Original Research Article

CHANGES IN AMINO ACIDS, ANTI-NUTRIENTS AND FUNCTIONAL PROPERTIES OF AFRICAN YAM BEAN FLOUR CAUSED BY VARIATION IN STEEPING TIME PRIOR TO AUTOCLAVING

ABSTRACT

Background and Aim:

Legume seeds are usually steeped in water or bicarbonate solution before further processing and this has some effect on the constituents and functional properties of the flour. The present study was to evaluate the effect of steeping time in 0.50% solution of unripe plantain peel ash prior to autoclaving on the amino acids, anti-nutrients and functional properties of African yam bean flour.

Study Design:

Analysis of variance (ANOVA) was carried out.

Place and Duration:

Department of Food Science and Technology, University of Uyo, Akwa Ibom State, Nigeria, from November 2016 to May 2017.

Methodology:

African yam bean seeds were sorted, washed and divided into four portions of 500g each. Portion I was not steeped and served as control sample while portions 2, 3 and 4 were steeped in 0.50% solution of unripe plantain peel ash (1:5w/v) at ambient temperature (27±2^{o}C) for 24, 48 and 72h respectively. Both the unsteeped and steeped portions were separately autoclaved, dehulled, oven dried, milled and sieved to obtain the flours used for analysis.

Result:

The result revealed that all the parameters varied with steeping time. The total amino acids and total essential amino acids increased from 75.52g/100g and 30.07g/100g in the flour from unsteeped seeds to 80.29g/100g and 32.87g/100g respectively in the flour from the seeds that were steeped for 72h. Phytate, tannin, trypsin inhibitor, reffinose, stachyose, bulk density, water absorption capacity and swelling index decreased while oil absorption and foaming capacities increased with steeping time. Percentage reduction of phytate, tannin, trypsin inhibitor, raffinose and stachyose after 72h steeping were 80, 86, 98, 97 and 94%, respectively.

Conclusion:

The treatment caused significant ($p<0.05$) reduction in anti-nutrients and flatulence causing factors and enhanced amino acid profile of the flour.

Keywords: African yam bean flour, steeping time, amino acids, anti-nutrients, functional properties.

1. INTRODUCTION

Legumes are good sources of cheap and readily available protein for human consumption [1]. Due to their high protein content, legumes have been promoted as a source of protein especially for low income families in countries with high rates of protein – energy malnutrition and the usage of animal protein is an economic constraint. They are also excellent sources of carbohydrate, fairly good sources of minerals and vitamins [2, 3] as well as health protecting bioactive compounds ([4, 5]. However, only a few of the known legume species are extensively promoted and use in Nigeria while the rest are underexploited and underutilized. Studies have shown that lesser known legumes together with conventional legumes can be used for combating protein – energy malnutrition in the developing countries [6].

African Yam Bean (AYB) is among the lesser known legumes having the potential to reduce protein deficiency in developing nations. It is a climbing legume with an exceptional ability for adaptation to low land tropical conditions [7]. In Nigeria, the beans are cultivated by subsistence farmers for their seeds although there are reports about the use of tubers as food [8]. The protein contents in the seeds range from 15.5% to 34.7% with a fairly good source of amino acids [7, 8]. Amino acid analysis indicated that the level of lysine and methionine in the seed protein are equal to or better than those of soybean [9]. This implies that the seed could be used to supplement cereal proteins which are deficient in lysine. The seeds are also rich in mineral elements including potassium, calcium, phosphorus, magnesium, iron and zinc but low in sodium content [9].

Despite the nutritional potentials of African yam bean, its utilization has been limited because of the hard-to-cook characteristics which lead to high fuel requirement, possession of objectionable beany flavour, and problem of flatulence upon consumption and the presence of anti-nutritional substances. Trypsin inhibitors, phytic acid, tannin, saponin and oxalate are among the anti-nutrients present in African yam bean seeds [10, 11, 12]. These anti-nutrients hinder the efficient utilization, absorption or digestion of some nutrients and thus reduce their bioavailability and their nutritional value. Attempt to increase the utilization of legumes have employed a wide range of processing techniques such as soaking, boiling, sprouting, fermentation, autoclaving and toasting. Shimelis *et al.* [13] however noted that no single method can effectively eliminate most the toxic factors in legumes and therefore suggested a combination of methods to remove them. These processing techniques may also have positive or negative effects on other constituents in the seeds and functional properties of the flour.

