thee determinations. Values with different superscript within the same row are significantly different from each other ($p \leq 0.05$).

Effect of germination on anti-nutrient content

The anti-nutritional concentrations of flour samples from germinated sesame seeds compared to the control are presented in table 3. The phytate content of raw sesame sample (9.02 mg/g) was higher than the germinated samples. There was significant decrease in the concentration of phytic acid as germination time progressed. Reduction in phytic acid content may be attributed to increased synthesis of phytase during germination and the subsequent increase in phytic acid degradation. Because germination is mainly a catabolic process that supplies important nutrients to the growing plant though hydrolysis of reserve nutrients, reduction in phytic acid was expected as it is primary source of phosphorus and cations during the process [30]. Similarly, there were significant decrease in oxalate and tannin concentrations as germination time progressed compared to raw sesame. Decrease in oxalate during germination could be as a result of the activation of oxalate oxidase which breakdown oxalic acid into carbon dioxide and hydrogen peroxide and consequently releasing calcium [31]. Phytate, oxalate and tannins have been implicated in binding of mineral elements thereby making them metabolically unavailable for assimilation in human body.

Sample	Tannin	Oxalate	Phytate
GSS_0	16.64e ± 0.07	3.05e ± 0.01	9.02e ± 0.06
GSS_{24}	10.07d ± 0.03	2.78d ± 0.02	7.72d ± 0.04
GSS_{48}	8.93c ± 0.02	2.68c ± 0.02	6.27c ± 0.11
GSS_{72}	7.11b ± 0.03	2.26b ± 0.05	6.07b ± 0.03
GSS_{96}	3.97a ± 0.01	2.04a ± 0.03	5.78a ± 0.01

Table 3: Anti-Nutrient Composition of Sesame Seed at Different Germination Time (mg/g)

Values are mean of thee determinations. Values with different superscript within the same row are significantly different from each other ($p \leq 0.05$).

Effect of germination on mineral bioavailability

The molar ratio of phytate and zinc, iron, calcium, magnesium and potassium to predict their bioavailability is shown in table 4. The phytate: zinc molar ratio was in a range of 0.980 to 1.960, phytate: iron 0.550 to 1.630, phytate: calcium 0.049 to 0.116; while that of phytate: magnesium and phytate: potassium was between 0.006 to 0.018 and 0.009 to 0.021, respectively. Molar ratios between phytic acid and mineral elements are good indicator of their potential bioavailability in human system. Germination of sesame seeds showed a decrease in the phytate/mineral element ratio when compared to raw seeds due to massive breakdown of phytate. A greater reduction in the ratio was reported in germinated seeds after 96 h as compared to raw seeds. It is imperative to note that trace elements are essential for human nutrition. However, the optimum dietary level for the individual elements required for humans is very difficult to clarify because of variation in physiological response. In essence, children are more vulnerable to sub-optimal of these trace elements with adverse effects on their growth rate and cognitive development [32]. Most importantly, an issue to contend with is the interference of phytate with mineral availability in biological system. Phytic acid may reduce the bioavailability of dietary mineral elements by forming insoluble mineral chelate at physiological pH. The molar ratio between phytate and zinc in meals or diets is a useful indicator of the effect of phytate in depressing zinc absorption. At molar ratios above the range of 6 to10, zinc absorption starts to decline; at ratios above 15, absorption is typically less than 15% [33].

However, the effect of phytate on zinc is modified by the source and amount of dietary proteins consumed. Animal proteins improve zinc absorption from a phytate-containing diet compared to plant proteins [33]. Conclusively, the availability of zinc from the diet can be improved by reducing the phytate content and including sources of animal protein.

Sample	Phytate: Ca molar ratio	Phytate: Mg molar ratio	Phytate: K molar ratio	Phytate: Fe molar ratio	Phytate: Zn molar ratio
GSS_0	0.116	0.018	0.021	1.630	1.960
GSS_{24}	0.087	0.012	0.016	1.230	1.600
GSS_{48}	0.064	0.010	0.012	0.700	1.110
GSS_{72}	0.052	0.009	0.011	0.610	1.050
GSS_{96}	0.049	0.006	0.009	0.550	0.980

Table 4: Mineral Bioavailability of Sesame Seed at Different Germination Time.

Values are mean of thee determinations. Values with different superscript within the same row are significantly different from each other ($p \leq 0.05$).

