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Qualities Of African Breadfruit (Treculia Africana) Seed Flour As Influenced By Thermal Processing Methods And Duration

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ABSTRACT: The effects of thermal processing methods and duration on some nutritional and anti-nutritional composition of African breadfruit seed (Treculia africana) flour were investigated. Matured African breadfruit seeds were sorted, washed and drained. The drained seeds were dehulled manually to obtain a full fat dehulled breadfruit seed. With the initial nutritional and anti-nutritional compositions determined, the samples were divided into three portions of 600g each of the breadfruit seed. The three portions were boiled, roasted and autoclaved respectively. The boiled and autoclaved samples were dried in an oven set at 60°C for 15mins. Similar quantity was left raw to serve as control. All samples were milled into flour of particle size 1mm mesh. The flours were analyzed for their nutritional and anti-nutritional composition using standard methods. The results showed that the raw sample contained 3.33%, 4.33%, 15.67%, 4.64%, 25.62% and 43.49% of moisture, ash, crude fat, crude fibre, crude protein and carbohydrate (CHO) respectively. It also contains 1.49mg/100g, 1.30TUI/mg, 32.03mg/100g, 2.07mg/100g, 4.00% and 3.24mg/100g of Hydrogen cyanide (HCN), Trypsin inhibitors, Tannin, Phytate, Alkaloids and Oxalate respectively. Boiling and autoclaving yield a better fat and CHO content, with boiling for 90mins having the highest fat content of 18.50%. Increase in thermal processing duration also resulted to a significant ($P<0.05$) decrease in crude fibre and ash content. Roasting was more effective in reducing moisture content as roasting for 90mins significantly ($P<0.05$) reduced moisture content to as low as 1.67%. There was a significant decrease ($P>0.05$) in anti-nutritional composition of the flour irrespective of the thermal processing methods and duration. Boiling and autoclaving for 90mins significantly ($P<0.05$) reduced hydrogen cyanide content to as low as 0.48mg/100g and 0.80mg/100g respectively and reduced phytate to 0.79mg/100g and 0.57mg/100g respectively. Statistically, no significant difference ($P>0.05$) was observed in the mean values of the boiled and autoclaved samples for tannins. It was concluded that either of the thermal processing methods used in the study can be used as a safe processing method for African breadfruit seed. Boiling or autoclaving of breadfruit seed prior consumption or conversion into flour is recommended in terms of increased nutrients and reduced anti-nutrients. This electronic document is a "live" template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document. (Abstract)

Keywords: Autoclaving, boiling, carbohydrate, fat, hydrogen cyanide, phytate**,** Component; Formatting; Style; Styling; insert (keywords)

1 INTRODUCTION

African breadfruit (Treculia africana), is a tropical African leguminous crop of the family moraceace and genus treculia. It is an important food crop in Nigeria, and is widely grown in the humid South Eastern ecological zone of Nigeria and humid rain forest of Southeast Cameroon [1]. African breadfruit (Treculia africana) locally referred to as Ukwa in Igbo language; it is one of the many treasured economical plants. The fruits are usually used as an economical substitute for yam. A matured seed of the crop is made up of the inner endosperm, an outer covering and the husk. The cooked seeds are a valuable food among the "Igbos" in particular and the Efiks, Kalabaris, Edos and the Ika Igbos in Delta State and most tribes of the Southern part of Nigeria [2]. The extracted seeds of T. africana are identified to become extremely healthy whenever it is correctly processed [3] [4]. The seeds are roasted and are useful as thickeners in soups and are eaten as snacks. The seed is a rich protein source (25-35%) therefore among the plants consumed in the world; it is one of the richest in terms of its benefits [5]. The de-fated seed contains 20% protein, which is higher than that for cereals and comparable to most pulses. It is primarily high in aromatic amino acids, hence making it a feasible method to obtain good quality protein [6]. The raw seed contains 40 - 45% carbohydrates and also a good amount of vitamins and minerals [7]. It is also a good source of vegetable oil 15 – 20%. The oil yield of the seed compares well with that of cotton seeds, palm kernel and sunflower seeds. The fat and oil content of the seed makes it probable industrial raw materials in producing pharmaceutical drugs, vegetable-oils, soaps, paints with perfumes [8]. The seeds are found to have an excellent polyvalent dietetic value with biological value of its proteins exceeding that of vegetable cowpea and soybean [9]. The use of breadfruit seed flour and wheat flour in composite bread production has been reported and could be used for pastries, weaning foods, breakfast cereals and non alcoholic beverages [10] [11] [12]. However, its usage is limited by the presence of anti-nutrients. Anti-nutrients are natural or synthetic substances found in plant materials like legumes. Breadfruit seed like any other legumes are known to contain some anti-nutrients, these includes hydrogen cyanide, tannins, haemagglutein, oxalate, alkaloids, lectins, saponins, protease inhibitors, stachyose, raffinose and flatulence factors [13]. This anti-nutrient limits the use of leguminous crops, and has the possibilities to adversely influence health and growth by means of avoiding the absorption of nutrients from food [5]. However, this anti-nutrient could be completely eliminated using techniques such as; autoclaving, roasting, fermentation, soaking, germination and boiling. The knowledge of the appropriate set of processing parameter will enhance the use of African breadfruit seed, to be a cheap necessary protein source. It will also help in formulation of very effective methods in eliminating its toxic component. The aim of this study was to evaluate the effects of thermal processing methods and duration on some nutritional and anti-nutritional compositions of African breadfruit seed flour.

