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EFFECT OF DOMESTIC FOOD PROCESSING METHODS ON ANTI NUTRIENTS, SOME MINERAL CONTENT AND FUNCTIONAL PROPERTIES OF MUNGBEAN (*Vigna radiata*) FLOURS

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ABSTRACT
Background: Grain legumes are known to contribute to improving the nutritional status of poor segment of populations and especially when combined with cereals. Processing techniques have been reported to affect the quality of grain foods.
Objective: This study investigated the effect of five domestic food processing methods on some minerals, antinutrients and functional properties of mungbean flour.
Methodology: Two thousand four hundred grammes (2400g) of mungbeans were weighed out and divided into six equal portions and processed differently: dehulled and shade dried (DSH); dehulled and sun dried (DSU); fermented for 24hours (F24), fermented for 48hours (F48); sprouted for seven days (SP7) respectively. The control (UDSH) was washed, undehulled and shade dried. The portions were milled, sifted and later analysed for minerals, anti-nutrients and functional properties. The analyses were done on dry weight basis. The data were analyzed using means and standard deviation. Significance level was accepted at ($P<0.05$).
Results: The F24 and F48 flours had higher calcium values (84.39.± 0.46 and 81.99 ± 0.14mg/100g) relative to the other samples. The UDSH had lower sodium 7.51± 0.71mg/100g while F24 had the highest value (9.16 ±0.43) that were relatively different ($p<0.05$) from the other samples. The F24 and control (UDSH) flours had lower comparable ($p<0.05$) phytate values (5.89±0.12g/100g and (5.55 ±0.12±0.11g/100g)relative to the other flours. Values for tannins ranged from 4.02± 0.12g/100g in (SP7) to 6.87±0.07g/100g in (F48). Oxalate values of 2.00±0.04g/100g in (SP7) and 2.16±0.11g/100g in the control (UDSH) sample were comparable ($p<0.05$) to the other groups. The solubility (Psol) values ranged was from 4.70±.20mg in the control sample to 5.28±0.13mg in the SP7 sample.
Conclusion: The study showed that fermentation had an edge over other methods of food processing. Fermented mungbean flour could therefore be used in formulation and development of nutritious products.

Key words: *mungbeans, processing, antinurients, minerals, functional properties*

INTRODUCTION
Legumes are one of the largest family of angiosperms belonging to Fabaceae/Leguminosae (1).They are said to be one of the first crops cultivated by man (2).Legumes are the important constituents of a healthy diet and play a vital role in the traditional diets globally (3).Legumes are valued globally as a cheap meat alternative and are considered the second most important food source after cereals [2]. They include peas, lentils, beans, peanuts and other podded plants that are consumed as food (4). Legumes are rich in both protein and dietary fibre. In addition, legumes are richer in protein than other cultivated crops because of the nitrogen-fixing bacteria that live in the nodules of legume roots (5). Protein derived bioactive peptides of legume plants have many important roles as health-enhancing compounds. Presence of these bioactive compounds in legumes may contribute to the food quality (6,7). Also, the observed effects on diseases including cardiovascular diseases, diabetes, cancer and obesity, may derive from the synergistic combination of bioactive substances of legume seeds (8). There are many observations regarding the activities of these peptides. They are said to have antimicrobial properties, blood pressure-lowering effects, cholesterol-lowering ability, antithrombotic, antioxidant activities, enhancement of mineral absorption/bioavailability, cyto-or immuno-modulatory effects, and opioid-like activities (9,10,11,12). There are some studies reporting the reduction of CHD by consumption of legumes because of their high saponin and phytosterol contents (13,14,15). The consumption of dry legumes with a low saturated-fat diet may help improve the lipid homeostasis and as a result reduce the risk of CVD (16). It has been suggested that legumous saponins may have anticancer activity, and be beneficial for hyperlipidemia (17,18,19,20).