Traditionally, cereals and legumes are prepared in common household by soaking or steeping in water or alkaline solution followed by cooking or other thermal treatment. Steeping is often used as secondary process aid to most of plant-based food preparations. Soaking has been reported to reduce the cooking time of legumes [14], decrease the anti-nutrients [15, 16] as well as concentration of stachyose and raffinose which are related to flatulence problem [17, 18]. It also affects the nutrient content [19, 20] and functional properties of the flour prepared from the soaked seeds [21]. The present study was conducted to assess the effect of varying the duration of steeping African yam bean seeds in 0.50% solution of unripe plantain peel ash prior to autoclaving on the amino acids content, anti-nutrients and functional properties of the flours.

2. MATERIALS AND METHODS

2.1 Sample Procurement

Brown coloured variety of African yam beans (*Sphenostylis stenocarpa*) used for this study were purchased from a local market in Ini Local Government Area of Akwa Ibom State, Nigeria and transported to the Department of Food Science and Technology Laboratory, University of Uyo, Nigeria for processing and analysis.

2.2 Preparation of Unripe Plantain Peel Ash

The unripe plantain peels usually thrown away as waste product were washed in potable water, drained, dried at $100^{o}C$ in a hot air oven (model pp. 22 US, Genlab, England) for 18 hr, incinerated, cool in a desiccators, packaged in an air tight container and stored at $4^{o}C$ for subsequent use.

2.3 Processing of African Yam Bean Seeds into Flours

Immature and infected seeds as well as other unwanted materials were carefully sorted out and discarded while the good seeds were used for the study. Two kilograms (2kg) of the sorted seeds were washed in potable water, drained and shared into four equal portions of 500 grams each. Portion 1 was not steeped and served as the control sample while portions 2, 3 and 4 were separately steeped in 0.50% solution of unripe plantain peel ash (1:5w/v) in a plastic container and kept in a dark room at ambient temperature (27±2^{o}C) for 24, 48 and 72h respectively. At the end of each steeping period, the solution was decanted, the seeds rinsed twice with potable water and autoclaved at 121^{o}C under 15 atmospheric pressure in distilled water (1:3w/v) for 15 minutes. Unsteeped seeds were also autoclaved under the same condition. The autoclaved seeds were drained from the excess autoclaving solution, rinsed with water and manually decorticated. The decorticated seeds were dried in an oven (model pp. 22 US, Genlab, England) at 60^{o}C to constant weight, winnowed, milled and sieved to pass through 450 micrometer mesh screen. Flour from each of the portions was separately packaged in an air tight plastic container, labeled and stored at 4^{o}C for various determinations.

2.4 METHODS OF ANALYSIS

Amino acid profile of the samples was determined by the method described by Spackman *et al.* [22]. The samples for amino acid determination were dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator (Labratorums Technic AG, Model CH – 9230) and loaded into a Technicon Multi-Samle Amino Acid Acid Analyzer (TSM) (Technicon TSM-1, Model DNA 0209, Dublin, Republic of Ireland). pH of flours was measured using a digital pH meter (JENWAY, PHS – 25, ALibata). Total titratable acidity and tannin were determined following the methods described in AOAC [23]. The method described by Oberleas [24] was used for phytate determination. Trypsin inhibitor analysis was done using spectrophotometric method described by Arntfield [25]. Oligosaccharides (raffinose and stachyose) were determined following the method described by Doss *et al.* [6]. The method described by Okezie and Bello [26] was followed for the determination of bulk density of the flours. Water absorption capacity (WAC), oil absorption capacity (OAC), foaming capacity (FC) and swelling index (SI) were determined following the methods described by Abbey and Ibeh [27].

2.5 Statistical Analysis

Data obtained (in triplicate) were subjected to One Way Analysis of Variance (ANOVA) using SPSS version 18 statistical package (SPSS, Inc., USA) software. Significant difference comparisons were made using the Duncan's Multiple Range Test (DMRT) at P = 0.05.

