

Influence of Roasting on Nutritional and Anti-nutritional Factors of Jackbean, *Canavalia ensiformis* (L) D.C. Flour

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Abstract

Jackbean (*Canavalia ensiformis*) is an underutilized legume but with high nutritional value. Prolonged cooking time, tough testa and presence of anti-nutrients have been its militating factors. Jackbean obtained from International Institute of Tropical Agriculture (IITA), Ibadan were sorted, dehulled and subjected to roasting at 160 °C for (10-50 min). The beans were thereafter milled into flour (1 μ m) and analyzed for nutritional and anti-nutritional factors. The result revealed that roasting had a reducing effect on moisture and crude fibre contents ($7.57 \pm 1.90 - 5.07 \pm 0.11\%$) and ($5.01 \pm 0.33 - 4.43 \pm 0.02\%$) respectively. However, incremental effect was recorded for fat, ash and carbohydrate contents: ($3.83 \pm 0.06 - 4.45 \pm 0.05\%$), ($4.39 \pm 0.17 - 4.72 \pm 0.08\%$) and ($46.29 \pm 0.63 - 49.43 \pm 0.07\%$) respectively. Highest protein ($34.17 \pm 0.15\%$) content was recorded upon roasting at 160 °C for 40 min. Anti-nutritional factors result showed that roasting had a reducing effect on phenolic ($2.52 \pm 0.06 - 1.98 \pm 0.04$ mg/g), tannin ($1.67 \pm 0.08 - 0.86 \pm 0.02$ mg/g), oxalate ($0.08 \pm 0.01 - 0.05 \pm 0.02$ mg/g), trypsin inhibitor ($29.10 \pm 0.01 - 18.15 \pm 0.08$ mg/g) while slight incremental effect was recorded for phytate ($0.15 \pm 0.01 - 0.36 \pm 0.01$ mg/g) and saponin ($0.53 \pm 0.03 - 0.85 \pm 0.07$ mg/g). This study revealed that roasting improved the bioavailability of significant percentage of proximate constituents of jackbean and reduced major anti-nutritional factors.

Keywords: Roasting, jackbean, nutritional, anti-nutritional, legume

Introduction

Legumes are the pea and beans family referred to as *Leguminoceae*. This comprises the Senna Family (*Caesalpinaceae*), Locust bean (*Mimosaceae*), and *Pappilionaceae* (Agbolade, 2012, Akande, Odedeji and Agbolade, 2014). They are of nutritional significance being sources of protein, energy and other nutrients in diets of most developing countries. Their seeds contained as high as 20 to 50 % protein, which is well above twice the level found in cereal grains and significantly more than the level in conventional root crops (Chel-Guerrero *et al.*, 2002). The protein is high in lysine content, a factor of much nutritional importance especially when combined with cereal proteins that have lower level of this amino acid (Duranti and Gaius, 1997).

Legumes surpass meat in most nutrients except for their low fat content (which even makes them healthier) and vitamin B₁₂. There is no other food as rich in protein as legumes in their natural state. The protein contained most of the essential and non-essential amino acids in proportions very similar to those of animal protein. They therefore, form a healthy alternative for obtaining proteins compared to animal food such as meat (NSRL, 2002). They are generally anti-diabetic; prevent constipation by promoting proper bowel function due to their high fibre content. They equally combat iron-deficiency anemia (Akande *et al.*, 2013). Legumes contained phytochemicals and so reduce the risk of colon cancer (Okon, 1983). The carbohydrate content is about 60 (%) in which starch constitutes the major portion (Okon, 1983).

Legumes are of two major types, the major and minor. Major legumes include; soybean, groundnut, cowpea and African locust bean while the minor ones are Bambara groundnut, Lima beans, Pigeon peas, Lablab, Jackbean which are otherwise known as miscellaneous, neglected, and underutilized (Omitogun *et al.*, 2001; Aremu *et al.*, 2006 and Adebooye, 2008). The major legumes have received much research attention unlike the minor legumes.

Jackbean (*Canavalia ensiformis*), referred to as "Sese nla" in Yoruba, is one of the common tropical legumes that does well in Nigeria but it is neglected (Okonkwo and Udedibie, 1991). It is native to tropical America, Southern United States of America. The seeds are rich in most essential amino acids, including those deficient in wheat (Lawal and Adebawale, 2005). It has potential in product development and consumption, which is on the low side because of its peculiar beany flavour and prolong cooking time (Akande *et al.*, 2013). Legumes generally present some attendant problems such as the presence of some anti-nutritional factors, extensive period of processing, and tough seed coat. These are more pronounced in Jackbean and have affected the nutritional compositions of the crop.