Similarly, the presence of phytate influences the availability of calcium for absorption and the absorptive mechanism itself. Phytates can form insoluble calcium phytate salts in the gastrointestinal tract. However, the molar ratio of phytate to calcium was far below the recommended maximum value 0.24 [34] in all the flour samples. The relatively lower phytate: calcium ratio of in germinated sesame seeds compared with raw seeds may be a factor in the higher absorption of calcium. As with zinc and calcium, the phytate: magnesium ratio is significantly lower in germinated samples than raw seeds. Moreso, the molar ratio of phytate to magnesium and iron was far below the recommended maximum value 0.24 and `1 [35] in all the flour samples indicating better bioavailability for absorption.

In general, the reduction achieved for the anti-nutrient in germinated samples when compared to raw sample could be directly related to this improved availability. However, an important fact to consider is the contribution of the colon in the overall absorption of minerals. Mineral elements are strongly associated with plant cell walls and can be released by the microbial breakdown of these complex polysaccharides in the large intestine. In fact, the effects of fermentable carbohydrates and phytic acid on mineral bioavailability are controversial partially because the digestive microflora can express a phytase activity [36] and microbial fermentations can increase the solubility of divalent cations in the large intestine, which improve their absorption in situ across the cercal wall of experimental rat [37]. Thus, there is a possible shift of absorptive sites from the small intestine toward the large intestine, with a potential enhancement of their availability for absorption, especially for calcium and magnesium [38]. Consequently, it is expected that such a shift would overcome the negative chelating effects of phytic acid.

Effect of germination on functional properties

The result of the effect of germination on some physicochemical properties of sesame flour is shown in table 5. Germination significantly ($p \leq 0.05$) increased the water absorption capacity (WAC), oil absorption capacity (OAC) and least gelation concentration (LGC) while the swelling power (SP) and pH of the flours decreased. Values obtained for water absorption capacity, oil absorption capacity, gelation capacity, swelling power and pH ranged from 0.87 to 1.01 mL/g, 0.66 to 0.93 mL/g, 16.00 to 18.00%, 1.54 to 1.84 mg/g and 6.27 to 6.60, respectively. Data showed that germinated sesame flours had relatively good water absorption properties. The increase in WAC of germinated sesame seed flour may be due to increase in protein content which absorbs more water probably due to protein synthesis during germination [39]. Oil absorption capacity of the control sample was 0.87 mL/g which was statistically significantly different from that of germinated sesame from 24 to 96 h. The slight but insignificant increase in oil absorption capacity of germinated samples may be due to entrapment of oil related to the non-polar side chains of proteins. It is apparent from the results obtained that the water absorption capacities are slightly more than oil absorption capacities in raw and germinated samples; a factor important in the preparation of soup condiments.

Germination time resulted in reduced gelling property notably after 72 h which may be as a result of altered carbohydrate composition of the grain. Gel forming ability is known to be influenced by the nature of protein, starch and gums in the sample as well as their interaction during heat treatment as reported by Enujiugha., *et al*. [40]. The pH decreased significantly ($p \leq 0.05$) with increase in germination time. Sesame seeds germinated for 96 h had the lowest pH value of 6.27. The decrease observed in pH might have

been as a result of secretion of enzymes resulting in the hydrolysis of complex organic molecules such as phytin and protein into simpler and more acidic compounds such as phosphate and amino acids, respectively [41].

There was a significant difference ($p \leq 0.05$) in swelling power of the samples with raw sesame having the highest value. Germination decreased the swelling power of the samples probably as a result of disruption of hydrogen atoms inherent in sesame by amylases and proteases into sugars and amino acid respectively [42]. It is however important to note that sesame flour had swelling power that ranged from 1.54 to 1.84% which suggests that the starch extracts obtained were highly restricted type. Similarly, the observed reduction in swelling power of the germinated flour samples as compared to the flour from raw sesame seeds may be due to reduction in pH value as germination progressed. It has been reported that high pH value imparts a free swelling property to starch content of flour [43].