3. RESULTS

3.1 Effect of Steeping Time Prior to Autoclaving on Amino Acids Content in African yam Bean Flour

The effect of steeping time prior to autoclaving of African yam bean seeds on the amino acid profile of the flour is presented on Table 1. The result showed that the individual, total amino acids and total essential amino acids in the flours varied with the steeping period. The total amino acids in the flour from unsteeped but autoclaved seeds was 75.52g/100g protein while the values for the flours from seeds that were steeped for 24, 48 and 72h prior to autoclaving increased to 79.15, 76.26 and 80.29g/100g protein respectively. Glutamic acid was the highest contributor in the total amino acid content and was followed by aspartic acid. The total essential amino acid for the flour from unsteeped but autoclaved seed was 30.07g/100g protein. Steeping the seeds for 24, 48 and 72h prior to autoclaving led to insignificant ($p>0.05$) increased in the total essential amino acids to 32.22, 31.49 and 32.87g/100g protein respectively. Leucine was the highest contributor of the total essential amino acids and was followed by lysine. Histidine and methionine were the two least essential amino acids in the flours from the unsteeped and steeped seeds.

Table 1: Effect of steeping time prior to autoclaving on the amino acid content in African yam bean flour (g/100g Protein)

Amino Acids	Soaking Time (hrs)			
	0	24	48	72
Lysine	5.30^{a}±0.01	5.56^{a}±0.06	5.52^{a}±0.02	5.59^{a}±0.03
Histidine	2.04^{a}±0.04	2.14^{a}±0.02	2.11^{a}±0.01	2.16^{a}±0.12
Arginine	6.36^{b}±0.01	6.79^{a}±0.01	6.59^{a}±0.06	6.88^{a}±0.05
Aspartic acid	8.74^{a}±0.03	8.80^{a}±0.03	8.65^{a}±0.02	8.80^{a}±0.03
Threonine	2.94^{a}±0.02	2.99^{a}±0.01	2.92^{a}±0.03	3.15^{a}±0.10
Serine	3.13^{a}±0.01	3.32^{a}±0.04	3.14^{a}±0.01	3.40^{a}±0.06
Glutamic acid	11.51^{a}±0.05	11.66^{a}±0.02	10.90^{b}±0.05	11.71^{b}±0.02
Proline	3.35^{a}±0.00	3.45^{a}±0.02	3.30^{a}±0.02	3.58^{a}±0.01
Glycine	3.70^{a}±0.10	3.80^{a}±0.05	3.61^{a}±0.04	3.82^{a}±0.02
Alanine	3.37^{b}±0.03	3.75^{a}±0.03	3.50^{b}±0.10	3.80^{b}±0.04
Cystine	1.45^{a}±0.04	1.45^{a}±0.04	1.33^{a}±0.08	1.45^{a}±0.06
Valine	4.38^{b}±0.02	4.70^{a}±0.10	4.64^{a}±0.03	4.91^{a}±0.01
Methionine	1.01^{a}±0.03	1.20^{a}±0.02	1.17^{a}±0.01	1.23^{a}±0.05
Isoleucine	4.09^{b}±0.12	4.55^{a}±0.06	4.41^{a}±0.05	4.45^{a}±0.00
Leucine	6.77^{b}±0.05	7.18^{a}±0.02	6.94^{b}±0.03	7.30^{b}±0.04
Tyrosine	2.92^{a}±0.02	2.92^{a}±0.00	2.81^{a}±0.02	2.92^{a}±0.06
Tryptophan	0.92^{a}±0.02	0.99^{a}±0.03	0.94^{a}±0.11	1.06^{a}±0.05
Phenylalanine	3.54^{c}±0.04	3.90^{a}±0.02	3.78^{b}±0.02	4.08^{b}±0.02
TAA	75.52^{b}±0.02	79.15^{a}±0.01	76.26^{b}±0.04	80.29^{a}±0.03
TEAA	30.07^{a}±0.01	32.22^{a}±0.02	31.49^{a}±0.01	32.87^{a}±0.02

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at P = 0.05. TAA = total amino acid; TEAA = total essential amino acid

3.2 Effect of Treatment on pH, Total Titratable Acidity and Anti-Nutrients of AYB Flour

Result on Table 2 shows that the pH and total titratable acidity of the flours were affected by the steeping time prior to autoclaving.