Although, legumes possess these qualities, they are underutilized due to paucity of information on the effect of some treatments on their quality. Processing techniques have been reported to: increase food security; reduce moisture content thereby preventing microorganisms (bacteria, yeasts, viruses, moulds which produce aflatoxins); reduce the risk of food borne diseases and increase the nutrient densities; breakdown cell walls, enhancing digestibility; cause reduction in fibre content thereby preventing flatulence for susceptible individuals; reduction of phytate resulting in increased bioavailability of non-haem iron and zinc; reduction fat and enzymes, which cause rancidity as well as diversify their usage (21). Additionally, processing methods influence the suitability of food materials for various food products. This they do by influencing such food material properties as swelling capacity, water absorption capacity, oil absorption capacity, emulsion stability, bulk density, gelatinization, water solubility, foaming capacity, gelation, viscocity and emulsification. These functional properties of food materials determine the characteristics of their food products such as appearance, taste, feel, bulking, and texture.

Mungbean is native to the Asian countries (China, India, Burma, Bangladesh, and Indonesia) where they are used to prepare assorted dishes and snacks. In Nigeria, it is categorized among the lesser known legumes and so mungbean is a lesser known legume and so has not been introduced into Nigerian recipes and cuisine. As a legume, exploiting its potentials my help in broadening the food base of the country and probably help in addressing malnutrition which is a concern in the developing countries. In these countries, malnutrition is usually very common among the poorer segment of the population who obviously depend on plant-based foods for their nutritional supply. However, it has become clear that malnutrition among the poor is attributable not solely to insufficient amounts of food but also to the poor nutritional quality of the available food supply (26,27), particularly among plant-based diets. The low bioavailability of nutrients, arising from the presence of antinutrients such as phytate, polyphenols, and oxalate, is another factor that limits the quality of predominantly plant-based diets (28,29).The use of appropriate household food processing methods and the subsequent formulation of nutritious products from the processed foods will help in addressing this problem. The purpose of this study is therefore to provide background information on the effect of household processing techniques on some chemical and functional properties of the mungbean with a view of formulating low-cost nutritious products from its flour.

MATERIALS AND METHODS

The legume, mungbean (*Vignaradiata*) grain was purchased from Agronomy Department, Michael *Okpara* University of Agriculture, *Umudike, Umuahia, Abia* State Nigeria. Mungbean seeds that weighed 3.750kg were collected for the study. The seeds were cleaned by removing extraneous materials. The clean seeds were washed in cooled warm water and drained to remove traces of dust and other possible contaminants. The bakery material, beans and other ingredients used in sensory evaluation were purchased from *Eke Awka* main market, *Awka, Anambra* State, Nigeria.

Sample preparation

Two thousand four hundred grammes (2400g) of mungbean seeds were divided into six equal portions. Sample 1(UDSH), these seeds were washed in cooled warm water, undehulled and shade dried served as the control. Sample 2(DSH), was soaked, dehulled, and shade dried. Sample 3(DSU), these seeds were soaked, dehulled, and sun dried. Sample 4(F24), the seeds were fermented for 24h, dehulled and shade dried. Sample 5(F48), was fermented for 48hrs and shade dried. Sample 6 (SP7), these seeds were moist and sprouted for 7 days. The samples were milled and sifted through 70mm screen sieve. The samples were packaged, labeled and stored for analysis.

Mineral Determination

Analysis of the mineral elements was carried out according to Ranjiham and Gapal (22).

Determination of the Anti-Nutrient Composition

A portion of the sample was homogenized and used in the quantitative determination of oxalates, saponins, tannins and phytates, using standard methods. Assays were carried out in triplicates.

Assay of the Oxalate Content

The oxalate was determined according to AOAC Official Method 974.24 (23), with modifications. An aliquot of 10mL of 6mol/L HCL was added to 2g of homogenized sample in a 250mL volumetric flask, which was then placed in a water bath at 80 ℃ for one hour. The resultant mixture was further diluted with 50mL of deionized water and filtered through Whatman #1 filter paper. The pH of the filtrate was adjusted with concentrated NH4OH solution until the colour of solution changed from salmon pink colour to a faint yellow colour. Thereafter, the filtrate was treated with 10mL of 5% $CaCl_2$ solution to precipitate the oxalate. The suspension was centrifuged at 2500rpm for 20min, after which the supernatant was decanted, and the precipitate was completely dissolved in 10mL of 20% (v/v) H_2SO_4. The resultant solution was made up to 300mL. An

aliquot of 125mL of the this solution was heated until near boiling point and then titrated against 0.05mol/L KMnO4 solution, to a faint pink colour which persisted for about 30s. The oxalate content (mg/100g sample) was computed from the titre value, with the following formula.