Effect of germination on the pasting profile of sesame flour

The pasting profile of raw and germinated sesame samples is shown in table 6. Peak viscosity ranged from 45.00 RVU to 202.50 RVU. Germination process had a significant effect ($p \leq 0.05$) on the peak viscosity of samples. Generally, germinated sesame samples had significantly ($p \leq 0.05$) lower values than control sample. Low peak viscosity values recorded in germinated samples could be as a result of rupturing of starch molecules. Peak viscosity is correlated with the water binding capacity of the starch or mixture, which occurs at the equilibrium point between swelling causing an increase in viscosity while rupturing and alignment cause its reduction [44]. Germination process also had significant ($p \leq 0.05$) effect on trough, breakdown, final and setback viscosity values of the samples. Values obtained for these parameters ranged from 37.50 to 125.50 RVU; 7.50 to 77.00; 44.00 to 120.5 and -5.00 to 8.00 RVU, respectively. Raw sesame flour had a significantly ($p \leq 0.05$) higher trough than samples subjected to germination. Similarly, samples produced from germinated sesame all had significantly ($p \leq 0.05$) lower breakdown than sample produced from raw sesame. The final viscosity of raw sesame flour recorded the highest value of 120.50 RVU. However, germination of sesame seed over time decreased the final viscosity of the resultant flour. Generally, the low setback viscosities recorded in raw and germinated sesame flour samples suggests their insusceptibility to retrogradation. Phattanakulkaewmorie., *et al.* [45] also reported low setback viscosity for germinated sorghum. Lower peak time was recorded for germinated sesame samples compared to raw seed. There was no significant difference in the pasting temperature of the raw and germinated flour samples. However, the observed high pasting temperature could be due to the buffering effect of fat on the starch component of sesame seeds [46].

Sample	PV(RVU)	TV(RVU)	BV(RVU)	FV(RVU)	SV(RVU)	PT (min)	P Temp. (^{0}C)
GSS_0	202.50e ± 0.62	125.50e ± 1.10	77.00e ± 0.68	120.50e ± 0.17	-5.00a ± 0.02	7.00cd ± 0.02	95.05a ± 0.01
GSS_{24}	162.50d ± 0.83	95.50d ± 0.05	67.00d ± 0.83	99.00d ± 0.33	3.50c ± 0.02	6.80c ± 0.02	95.05a ± 0.05
GSS_{48}	117.00c ± 0.15	71.00b ± 0.55	46.00c ± 0.04	71.50b ± 0.09	0.50b ± 0.01	6.73b ± 0.01	95.00a ± 0.03
GSS_{72}	107.00b ± 0.51	73.00c ± 0.03	34.00b ± 0.05	81.00c ± 0.42	8.00e ± 0.02	7.00cd ± 0.03	95.00a ± 0.03
GSS_{96}	45.00a ± 0.09	37.50a ± 0.32	7.50a ± 0.02	44.00a ± 0.05	6.50d ± 0.02	6.54a ± 0.02	95.00a ± 0.07

Table 6: Pasting Properties of Sesame Seed at Different Germination Time.

Values are mean of thee determinations. Values with different superscript within the same row are significantly different from each other ($p \leq 0.05$). PV- peak viscosity; TV- trough viscosity; BV-breakdown viscosity; FV- final viscosity; SV- setback viscosity; PT- pasting time; P Temp.- pasting temperature; RVU -Rapid Visco Unit.

Conclusions

There were indications of improved nutritional value and functionality as a result of germination of sesame seeds. Germination significantly decreased the levels of phytate, oxalate and tannin with corresponding improvement in mineral bioavailability. There exist variations in the pasting properties of the sesame flours which are desirable characteristics for the manufacture of various food products.

Bibliography

1. Kumar V., *et al*. "Dietary Roles of Phytate and Phytase in Human Nutrition A Review". *Food Chemistry* 120 (2010): 945-959.

2. Sangronis E and Machado CJ. "Influence of Germination on the Nutritional Quality of *Phaseolus vulgaris and Cajanus cajan*". *LWT-Food Science and Technology* 40 (2007): 116-120.

3. Shimelis EA and Rakshit SK. "Effect of Processing on Antinutrients and In Vitro Protein Digestibility of Kidney Bean (Phaseolus vulgaris L.) Varieties Grown in East Africa". *Food Chemistry* 103 (2007): 161-172.

4. Lopez-Amoros ML., *et al*. "Effect of Germination on Legume Phenolic Compounds and Their Antioxidant Activity". *Journal of Food Composition and Analysis* 19 (2006): 277-283.

5. Park S., *et al*. "Antioxidant Compounds as Potential Neuroprotective Agents in Sesame (*Sesamum indicum* L.)". *Food Review International* 26 (2010): 103-121.

6. Oduntan AO., *et al*. "Effect of Plant Maturity on the Anti-nutrient of *Sesamum radiatum* Leaves". *Global Journal of Scientific Researches* 2.1 (2014): 7-11.