2.0 Materials and Methods

2.1 Materials

The breadfruit variety that was used for this study was obtained from a market in Isiala-Mbano Local Government Area, Imo State, Nigeria. The reagents and chemicals used for the various analyses were of quality analytical grades.

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Equipment and utensils used for further analyses of this work were from Federal University of Technology Minna, Niger State, Nigeria.

2.2 Experimental Set-up
African breadfruit seeds were sorted, washed and drained. The drained seeds were dehulled manually to obtain a full fat dehulled breadfruit seed. With the initial nutritional and antinutritional compositions determined, the samples were divided into three portions, with each portion containing six hundred grammes (600g) of the breadfruit seed. The experiment was carried out using a Three by Three Completely Randomized Block Design (3 heat treatment x 3 time durations x 3 replicate =27). Data collected were analyzed statistically using the SPSS 16.0 statistical package, with analysis of variance based on t- test method and Duncan Multiple Range Test.

2.2.1 Preparation of Boiled Breadfruit Seed Flour Sample
Six hundred grammes (600g) of the dehulled raw breadfruit seed sample were weighed and subdivided into two hundred grammes (200g) each and boiled, using a conventional water bath at 100°C for 30, 60 and 90mins respectively. The breadfruit seeds were drained, oven dried at 60^{o}C for 15mins and milled in an attrition mill and passed through a sieve of mesh size 1mm. The dried seed flour were packaged and kept for further analysis.

2.2.2 Preparation of Roasted Breadfruit Seed Flour Sample
Six hundred grammes (600g) of the dehulled raw breadfruit seed sample were weighed and subdivided into two hundred grammes (200g) each and roasted using a hotbox oven set at 121°C for 30, 60 and 90mins respectively. The dried seeds were cooled and milled in an attrition mill to pass through a sieve of mesh size 1mm. The dried seed flour were packaged and kept for further analysis.

2.2.3 Preparation of Autoclaved Breadfruit Seed Flour Sample
Six hundred grammes (600g) of the dehulled raw breadfruit seed sample were weighed, and subdivided into two hundred grammes (200g) each and autoclaved. The autoclaving was carried out with the aid of an autoclaved set at 126°C, 15psi for 30, 60 and 90mins respectively. The autoclaved seed were drained and dried using an oven set at 60^{o}C for 15mins, and milled using an attrition mill then passed through a sieve of mesh size 1mm. The dried seed flour were packaged and kept for further analysis.

2.3 Nutritional and Anti-Nutritional composition determination
The nutritional composition of the bread fruit flour which includes the moisture content, ash, crude fiber, crude fat, crude protein, and carbohydrate as well as the anti nutritional compositions which includes trypsin inhibitor, tannin, phytate, alkaloid and oxalate contents were determined using prescribed methods [14].

3.0 Results and Discussion

3.1 Properties of the Raw (Undehulled) African breadfruit Seed Flour.
The raw Treculia africana seed flour consists of 3.33% moisture, 4.33% Ash, 15.67% crude fat, 4.64% crude fiber, 25.62% Crude protein and 46.74% Carbohydrates. A range of 3.65 – 5.60% for moisture content of breadfruit seed species from some countries had been reported [15], this agrees with results obtained in this study. Moisture content of less than 5% observed in the raw breadfruit seed could be attributed to be partially responsible for the longer shelf life of the dehulled breadfruit seeds for a longer period. The moisture level of food is usually a measure of the stability and susceptibility to microbial contamination [16] [17]. The ash content was similar to that of sesame seed 4.00% [18], the fat and fibre content were similar also similar to previous report [19]. The protein and carbohydrate content were higher than that of cowpea (20.05 and 48.00%) and lowers than that of soyabeans Glycine max (30.65 and 40.05) respectively [11]. The raw Treculia africana seed also consist of 1.49mg/100g Hydrogen cyanide, 1.30TUI/mg Trypsin inhibitor, 32.03mg/100g Tannin, 2.07mg/100g Phytate, 4.00% Alkaloid, 3.23mg/100g Oxalate. The Hydrogen cyanide is higher than the value for cowpea 20 mg/kg [20]. The trypsin inhibitor and alkaloids content of the raw breadfruit seed is similar to that reported for breadfruit seed samples 1.41TUI/mg and 3.39% respectively [21]. The tannin content was higher when compared with some plant of leguminous origin such as Brachystegia euryoma seed 15.15mg/100g. The value obtained for the phytate was lower than the 888 mg/g reported for moth beans and the value 51.6 mg/g reported for Prospis chilenisi (Vijayakumari et al., 1996). The result for oxalate is similar to the previous work done on the anti-nutrients in breadfruit seed flours (3.00mg/100g) [18].