Table 2: Effect of steeping time prior to autoclaving on pH, titratable acidity and some anti-nutritional factors in African yam bean flour

Parameters	Soaking Time (hrs)			
	0	24	48	72
pH	5.53^{b}±0.00	5.81^{a}±0.00	5.58^{b}±0.00	5.34^{a}±0.00
TTA (%)	0.13^{c}±0.05	0.10^{c}±0.11	0.18^{b}±0.20	0.23^{a}±0.04
Phytate (mg/100g)	8.60^{b}±1.2 (0.00)	5.21^{b}±0.09 (39.42)	2.97^{c}±0.11 (65.47)	1.65^{a}±0.08 (80.81)
Tannin (mg/100g)	7.90^{a}±0.30 (0.00)	5.36^{b}±0.75 (32.15)	2.14^{c}±0.40 (72.91)	1.10^{a}±0.15 (86.08)
TIA (TIU/mg)	18.72^{a}±0.51 (0.00)	10.45^{b}±0.60 (44.18)	4.96^{c}±0.13 (73.50)	0.24^{a}±0.32 (98.72)
Raffinose (%)	0.43^{a}±0.09 (0.00)	0.14^{b}±0.03 (67.44)	0.07^{c}±0.12 (83.72)	0.02^{a}±0.05 (95.35)
Stachyose (%)	0.51^{a}±0.04 (0.00)	0.16^{b}±0.10 (68.63)	0.10^{c}±0.08 (80.39)	0.04^{b}±0.20 (92.17)

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at P = 0.05. TTA = total titratable acidity; TIA = trypsin inhibitor activity. Values in parenthesis indicate percent reduction

The pH and total titratable acidity of the flour prepared from unsteeped but autoclaved seeds were 5.53 and 0.13%, respectively. Steeping the seeds for 24h led to increase in pH to 5.81 and a decrease in total titratable acidity to 0.10. Prolonging the steeping time to 48 and 72h resulted in decreased in pH while the total titratable acidity significantly ($p<0.05$) increased.

The results on Table 2 also show that phytate, tannin, trypsin inhibitors, raffinose and stachyose significantly ($p<0.05$) decreased from 8.60mg/100g, 7.90mg/100g, 18.72TIU/mg, 0.43% and 0.51% in the flour from unsteeped but autoclaved seeds to 1.65mg/100g, 1.10mg/100g, 0.24TIU/mg, 0.01% and 0.03%, respectively in the flour from 72h steeped and autoclaved seeds.

3.3 Effect of the Treatment on Functional Properties of AYB Flour

Data on Table 3 depicts the effect of steeping time prior to autoclaving on some functional properties of African yam bean flour.

Table 3: Effect of steeping time prior to autoclaving on functional properties of African yam bean flour

Parameters	Soaking Time (hrs)			
	0	24	48	72
Bulk density (g/cm^3)	$0.67^a \pm 0.01$	$0.64^a \pm 0.05$	$0.63^a \pm 0.02$	$0.61^a \pm 0.04$
OAC (ml/g)	$0.75^a \pm 0.09$	$0.78^a \pm 0.12$	$0.77^a \pm 0.06$	$0.79^a \pm 0.11$
WAC (ml/g)	$1.82^a \pm 0.14$	$1.75^b \pm 0.08$	$1.71^b \pm 0.03$	$1.69^b \pm 0.05$
Foaming capacity (%)	$2.65^b \pm 0.06$	$3.82^a \pm 0.04$	$3.86^a \pm 0.10$	$3.92^a \pm 0.02$
Swelling index (ml/g)	$1.58^a \pm 0.03$	$1.44^a \pm 0.02$	$1.32^a \pm 0.05$	$1.21^b \pm 0.08$

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at P = 0.05. OAC = oil absorption capacity; WAC = water absorption capacity.

The result showed that the bulk density, water absorption capacity (WAC) and swelling index progressively decreased while oil absorption capacity (OAC) and foaming capacity increased with longer steeping time. The bulk density, water absorption capacity and swelling index decreased from 0.67g/cm^3, 1.82ml/g and 1.58ml/g for the flour prepared from unsteeped but autoclaved seeds to 0.61g/cm^3, 1.69ml/g and 1.21ml/g, respectively for the flour from seeds that were steeped for 72h prior to autoclaving. Conversely, the oil absorption capacity and foaming capacity increased from 0.75ml/g and 2.65% for the flour prepared from unsteeped seeds to 0.79ml/g and 3.92%, respectively for the flour from the seeds that were steeped for 72h prior to autoclaving.