Oxalate content (mg/100g)

$$=\frac{\text{titre(mL)}\times 0.05\times 2\times 300}{5\times 125\times 2}\times 1$$

Determination of saponin content

The determination was as previously described by Mbatchou and Kosoono(24). Four grams of the homogenized sample was added to 20mL of 20% aqueous ethanol and kept in a shaker for 30 min, before heating on a water bath for 4h at 55°C. The mixture was then filtered and the residue re- extracted with another 40mL of 20% aqueous ethanol. The combined extracts were reduced to approximately 40mL over waterbathat90°C.The concentrate was transferred into a separating funnel, and extracted twice with4mL of diethyl ether. The diethyl ether layer was discarded, while aqueous layer was retained, and 12mL of n-butanol was added to it. The n-butanol extract was washed twice with 2mL of 5% aqueous sodium chloride. The remaining solution was heated on a water bath, and after evaporation the residue was dried in an oven (40°C) to a constant weight. The saponin content (mg/100g sample) was calculated using the following formula.

Saponin content (mg/100g)

$$=\frac{weight\ of\ residue(mg)}{4}\times 100$$

Where 4 = weight of sample used (g).

Assay of Tannins Content

The determination was as previously described by Mbatchou and Kosoono (24). Distilled water (25mL) was added to 250 mg of the sample in a 250mL flask and kept in a shaker for one hour. The resultant mixture was filtered into a25mL volumetric flask and made up to the mark. The filtrate (2.5mL) was pipetted into a test tube and mixed with 1mL of0.1mol/L FeCl3in0.1mol/L HCl and 0.008mol/L potassium ferrocyanide. The absorbance was measured at 605 nm within10 minutes. Tannic acid was used to prepare the standard. The tannin content was determined as tannic acid equivalent in mg per 100 g sample, using the following formula.

Tannin content(mg/100g)

$$=\frac{C\times A_{filtrate}\times 25\times 1000}{A_{standard}\times 250}\times 100$$

Where C = concentration of standard (mg/L); 25 = total volume of filtrate (mL); 1000 = conversion factor from mg to g; 250 = weight of sample used (mg); A = absorbance.

Assay of the Phytate Content

The determination was as previously described by Mbatchou and Kosoono (24). A portion (0.8g) of the homogenized sample was soaked in 20mL of 2% hydrochloric acid for 5h and was filtered. Then, 5mL of the filtrate was taken into a conical flask and 1.0mL of 3% ammonium thiocyanate solution was added. The resultant solution was titrated with iron (III) chloride until a brownish-yellow colour persisted for 5min.Standard phytate solution was prepared by dissolving sodium phytate in distilled water and subjected to the same treatment as the sample. The phytate content (mg/100g sample) was determined with the following formula.

Phytate Content (mg/100g)

$$=\frac{C\times titre_{sample}\times 20}{titre_{standard}\times 0.8}\times 100$$

Where C= concentration of standard (mg/mL); 20 = total volume of homogenate solution (mL); 0.8 = weight of sample used (g).

Functional Properties Determination

Water absorption capacity (WAC):

This was determined using (25) procedure. Fifteen millilitres (15ml) of distilled water was added to 1g of flour in a weighed 25ml centrifuge tube. The tube was agitated with a vortex mixer for two minutes and centrifuged at 400rpm for twenty minutes (20mins). The clear supernatant was decanted and discarded. The adhering drop of water was removed prior to reweighing the centrifuge tube.

Calculation: Water absorption capacity was expressed as the weight of water bound by 100g dry flour.