In order to ameliorate these problems associated with legumes, various pre-processing methods have been employed in order to improve the processing, nutritional quality, organoleptic acceptability, reduction in the oligosaccharides and other anti-nutritional factors in them. Some of the commonly used pre-processing methods include; soaking, boiling at high temperatures (in water, alkaline or acidic solutions), sprouting, autoclaving, dehulling, fermentation, microwaving, steam blanching and roasting (El-Adawy, 2002 and Skulinova *et al.*, 2002). These have been found to improve the nutrient compositions of the food crops. Roasting has been shown to reduce viscosity through dextrinization (Ezeocha and Onwuka, 2010). It improves flavour, impact colour that hypothetically resulted from the reaction of reducing sugars with amino acids, peptides and protein as implicated in maillard reaction or caramelization from roasting temperature (Kirbaslar and Erkmen, 2003). This study therefore investigated the effect of roasting on the nutritional and anti-nutritional factors of Jackbean (*Canavalia ensiformis*) flour.

Materials and Methods

Materials

The seeds of Jackbean (*Canavalia ensiformis*) with Accession Number: TCe4 locally referred to as "Sese nla" was procured from the Genetic Resources Unit of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Methods

Preparation of the beans

The fruits pods after maturity (four months) were harvested from the parent plants and sun dried to 15% moisture content. The beans were removed from the pod by shelling. The Jackbean were thereafter winnowed to remove chaff.

Roasting

The method reported by Adebisi *et al.* (2002) was adopted for roasting of the Jackbean seed. Two hundred grams (200 g) of the beans were dehulled and dried inside regulated oven to reduce the moisture content to 12 %. The dried seeds were roasted inside universal hot air regulated oven at 160 °C for 10, 20, 30, 40 and 50 min after cleaning and sorting operation. The beans were allowed to cool and milled into flour (1µm) using the flow chart in Fig 1.0 below.

The flour samples were packaged using high density polyethylene material for further analytical work (Uche *et al.*, 2014).

Effect of Roasting on Proximate Constituents of Jackbean Flour

The proximate constituents: moisture content, crude protein, fat, ash, crude fibre were determined according to the method described by AOAC (2006). Carbohydrate was determined by difference between the addition of all other proximate constituents and 100.

Effect of Pre-treatment on the Anti-nutritional Factors of the Flour

Phytate content

The phytate content of the flour was determined using the method of Inuwa *et al.*, (2011). Two (2 g) of each finely ground flour sample was soaked in 20 ml of 0.2N HCl and filtered. After filtration, 0.5 ml of the filtrate was mixed with 1ml Ferric ammonium sulphate solution in a test tube, boiled for 30 min in a water bath, cooled in ice for 15 min and centrifuged for 15 min. One milliliter 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.

Tannin content

Tannin content was determined by adding 10 ml, 70% aqueous acetone to 200 mg of finely ground sample in a bottle and properly covered. The bottle was placed in an ice bath shaker for 2 hr at 30 °C. The solution was centrifuged and the supernatant was stored in ice. After this, 0.2 ml of the supernatant was pipetted into 0.8 ml distilled water. Standard tannic acid solution was prepared. Folin reagent (0.5 ml) was added to both samples and standard followed by 2.5 ml 20% Na₂CO₃. The solution was vortexed and allowed to incubate for 40 min at room temperature after which absorbance was read at 725 nm. The concentration of tannin in the sample was estimated from the standard tannic acid curve (Makkar and Goodchild, 1996).

Oxalate content

Titration method described by Inuwa *et al.* (2011) was used to determine the oxalate content. One gram of the sample was weighed into 100 ml conical flask where 75 ml 3N N₂SO₄ added and stirred intermittently with a magnetic stirrer for 1 hr. It was filtered using whatman No. 1 filter paper. From the filtrate, 25 ml was taken and titrated while hot (80 – 90 °C) against 0.1N KMnO₄ solution until a faint pink colour persisted for at least 30 sec.

Polyphenols content

The total polyphenols in the sample was determined using spectrophotometric method with tannic acid as the standard according to the method described by Oladele *et al.* (2009).