4. DISCUSSION

4.1 Effect of Treatment on Amino Acid Profile of AYB Flour

Steeping legumes in water or alkaline solution for varying period is a traditional practice that impart positively on the nutritional qualities of these legumes for those who consume them. Amino acids are component subunits of proteins and are used for growth and maintenance of living systems. The observed higher levels of total amino acids and total essential amino acids in the flours from the steeped seeds relative to unsteeped seeds prior to autoclaving (Table 1) could possibly be due to the solubilization of some easy hydrolyzing components and their migration to steeped solution resulting in amino acids increase by concentration effect [28, 29]. This result is in agreement with the findings of Bujang and Taib [20] who reported that soaking of soybean, groundnut and garbanzo beans for 18h resulted in increases in amino acid contents of the soaked product. Ferial and Esmat [30] also reported that soaking for 12hr increased the essential amino acids content in chickpea seeds by 8.76% and attributed the increment to the hydrolytic breakdown of the components during soaking. Other authors [19, 29, 31] similarly reported of increases in protein content of legume seeds during soaking.

The long-term steeping (48 – 72h) might have resulted in increased multiplication of microflora in the seeds and this might have contributed to increase in protein content of the flour with steeping period. Balogun [19] had similarly reported that the protein and essential amino acids content of *Bauhinra* seed meal increased with soaking time ranging from 30.81% and 0.63% for seeds that were soaked for 24h to 32.45% and 0.64% for seeds that were soaked for 96h. The observed glutamic acid as the major contributor in the total amino acids and leucine as the major contributor in the total essential amino acid are in accordance with the report by Bujang and Taid [20] for soybean, groundnut and garbanzo beans.

4.2 Effect of Treatment on pH, Total Titratable Acidity and Anti-nutrients in the AYB Flour

Steeping of dry cereal and legume seeds is usually associated with migration of the steeped water or solution into the steeped seeds. Therefore, the observed highest pH value (5.81) and lowest total titratable acidity value (0.10%) for the flour from seeds that were soaked for 24h (Table 2) could be attributed to the migration of the ash solution (alkaline solution) into the steeped seeds. The drop in pH and increase in total titratable acidity with extension of steeping time to 48 and 72h might be attributed to the actions of micro-organisms which could have induced acidity. The acid produced in the steeping solution might have diffused into the seed thereby increasing the total titratable acidity content of the flour from the seeds that were steeped for 48 and 72h. Hassan *et al.* [32] similarly reported of decrease in pH and increase in total titratable acidity of cocoyam soaked in distilled water for 72h. Mulyowidarso *et al.* [33] reported that lactic acid bacteria dominate during the soaking stage of a traditional process and as a result, a significant increase in organic acids takes place.

African yam bean seed is a valuable source of protein for human consumption [7, 8]. However, phytate, tannin and trypsin inhibitor present in the seed as anti-nutrients hinder digestion of protein and suppress release of amino acids for absorption into the body thereby reducing nutritional value. Result on Table 2 revealed that flour prepared from unsteeped but autoclaved seeds had significantly ($p<0.05$) higher levels of phytate, tannin and trypsin inhibitors than the flour from steeped and autoclaved seeds. The lower levels of these anti-nutrients in the flours from the steeped seeds relative to their values in the flour from unsteeped but autoclaved seeds could be attributed to their leaching out into the steeped solution under the influence of concentration gradient. Steeping of legumes in alkaline solution have been reported to enhance permeability of the seed coat, soften the cotyledon and help the leaching out of anti-nutrients into the steeping medium [34]. Other authors had similarly reported of reduction of anti-nutrients in legume seeds as a result of soaking in water or bicarbonate solution [21, 34, 35, 36]. Longer steeping time resulted in higher reduction of phytate, tannin and trypsin inhibitor in the flour ranging from 39.42, 32.15 and 44.18% reduction for the flour from seeds that were steeped for 24h to 80.81, 86.08 and 98.72%, respectively for flour from seeds that were steeped for 72h. Similar observations were reported by other authors [37, 38]. Reduction of these anti-nutrients is essential to improve the nutritional quality of the flour and effective utilization of the full potential of the flour as a source of protein.