Swelling Power and Solubility:

These were determined using the procedure (25). The sample milled into fine powder was dried to constant weight. One gramme (1g) dried sample was weighed into 100ml conical flask. Fifteen millilitres (15ml) of distilled water was added to the sample and shaken for five minutes (5mins) at low speed. The solution was transferred into water bath heated for 40minutes at 80-850C with constant stirring. The sample was again transferred into pre-weighed centrifuge tube; 7.5ml of distilled water was added and centrifuged at 2.200rpm for (20) twenty minutes. A careful decantation of the supernatant into a pre-weighed can was done, dried at 1000C to a constant weight, put in a dessicator and weighed. The precipitate was weighed in a centrifuge tube.

Calculation:

1. Weight of can =A
2. Weight of can dried supernatant t=B
3. Weight of soluble =A-B

4. Weight of empty centrifuge tube =D
5. Weight of centrifuge +sediment =E
6. Weight of sediment =E-D

$$\text{Swelling power} = \frac{\text{Wt of sediment}}{\text{Sample weight-weight of soluble}}$$

$$\%\ \text{solubility} = \frac{\text{Wt of soluble x 100}}{\text{Wt of sample}}$$

Statistical Analysis

The data were analyzed using means and standard deviation. One way analysis of variance (ANOVA) was use to compare the mean. Post-hoc analysis was performed with Duncan's New multiple Range Test. Significance level was accepted at (P<0.05).

RESULTS

Table 1 presents the effect of processing on mineral contents of the mungnbean flour samples in mg/100.Calcium content was lowest (76.45±0.10) in the control sample (UDSH) and highest (84.39± 0.46)in the 24-hour fermented(F24). The values were significantly different (p<0.05) (Fermented F48 sample had significantly (p<0.05) higher iron value (6.32± 0.57) than the other methods.F24 and UDSH had the highest and lowest sodium values (9.16±0.43 and 7.51±0.71) respectively that were significant to the values of the other samples. Sprouted sample (SP7) had the least value for zinc (1.57± 0.24) which was significantly (p<0.05) lower than DSH (2.22 ±0. 25) and UDSH (2.18± 0.54).

Table 1: Effects of Processing on Mineral Content of Six Mungbean Flours (mg/ dry matter)

Samples	Calcium	Iron	Sodium	Zinc
UDSH	76.45^{b}±0.10	5.74^{b}±0.22	7.51^{c}±0.71	2.18^{a}± 0.14
DSH	78.39^{b} ±0.09	5.42^{b}± 0.26	8.92^{b}± 0.87	2.22^{a} ±0.04
DSU	79.22^{b}±0.22	5.77^{b} ±0.21	7.99^{b} ±0.91	2.12^{a}±0.25
F24	84.39^{a}± 0.46	5.67^{b}±0.69	9.16^{a}± 0.43	1.93^{b}± 0.06
F48	81.99^{a}±0.14	6.32^{a}± 0.57	8.19^{b} ±0.47	1.63^{b}±0.24
SP7	78.56^{b} ± 0.11	5.94^{b}±0. 04	8.36^{b}±0.94	1.57^{b}± 0.24

Means in the same column with different superscript letters differed (P<0.05)
UDSH = control, undehulled shade dried mungbean;DSH = dehulled shade dried mungbean
DSU = dehulled, sundried mungbean; F24 = 24h fermented mungbean
F48 = 48h fermented mungbean; SP7 = 7 days sprouted mungbean

Table 2 presents the anti-nutrient content of the Mungbean Flour (mg/100g). The 24h fermented sample (F24) had comparable ((p<0.05)) lower phytate value(5.89± 0.02) to the control sample (UDSH) (5.55± 0.11).Tannin level was increased significantly (p<0.05) in the fermented groups (F24 and F48)(5.29± 0.12 and 6.87± 0.07).Oxalate value was decreased by all the treatments but F48 had the lowest value. The same trend was observed in saponin values. There was however no significant (p<0.05) difference in values across the samples.

Table 2: Anti-nutrient Content of Six Mungbean Flour Samples (g/100g).