Trypsin inhibitor

The method of Arntified *et al.* (1985) was used in the determination of trypsin inhibitor. 0.5 g of the sample was dispensed in 50 mls of 0.5 m NaCl solution and shaken for 30 min at room temperature. The mixture was centrifuged and the supernatant was used as the extract. Assay for trypsin activity involved mixing a portion (1ml) of the extract with 90 mls of 0.03% trypsin substrate in a test tube containing 1ml of 0.6% trypsin enzyme solution. After mixing, the mixture was allowed to stand for 15 min before its absorbance was read at 410 nm in a spectrophotometer.

A control, which consists of 1ml enzyme solution in 9 mls of Trypsin substrate but no extract, was set up as described above. The absorbance for the control was measured. Trypsin inhibitor activity was calculated using the formula:

$$\text{Tml/g} = \frac{1}{W} \times \frac{au-as}{0.01} \times \frac{vf}{va}$$

Where:

w	=	Weight of sample
au	=	Absorbance of sample at 410 nm
as	=	Absorbance of control
vf	=	Total extract volume
va	=	Volume of extract analyzed

Saponin content

The solvent extraction gravimetric method described by Nwosu, (2010) was used for the determination of saponin content of the sample. Two grams of the sample was mixed with 50 ml of 20% aqueous ethanol solution. The mixture was incubated at 55 °C in a water bath with periodic agitation for 90 minutes. It was then filtered through whatman filter paper (No. 40). Saponin was extracted with 60 ml of normal butanol solution and evaporated to dryness in a pre-weighed evaporating dish. It was dried at 60 °C for 30 min in the oven (to remove any residual solvent), cooled and re-weighed. The saponin content was determined by difference and calculated as a percentage of the original sample thus:

$$\% \text{ Saponin} = \frac{W_2 - W_1}{\text{Wt of sample}} \times \frac{100}{1}$$

Where:

W ₁	=	Weight of evaporating dish
W ₂	=	Weight of dish of sample

Results and Discussion

Effect of Roasting on Proximate Compositions of Jackbean Flour

The result of the effect of roasting on proximate compositions of Jackbean flour is presented in Table 1.0. Raw sample (R₀) sample roasted at 160 °C for 10 min (R₁) recorded similar mean value of 7.57 ± 1.90% while sample roasted at the same temperature for 20 min recorded a mean value of 7.53 ± 0.46% but with similar significant effect (P<0.05) for moisture content. Samples R₃ and R₅ equally displayed similar significant effect but lower means of 5.73 ± 0.46 and 5.07 ± 0.11% respectively compared to R₀, R₁ and R₂. It was discovered that as roasting time increases, the moisture content was reducing. Lowest moisture content of 5.07 ± 0.11% was recorded by sample roasted at 160 °C for 50 min (R₅). The lower moisture content of the flours indicated that it would store well and that nutrient would be preserved which support the observation of Olanipekun *et al.* (2015). Similarly, Chew *et al.* (2011) had reported that reduced moisture content ensures inhibition of microbial growth thus preserving the product.

Roasted Jackbean flour at 160 °C for 40 min (R₄) showed higher significant effect (P<0.05) and mean 34.17 ± 0.15% for protein. It was observed that as the roasting time was on the increase, the protein content was equally increasing and becoming more bioavailable from 32.13 ± 0.70% in R₁ to 34.17 ± 0.15% in sample R₄ that recorded the highest protein content among all the samples (Table 1.0). The increase in protein content might be due to the destruction of anti-nutritional factor that is bounding the protein before this treatment. The increase in protein content due to roasting with time supports the findings of Olanipekun *et al.* (2015) who worked on effect of boiling and roasting on the nutrients compositions of Kidney beans seed flour. There was a sharp decrease in protein content (31.95 ± 0.05%) in sample roasted for 50 min. This might be due to protein denaturation due to prolonged roasting time.

Samples roasted at 160 °C for 40 min displayed a mean value of $4.37 \pm 0.06\%$ for fat content and sample roasted for 50 min recorded a mean value of $4.45 \pm 0.15\%$ for fat but showed no significant effect ($P < 0.05$) compared to the other roasting conditions and the untreated sample for fat content. Samples R_1 and R_3 recorded similar significant difference, though with slightly varied mean values of $4.03 \pm 0.06\%$ and $4.10 \pm 0.16\%$ respectively, which was higher than those of untreated sample and R_2 that recorded similar significant effect and mean values of $3.83 \pm 0.06\%$ and $3.90 \pm 0.00\%$ respectively.