The oligosaccharides (raffinose, stachyose and verbascose) present in legume seeds have been identified as one of the major contributors of flatulence [31, 39]. Soaking of raw legumes in water or bicarbonate solution is recommended to reduce oligosaccharides and their attendant physiological effects of flatulence with legume consumption [40]. The result of the present study showed that flour from unsteeped seeds had significantly ($p<0.05$) higher contents of raffinose and stachyose than flours from the steeped seeds. Reddy *et al.* [41] reported that the raffinose and stachyose are soluble in water and that soaking beans in water and discarding the soaked water will remove most of these sugars from the beans. The lower levels of raffinose and stachyose in the flour from the steeped seeds relative to their values in the flour from the unsteeped seeds could therefore be due to their leaching out into the steeped solution. Similar observation had been reported by other authors [18, 21, 42]. The extent of losses of both raffinose and stachyose was enhanced as the steeping time was increased ranging from 67.44 and 68.63% reduction for the flour from the seeds that were soaked for 24h to 95.35 and 92.17%, respectively for the flour from the seeds that were steeped for

72h. This observation is in accordance with the report by Vijayakumari *et al.* [39].

4.3 Effect of Treatment on Functional properties of AYB Flour

Functional properties like bulk density, water absorption capacity, oil absorption capacity, foaming capacity and swelling capacity of flour are critical in determining the suitability of such flour for a given purpose. The effect of steeping time prior to autoclaving on the functional properties of African yam bean flour as presented on Table 3 revealed that steeping duration had varying effects on the functional properties of the flour. The insignificant ($p>0.05$) reduction in bulk density of the flours with increasing steeping time could be attributed to decrease in carbohydrate with steeping time. According to Bhattachrya and Parkash [43], bulk density of flour increased with starch content. Similar reduction of bulk density as a result of soaking had been reported by other authors [44,45]. Bulk density is one of the parameters that help to decide the packaging material [45]. The low bulk densities exhibited by the flours are desirable in infant food production. The lower their values, the greater the amount of flour particles that can bind together leading to higher energy value [46].

All the flours exhibited high oil and water absorption capacities (Table 3). The increase in oil absorption capacity with longer steeping time could be attributed to increase in protein content with steeping time. This observation is in agreement with the reports by Agume *et al.* [35] and Desalegn [45]. The chemical component affecting oil absorption capacity is protein which is composed of both hydrophilic and hydrophobic parts. Non-polar amino acid side chain can form hydrophobic interaction with hydrocarbon chain of lipid [47]. Oil absorption capacity is of great importance since fat acts as flavour retainer, increases the mouth feel and improves palatability of food [48]. The high oil absorption capacity of the flour samples suggests that they could be useful in the preparation of bakery products, sausages and doughnuts [46].

The result showed that both water absorption capacity and swelling index insignificantly ($p>0.05$) decreased with steeping time (Table 3). This could be attributed to reduction in carbohydrate with steeping time. According to Tester and Morrison [49], the swelling capacity is due to the amount of amylopectin fraction in starch, which is subject to degration during soaking. Yellavila *et al.* [50] noted that swelling power is a measure of hydration capacity because the determination is a weight measure of swollen starch granule and other occluded water. Water absorption and swelling capacities are important parameters which ultimately determine sample consistency and are dependent on compositional structure of the sample [51].

Also, both water absorption and swelling capacities contribute to dough formation and stability [52]. The water absorption capacity and swelling index results obtained in this study are in accordance with the report by Aguma *et al.* [35]. Both the flour from unsteeped and steeped seeds exhibited very poor foaming capacity. The insignificant ($p<0.05$) increase in foaming capacity of the flour with longer steeping time (Table 3) could be due to increase in protein content with steeping time. According to Yellavila *et al.* [50], foaming capacity generally depends on the interfacial film formed by protein, which maintains the air bubbles in suspension and slows down the rate of coalescence.

5. CONCLUSION

The present study demonstrated that steeping African yam bean seeds in 0.50% solution of unripe plantain peel ash for 24 to 72h prior to autoclaving resulted in enhancement in total amino acids and total essential amino acids. Conversely, phytate, tannin, trypsin inhibitor and flatulence causing raffinose and stachyose significantly ($p<0.05$) decreased with steeping time. Bulk density, water absorption capacity and swelling index decreased while oil absorption and foaming capacities increased with steeping time.

Competing Interest

No competing interest

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