Samples	Phytate	Tannins	Oxalate	Saponins
UDSH	5.55^{b} ± 0.11	4.91^{b}±0.09	2.16^{a}±0.11	0.36^{a}±0.01
DSH	6.30^{a}± 0.02	4.76^{b}±0.15	2.09^{a}±0.10	0.18^{a}±0.01
DSU	6.20^{a}±0.34	4.31^{b}±0.05	2.10^{a}±0.12	0.20^{a}±0.02
F24	6.18^{a}± 0.51	5.29^{a}± 0.12	2.08^{a}± 0.20	0.20^{a}± 0.00
F48	5.89^{b}± 0.12	6.87^{a}± 0.07	2.00^{a}± 0.04	0.17^{a}± 0.01
SP7	6.25^{a}± 0.08	4.02^{b}± 0.12	2.07^{a}± 0.05	0.18^{a}± 0.00

Mean values in the same column with different superscript letters differed (P<0.05).UDSH = control, undehulled shade dried mungbean; DSH = dehulled shade dried mungbean; DSU = dehulled sundried mungbean; F24 = 24h fermented mungbeanF48 = 48h fermented mungbean; SP7 = 7 days sprouted mungbean

Table 3 presents the functional properties of mungbean flour samples (g/100g).There was no significant (P<0.05). difference in the water absorption capacity(WAC) values among the groups though F48 had the highest value (56.37± 0.05) while dehulled and shade dried (DSH) had lowest(52.13± 0.09).Swelling power (SWP) values for the dehulled samples DSH (5.06±0.01) and DSU (5.60±0.09) were significantly higher than the other samples. The control (UDSH) and the dehulled samples had significantly higher solubility values that the other processing methods.

Table 3: Functional Properties of Six Mungbean Flour (g/100g).

Samples	WAC	SWP	P.sol
UDSH	54.21[a]± 1.11	6.42[a]±0.10	4.70[b]±0.20
DSH	52.13[a]± 0.09	5.06[b]±0.01	4.89[b]± 0.11
DSU	54.20[a]± 1.52	5.60[b]± 0.09	4.79[b]± 0.80
F24	53.21[a]± 1.26	6.39[a]± 0.20	5.28[a]± 0.21
F48	56.37[a]± 0.05	6.18[a]±0.11	5.16[a]± 0.90
SP7	55.29[a]± 1.10	6.68[a]±0.14	5.28[a]± 0.13

Means in the same column with different superscript letters varied (P<0.05).UDS = control, undehulled shade-dried mungbean; DSH = dehulled shade dried mungbean;DSU = dehulled sundried mungbean;F24 =24h fermented mungbean;F48 = 48h fermented mungbean;SP7 =7 days sprouted mungbean

DISCUSSION

The level of mineral elements in the mungbean flour was affected by the different processing methods (Table1).The comparable (P>0.05) higher calcium values for the fermented groups (F24 and F48) over the control (UDSH) and the dehulled sun-dried flours showed that dehulling, sun shade drying mungbean and sprouted samples showed that they have edge over them in improving the mineral value. The higher (P>0.05) iron (Fe) for the F48 (6.32±0.57mg) relative to the other flours from other treatments meant that forty-eight hour fermentation was the optimum condition to increase and release Fe from mungbean. The 24h fermented sample had the higher (P<0.05) sodium value than the other samples with the contol having the least value. The least sodium (Na) value (P<0.05) for the control, UDSH (7.51±0.71mg) relative to the other higher (P<0.05) values have some nutrition implications. This means that persons on low sodium diet are better off on unprocessed mungbean flour. In a Similar observation by Hotz and Gibson (30) reported increased magnesium, iron, calcium, and zinc content in some fermented foods that are commonly consumed in India. Fermentation is known to hydrolyze the bonds among nutrients, antinutrients, enzymes and protein to release chelated minerals from organic compounds. There is also loss of dry matter during fermentation as microbes degrade carbohydrates and protein thereby increasing the mineral level (31).Increasing these mineral elements via processing methods is important because of their physiological role in the body. And the dependence of the poor communities on staples for their micronutrients need. Calcium is one of the abundant mineral minerals in the human body. It is vital for bone and teeth formation, muscle contraction, blood clotting, nerve impulse transmission and fluid balance within cells. Iron plays several vital roles in the body among which is blood formation and legumes are known to be the best source of non-heam iron (32).