It was observed that as roasting time increases, the fat content showed slight increase until 40 min of roasting and decreased thereafter. The increase in fat content might be because of the fact that direct heat helps to release oil from the cells of nuts and oil seed (Mohini and Eram, 2005). The reduction in the fat content at 50 min of roasting might be due to the subsequent loss of the released oil during milling as reported by Mohini and Eram, (2005).

The ash content of jackbean flour roasted at 160 °C for 40 min showed higher significant effect and mean value of $4.72 \pm 0.08\%$. There was noticeable decrease in this value to 4.67 ± 0.05 when the sample was roasted for 50 min. The ash content for the raw sample was $4.39 \pm 0.17\%$. Samples R_3 and R_5 showed similar significant difference, and mean values of $4.65 \pm 0.05\%$ and 4.67 ± 0.05 for ash content respectively. Roasting had a reducing effect on crude fibre, as the roasting time increased, the crude fibre was reduced from 5.01 ± 0.33 in R_0 to $4.43 \pm 0.02\%$ in R_5 . Higher significant effect ($P < 0.05$) with mean value of $5.01 \pm 0.33\%$ was recorded for raw sample. The carbohydrate content of the entire treated samples tend to increase with roasting time from $46.18 \pm 0.24\%$ in R_1 to $49.43 \pm 0.07\%$ in sample R_5 but there was slight reduction for sample R_1 compared with sample R_5 . Sample R_5 recorded the highest mean value for carbohydrate, which supported the submission of Nwosu, *et al.* (2011) work on the proximate and functional properties of African Yam Bean (*Sphenostylis sternocarpa*) seed as affected by roasting. The improvement in proximate compositions due to roasting especially sample R_4 might be due to the positive effect of roasting on the nutritive value and digestibility of legumes as reported by Vidal-Valverde *et al.* (2003) in their work on assessment of nutritional compounds and anti-nutritional factors in pea seeds.

Effect of Roasting on Anti-nutritional Factors of Jackbean Flour

The result of the effect of roasting on anti-nutritional factors of jackbean is presented in Table 2.0. Roasting is a heat treatment normally employed in food to drive off moisture and develop flavors e.g. roasting of coffee and nuts (Potters, 1987). The untreated jackbean flour showed higher significant difference ($P < 0.05$) and mean value of 2.52 ± 0.06 (mg/g) when compared with all the pre-processed samples. Samples R_1 , R_2 and R_3 showed no significant difference and mean values of 2.36 ± 0.03 , 2.27 ± 0.02 and 2.23 ± 0.03 mg/g respectively while samples R_4 and R_5 showed similar significant difference with varied means of 2.09 ± 0.16 and 1.98 ± 0.04 mg/g for phenolic compound. It was however observed that, as the roasting time increased the phenolic compound was reduced steadily from 2.36 ± 0.03 to 1.98 ± 0.04 . The reduction in this anti-nutritional factor over the roasting time is supported by the view of Udensi *et al.* (2008) on reduction in this parameter in legumes. Roasting of the seed at 160 °C for 50 min resulted in the least content of phenolic compound (1.98 ± 0.04 mg/g). This might be due to the effect of heat treatment (roasting) on this parameter.

Tannin recorded higher significant difference ($P < 0.05$) with a mean of 1.67 ± 0.08 mg/g for the raw sample (R_0) compared to other pre-processed samples. Similarly, reducing effect was observed for this factor over the roasting time. There was reduction from 1.04 ± 0.02 in sample R_1 to 0.86 ± 0.02 (mg/g) in sample R_5 . This observation supported the finding of Adegunwa *et al.* (2012) on reduction in tannin due to effect of thermal processing of Benniseed (*Sesamum indicum*) flour. Similarly, Jeanne *et al.* (2005) reported decrease in tannin content of red peanut and small red kidney beans due to roasting. The chemical property that provides the basis for most uses of tannin is its ready formation of precipitates with albumin gelatin and many alkaloids and metallic salts (Microsoft Encarta, 2006).

Higher significant difference ($P < 0.05$) with mean of 0.36 ± 0.01 was recorded for phytate for sample R_5 as opposed to other pre-processed samples and the untreated sample. Samples R_1 and R_2 showed no significant difference but slightly varied mean of 0.12 ± 0.02 and 0.13 ± 0.04 mg/g for this factor, which represented the least significant difference and mean. It was observed that there was steady increase starting from 0.19 ± 0.01 in sample R_3 up to 0.36 ± 0.01 in sample R_5 for this factor. Phytate is an important constituent of legumes, which is capable of chelating divalent cationic mineral like calcium ion, magnesium and zinc. Such chelates make the element nutritionally unavailable thereby introducing dietary deficiency. It equally inhibits the activity of enzymes (Microsoft Encarta, 2006). The level of occurrence of this anti-nutritional factor in the sample is low.