7. Borchani C., *et al*. "Chemical Characteristics and Oxidative Stability of Sesame Seed, Sesame Paste and Olive Oils". *Journal of Agricultural Science and Technology* 12 (2010): 585-596.

8. Ojiako OA., *et al*. "Protein and Amino Acid Compositions of *Sphenostylis stenocarpa*, *Sesamum indicum*, *Monodora myristica* and *Afzelia africana* Seeds from Nigeria". *Pakistan Journal of Nutrition* 9 (2010): 368-372.

9. Jannat B., *et al*. "Effects of Roasting Temperature and Time on Healthy Nutraceuticals of Antioxidants and Total Phenolic Content in Iranian Sesame Seeds (*Sesamum indicum* L.)". *Iranian Journal of Environmental Health Science and Engineering* 7 (2010): 97-102.

10. Mohamed., *et al*. "Quality Characteristics of Sesame Seeds and By-Products". *Food Chemistry* 103 (2007): 641-650.

11. Olagunju AI and Ifesan BOT. "Nutritional Composition and Acceptability of Cookies Made from Wheat flour and Germinated Sesame (*Sesamum Indicum*) Flour Blends". *British Journal of Applied Science and Technology* 3 (2013):702-713.

12. AOAC. Association of Official Analytical Chemist, Official Methods of Analysis. 19th Edition. AOAC international, Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland 20877-2417, USA (2000).

13. Guyot JP., *et al*. "Effect of Fermentation by Amylolytic Lactic Acid Bacteria, In Process Combinations, on Characteristics of Rice/Soybean Slurries: A New Method for Preparing High Energy Density Complementary Foods for Young Children". *Food Chemistry* 100 (2007): 623-63.

14. Oladele KA., *et al*. "Influence of Processing Techniques on the Nutrients and Antinutrients of Tigernut (*Cyperus esculentus* L.)". *World Journal of Dairy and Food Sciences* 4.2 (2009): 88-93.

15. Mugaboa E., *et al*. "Effect of Pre-treatments and Processing Conditions on Anti-Nutritional Factors in Climbing Bean Flours". *International Journal of Food Studies* 6 (2017): 34-43.

16. Woldegiorgis AZ., *et al*. "Major, Minor and Toxic Minerals and Anti-Nutrients Composition in Edible Mushrooms Collected From Ethiopia". *Food Processing Technology* 6 (2015): 134-142.

17. Onwuka GI. Food Analysis and Instrumentation. Theory and Practice. Naphtali Prints, Lagos, Nigeria. ISBN: 978047686. (2005).

18. Ikpeme-Emmanuel CA., *et al*. "Chemical and Protein Quality of Soybean (*Glycine max)* and Tigernut (*Cyperus esculentus)* Based Weaning Food". *Journal of Food Research* 1.2 (2010): 246-254.

19. Akpada MI and Miachi OE. "Proximate Composition and Selected Functional Properties of *Detarium microcarpum"*. *Plant Foods for Human Nutrition* 56 (2001): 297-302.

20. Adebayo WA., *et al*. "Effect of Spontaneous Fermentation on the Chemical Composition of Thermally Treated Jack Beans (*Canavalia ensiformis* L.)". *International Journal of Biological Chemistry* 1.2(2007):91-97.

21. Coffman CW and Garcia VV. "Functional Properties of Amino Acid Content of a Protein Isolate from Mung Bean Flour". *Journal of Food Technology* 12 (1977): 473.

22. Kordylas JM. "Processing and Preservation of Tropical and Sub Tropical Foods". Macmillian Educational Ltd, Hampshire (1990): 109-119.

23. Nonogaki H., *et al*. "Germination-Still a Mystery". *Plant Science* 179 (2010): 574-581.

24. Lee CK and Karunanithy R. "Effects of Germination on the Chemical Composition of Glycine and Phaseolus Beans". *Journal of Science Food Agriculture* 51 (1990): 437-445.

25. Suda CNK and Giorgini JF. "Seed Reserve Composition and Mobilization during Germination and Early Seedling Development of *Euphorbia Heterophylla*". *Brazilian Journal of Plant Physiology* 12 (2000): 226-245.

26. Gabriel RAO and Akharaiyi FC. "Effect of Spontaneous Fermentation on the Chemical Composition of Thermally Treated Jack Beans (*Canavalia ensiformis L.*)". *International Journal of Biological Chemistry* 1.2 (2007): 91-97.