Sodium, mostly found in the body fluid plays a major role in maintaining blood volume and blood pressure. Zinc is an antioxidant mineral involved in free radical scavenging in the body. In contrast to Hotz and Gibson (30) reported, decreased zinc level was observed in fermented samples and sprouting samples in this study which was not comparable (P<0.05) to values of the other samples. In a similar study on horsegram, Pal et al. (33), Sushms et al. (34) and Ogbonna et al. (35) recorded increase in iron and calcium levels in germinated horsegram samples and decease in zinc,iron and calcium in the same dehulled samples. The effect of the sprouting according to Perlas and Gbson (36) is due to decreased in level of phytatic acid during germination due to activation of phytase which hydrolyzes phytic acid into phosphoric acid and myoinositol thereby making minerals more bioavailable. While the effect of dehulling could be attributed to leaching of the minerals into the soaking water (36, 37). Antinutrient result showed increase in the phytate values in all the samples except in the fermented (F48) sample (Table2).The lower phytate value in F48 sample when compared to F24 sample meant that longer fermentation time has an edge over shorter fermentation time in reducing phytate and more minerals chelated would be released for increased bioavailability. However, the highest phytate level(6.30± 0.02mg/100g) observed in the control (DSH) sample is below the stipulated residual limit of 26.4-150mg/kg of food (38).Tannin values increased significantly(p<0.05) in the fermented samples while the sprouted sample had the lowest reduction value that was comparable to the values of the other groups(mg/100g), 5.29± 0.12, 6.87± 0.07 and 4.02± 0.12.The increase in tannin during fermentation could be attributed to hydrolysis of condensed tannins such as proanthocyanidin to phenols during the process(39).However, the tannins levels for all the samples were lower than the safe level, 120mg/kg (40,41).Oxalate and saponin had reduced values that are within the safe limits (42,43) in all the groups. These observations were supported by ogbonna et al. (35) ojha et al. (44) and onyango et al. (45) who reported decreased oxalates and saponins in germinated sorghum. Conversely, saponin, phytate, tannins and oxalates are among the class of chemicals defined as phytochemicals though they are termed “antinutrients” because of their adverse physiological effects like interference with protein digestibility and reduce

bioavailability of some nutrients (46). However, some of these "antinutrients" are heat labile (31), therefore, their residues in food after the preliminary household processing like dehulling, soaking, fermentation, etc. could be eliminated by heat during cooking (47) since such foods are not consumed raw. On the other hand, investigations have shown that some of these substances have positive physiological effects. Saponins for instance, has been shown (2) to possess hypocholesteremic, anticarcinogenic activity, improve learning process and memory retention in experimental animals, has protective actions against free radicals, and lower the risk of osteoporosis, and has antibiotic effect (48). Tannins have been reported (48) to have astringent, anti-inflammatory, analgesic effects on the skin and stops small surface hemorrhages.

Functional properties are those characteristics that govern the behavior of nutrients in food during processing, storage and preparation as they affect food quality and acceptability. They include water absorption capacity, swelling power and solubility. The water absorption capacity values in this study showed that the values increased in the processed samples with the fermented and sprouted having the highest values though not statistically ($p<0.05$) different from the other samples except the control. Water absorption capacity (WAC) is the absorbed amount of water per gram of flour. One of the factors affecting WAC values is protein content of foodstuffs (49). WAC is used to indicate protein ability in the food material to prevent fluid loss from a product during food storage or processing (48). The WAC values of the processed samples increased when compared to the control with relatively higher values in the fermented sample. It is expected that the swelling capacity (SWP) values would follow the trend of the WAC because of the linear relationship between water absorption and increase in volume. Instead, the dehulled samples had the higher SWP values. The higher swelling capacity values observed in these samples may be as a result of the removal of fibrous insoluble hull which made up the volume of the flour. Solubility is a measure of the presence of soluble molecules (50).The higher solubility values of the fermented samples may be attributed to hydrolysis of the starch component of the flour by the fermenting microorganisms. Therefore the relatively higher water absorption capacity and solubility values of the fermented samples meant that the flour could keep longer and form a smoother paste.

CONCLUSION

The findings of this study showed that fermentation as a method of domestic food processing proved a better alternative to the other methods with respect to measured parameters. Nutritious food products could be developed with fermented mungbean flour.

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