The level of occurrence of oxalate as an anti-nutritional factor in the sample is low. However, samples R_1 and R_2 showed no significant difference ($P < 0.05$) but with varied means of 0.15 ± 0.01 and 0.13 ± 0.02 for this anti-nutritional factor compared to other samples and the untreated sample. There is no significant difference ($P < 0.05$) between samples R_3 , R_4 and the untreated sample R_0 with mean value of 0.08 ± 0.01 while sample roasted at 160°C for 50 min had the least mean of 0.05 ± 0.02 , which implied that roasting had a reducing effect on this anti-nutritional factor. This is in line with the ascertainment of Udensi *et al.* (2008) on Bennisseed. Oxalate when absorbed by the intestine causes hyperoxaturia that in turns makes the risk of developing kidney stone greater.

Saponin showed higher significant ($P < 0.05$) effect for sample R_1 and a mean value of 0.97 ± 0.01 compared to other samples and the control. The raw sample recorded the least value of 0.53 ± 0.03 for this anti-nutritional factor while samples R_2 and R_3 showed no significant difference but with slightly varied means of 0.90 ± 0.07 and 0.88 ± 0.11 respectively, which is higher than the value recorded for samples R_4 (0.82 ± 0.03) and (0.85 ± 0.01) for R_5 that have no significant difference. The value for this anti-nutritional factor ranged between 0.97 ± 0.01 and 0.53 ± 0.03 % in the raw sample. Though there was slight increase from 0.53 ± 0.03 in R_0 to 0.97 ± 0.01 in R_1 , but as roasting time progressed, there was steady reduction to 0.82 ± 0.03 in sample R_4 . Saponin causes hypercholesterolemia by binding cholesterol, making it unavailable for absorption. They also cause hemolysis of red blood cells and are toxic to rats (Johnson *et al.*, 1986).

Trypsin inhibitors are prominent example of heat labile anti-nutritional factor that prevent protein metabolism (Myrene, 2013). There was drastic reduction in this anti-nutritional factor as the roasting time increased from 30.13 ± 0.16 in sample R_1 to 18.15 ± 0.08 in sample R_5 , which corroborated the ascertainment of Myrene, (2013). Sample of jackbean flour produced from roasted jackbean seed at 160°C for 10 mins displayed higher ($P < 0.05$) significant effect with a mean value of 30.13 ± 0.16 while sample R_5 showed the least significant effect and mean value of 18.15 ± 0.08 . This anti-nutritional factor possesses the ability to combine in a very specific manner with a number of proteolytic enzymes present in the digestive secretion of animals (Liener and kakade, 1980).

Conclusion

This study revealed that roasting, a pre-processing method, had effect on the proximate constituents of jackbean flour. There was reduction in moisture content of the sample over the roasting time. Protein became more bioavailable upon roasting for 40 min and became denatured beyond this time. There was improvement in significant percentage of proximate constituent. Roasting as a pre-processing method has a reducing effect on the anti-nutritional factors except for phytate and saponin that showed insignificant increase.

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Conflict of Interests

None

Tables, Figures and Charts

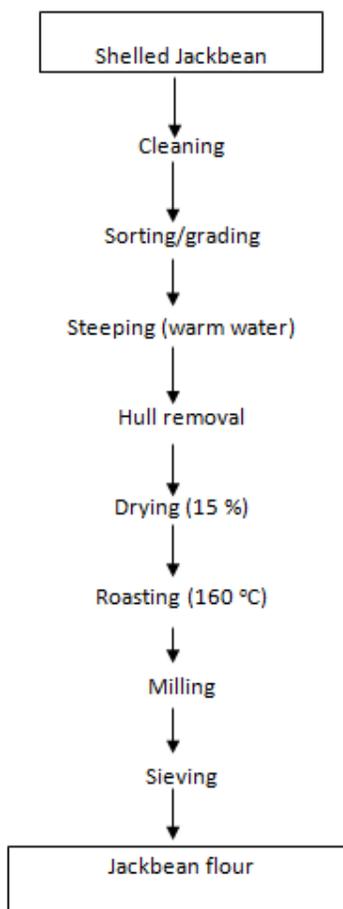


Fig. 1: Flow Chart for Flour Production from Jackbean (Uche *et al.*, 2014).