27. Banja GA., *et al*. "Effect of Soaking and Germinating Techniques on the Macronutrient Content of (*Hyptis Spicigera* Lam.) Seeds in Morobo County, South Sudan". *Sky Journal of Food Science* 5.3 (2016): 19-23.

28. El Maki HB., *et al*. "Changes in Chemical Composition, Grain Malting, Starch and Tannin Contents and Protein Digestibility during Germination of Sorghum Cultivars". *Food Chemistry* 64 (1999): 331-336.

29. Kaushik G., *et al*. "Effect of Domestic Processing Techniques on the Nutritional Quality of Soybean". *Mediterranean Journal of Nutrition and Metab*olism 3.1 (2010): 39-46.

30. Archana., *et al*. "Reduction of Phenolic and Phytic Acid Content of Pearl Millet Grains by Malting and Blanching". *Plant Foods for Human Nutrition* 53.2 (1999): 93-98.

31. Pal RS., *et al*. "Impact of Dehulling and Germination on Nutrients, Antinutrients, and Antioxidant Properties in Horsegram". *Journal Food Science Technology Mysore* 53 (2016): 337-347.

32. Hambidge KM., *et al*. "Growth Velocity of Young Children Receiving a Dietary Zinc Supplement". *Nutrition Research* 1 (1985): 306-3l6.

33. Sandström B., *et al*. "Effect of Protein Level and Protein Source on Zinc Absorption in Humans". *Journal of Nutrition* 119 (1989): 48-53.

34. Morris ER and Ellis R. "Bioavailability of Dietary Calcium-Effect of Phytate on Adult Men Consuming Non-Vegetarian Diets". In: ACS Symposium Series 75: Nutritional Bioavailability of Calcium. Kies C American Chemical Society (1985): 63.

35. Siegenberg D., *et al*. "Ascorbic Acid Prevents the Dose-Dependent Inhibitory Effects of Polyphenols and Phytates on Non-heme-Iron Absorption". *American Journal of Clinical Nutrition* 53 (1991): 537-541.

36. Yoshida T., *et al*. "The Effects of Gut Flora on the Utilization of Calcium, Phosphorus and Zinc in Rats Fed a Diet Containing Phytate". *Agricultural and Biological Chem*istry 49 (1985): 2199-2202.

37. Delzenne NM., *et al*. "Effect of Fermentable Fructo-Oligosaccharide on Mineral, Nitrogen and Energy Digestive Balance in the Rat". *Life Science* 57 (1995): 1579-1587.

38. Younes H., *et al*. "Acidic Fermentation in the Caecum Increases Absorption of Calcium and Magnesium in the Large Intestine of the Rat". *Brazilian Journal of Nutrition* 75 (1996): 301-314.

39. Asiedu M., *et al*. "Effect of Processing (Sprouting and Fermentation) on Sorghum and Maize, Vitamin and Amino Acid Composition, Biological Utilization of Maize Protein". *Food Chemistry* 48.2 (1993): 201-204.

40. Enujiugha VN "Chemical and Functional Characteristics of Conophur Nut*". Pakistan Journal of Nutrition* 2.6 (2003): 335-338.

41. Adedeji OE., *et al*. "Effects of Germination Time on the Functional Properties of Maize flour and the Degree of Gelatinization of Its Cookies". *African Journal of Food Science* 8 (2014): 42-47.

42. Egwim E and Adenomon M. "Predicting A-Amylase Yield and Malt Quality of Some Sprouting Cereals Using 2nd Order Polynomial Model". *African Journal of Biochemistry Research* 3.8 (2009): 288-292.

43. Lund D. "Influence of Time, Temperature, Moisture, Ingredients and Processing Conditions on Starch Gelatinization". *Critical Reviews in Food Science and Nutrition* 20 (1984): 249-273.

44. Sanni AI., *et al*. "Influence of Processing Conditions on the Nutritive Value of Ogi-Baba, a Nigerian Fermented Sorghum Gruel". *Plant Foods for Human Nutrition* 56.3 (2001): 217-223.

45. Phattanakulkaewmorie N., *et al*. "Chemical Compositions and Physico-Chemical Properties of Malted Sorghum Flour and Characteristics of Gluten Free Bread". *Word Academy of Science, Engineering and Technology* 57 (2011): 454-460.

46. Oluwamukomi MO., *et al*. "Effect of Soy Supplementation and Stage of Inclusion on Inclusion on the Quality of Ogi- A Fermented Maize Meal". *Food Chemistry* 91.4 (2005): 651-657.

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