Table 1: Effect of Roasting on Proximate Constituents of Jackbean Flour

Parameters (%)	Ro	R ₁	R ₂	R ₃	R ₄	R ₅
Moisture Content	7.57 ± 1.90 ^a	7.57 ± 0.11 ^a	7.53 ± 0.46 ^a	5.73 ± 0.46 ^b	6.20 ± 0.20 ^{ab}	5.07 ± 0.11 ^b
Protein	32.02 ± 0.03 ^c	32.13 ± 0.70 ^c	32.47 ± 0.64 ^{bc}	33.13 ± 0.23 ^b	34.17 ± 0.15 ^a	31.95 ± 0.05 ^c
Fat	3.83 ± 0.06 ^c	4.03 ± 0.06 ^b	3.90 ± 0.00 ^c	4.10 ± 0.16 ^b	4.37 ± 0.06 ^a	4.45 ± 0.05 ^a
Ash	4.39 ± 0.17 ^c	4.49 ± 0.02 ^{bc}	4.55 ± 0.05 ^{abc}	4.65 ± 0.05 ^{ab}	4.72 ± 0.08 ^a	4.67 ± 0.05 ^{ab}
Crude Fibre	5.01 ± 0.33 ^a	4.83 ± 0.40 ^{ab}	4.55 ± 0.05 ^{bc}	4.43 ± 0.05 ^c	4.43 ± 0.03 ^c	4.43 ± 0.02 ^c
Carbohydrate	46.29 ± 0.63 ^{cd}	46.18 ± 0.24 ^d	47.00 ± 0.00 ^c	47.87 ± 0.67 ^b	46.30 ± 0.00 ^{cd}	49.43 ± 0.07 ^a

Values are means of triplicate determinations

Means with the same alphabets are not significantly different ($P \leq 0.05$)

- Ro = Raw (Untreated Jackbean Flour)
 R₁ = Roasted Jackbean Flour at 160 °C for 10 min
 R₂ = Roasted Jackbean Flour at 160 °C for 20 min
 R₃ = Roasted Jackbean Flour at 160 °C for 30 min
 R₄ = Roasted Jackbean Flour at 160 °C for 40 min
 R₅ = Roasted Jackbean Flour at 160 °C for 50 min

Table 2: Effect of roasting on anti-nutritional factors of jackbean flour

Parameters	Ro	R ₁	R ₂	R ₃	R ₄	R ₅
Phenolic (mg/g)	2.52 ± 0.06 ^a	2.36 ± 0.03 ^b	2.27 ± 0.02 ^b	2.23 ± 0.03 ^b	2.09 ± 0.16 ^c	1.98 ± 0.04 ^c
Tannin (mg/g)	1.67 ± 0.08 ^d	1.04 ± 0.02 ^b	1.01 ± 0.01 ^b	0.99 ± 0.01 ^{bc}	0.92 ± 0.08 ^{cd}	0.86 ± 0.02 ^d
Phytate (mg/g)	0.15 ± 0.01 ^{cd}	0.12 ± 0.02 ^d	0.13 ± 0.04 ^d	0.19 ± 0.01 ^{bc}	0.20 ± 0.01 ^b	0.36 ± 0.01 ^a
Oxalate (%)	0.08 ± 0.01 ^b	0.15 ± 0.01 ^a	0.13 ± 0.02 ^a	0.08 ± 0.01 ^b	0.08 ± 0.01 ^b	0.05 ± 0.02 ^c
Saponin (%)	0.53 ± 0.03 ^c	0.97 ± 0.01 ^a	0.90 ± 0.07 ^{ab}	0.88 ± 0.11 ^{ab}	0.82 ± 0.03 ^b	0.85 ± 0.07 ^b
Trypsin Inhibito (%)	29.10 ± 0.01 ^b	30.13 ± 0.16 ^a	23.78 ± 0.42 ^c	22.88 ± 0.14 ^d	21.89 ± 0.03 ^e	18.15 ± 0.08 ^f

Values are means of triplicate determinations

Means with the same alphabets are not significantly different ($P \leq 0.05$)

Ro = Raw (Untreated Jackbean Flour)

R₁ = Roasted Jackbean Flour at 160 °C for 10 min

R₂ = Roasted Jackbean Flour at 160 °C for 20 min

R₃ = Roasted Jackbean Flour at 160 °C for 30 min

R₄ = Roasted Jackbean Flour at 160 °C for 40 min

R₅ = Roasted Jackbean Flour at 160 °C for 50 min

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