3.2 Effects of thermal processing methods and time on the nutritional composition of African breadfruit seed flour
The results of the effects of thermal processing methods and time on some nutritional compositions of African breadfruit seed are presented in Table 1.

Moisture content
The result showed that there were significant ($p < 0.05$) decreases in the moisture contents of the boiled breadfruit seed samples irrespective of the boiling duration except boiling for 60mins (B60). The moisture content of the boiled breadfruit seed samples ranged between 2.00 - 3.67%. Boiling for 60mins (B60) had the highest moisture content in the boiled thermally processed samples, with a mean value of 3.67%. A significant loss in moisture content was also observed in the roasted breadfruit seeds when compared to the boiled and autoclaved seeds. The moisture content of the roasted breadfruit seed sample ranged between 1.67 - 3.33%. Roasting for 90mins (R90) had the lowest moisture content of 1.67%, the values for the moisture content at different roasting time were not significantly ($p < 0.05$) different except roasting for 30mins (R30) which was not significantly ($p < 0.05$) different from the raw sample. The mean values for moisture content of the autoclaved breadfruit seed samples ranged between 2.67 – 4.33%. The ANOVA shows that there were no significant ($p < 0.05$) difference in the autoclaved samples, irrespective of the thermal duration except in autoclaving for 90mins (A90), which had the highest moisture content of 4.33%. The result indicates that moisture contents were higher for boiled and

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autoclaved samples, and lower for roasted breadfruit seed samples. This could be attributed to the processing time and the high oven drying temperature (121^{o}C) used during oven roasting.

Ash content

The result for the ash content of the raw sample 4.33% was similar to the work done on Treculia africana seeds who reported 4.34% ash content [18]. The ANOVA shows that there were no significant difference ($p < 0.05$) in the ash content of all samples irrespective of the thermal processing method and duration, except boiling for 90mins (B90), which was not significantly different from the raw sample. The ash content ranged from 2.00 – 4.33%, ash values for breadfruit and sesame seeds from Turkey, Mexico, Uganda and Venezuela had been reported to be between 3.67 and 5.39%, which is within the range obtained from this study [23]. Thermal processing method and duration generally results in a significant decrease in the ash content of African breadfruit seed. The reduction could be attributed to leaching out of soluble inorganic salts during heating. The ash content indicates a rough estimation of the mineral content of the product.

Fat content

The fat content of the African breadfruit seeds ranged between 13.00 – 18.50%. However, boiling for 90mins (B90) was significantly better (18.50%) than roasting and autoclaving for 90mins (R90), which are 15.58 and 16.16% respectively. The results are similar to that previously reported that African breadfruit seed were not very rich in fat as compared to protein and are usually recommended as part of weight reducing diet [19]. The result of the ANOVA for the fat content of the African breadfruit seed showed that there are no significant differences ($p < 0.05$) between the raw sample and the roasted and autoclaved samples except for the boiled samples and the sample autoclaved for 30mins (A30). Irrespective of the thermal processing method used, there was a slight decrease in the fat content of the sample at 30 and 60mins, but as processing time increased to 90mins there was an increase in the fat content. Therefore, longer processing duration resulted to an increase in fat content of African breadfruit seed flour hence processing the seeds for longer time could make them a good source of fat.

Protein content

The protein content in the raw seed was found to be 25.62%. This value is higher than that of cowpea (20.05%) and lowers than that of soyabeans Glycine max (30.65%) [11] [20]. Roasting for 90mins (R90) had the highest crude protein content of 31.74%. Irrespective of the thermal processing method used in this study, there was a significant increase in protein content as processing duration increased. However, there are no significant ($p < 0.05$) difference between the raw, the boiled and roasted sample for 30 and 90mins respectively. These findings are similar to previous raw African breadfruit seed and similar increase of more than 21% in the crude protein content of dehulled germinated African breadfruit seeds as compared to un-germinated seeds [24] [25]. The high crude protein recorded in this study therefore indicated that African breadfruit seed is a good source of protein.

Crude fiber

The results and ANOVA for crude fibre content of the African breadfruit seed showed that there was no significant difference ($p < 0.05$) in crude fibre content of all the samples irrespective of the thermal processing method and duration. However, there was a significant difference between the raw and the thermally processed samples. Increase in thermal processing duration significantly ($p < 0.05$) decreased the crude fibre. The mean value for the crude fibre content ranged between 1.29 – 2.54%. Boiling for 90mins had the highest crude fibre content. The crude fibre content obtained in this study compares well with that previously reported [26]. The results also showed that shorter thermal processing time (30mins) retained more crude fibre content in African breadfruit seed. Delignification and depolymerisation of the plant matrix are the major reasons for decrease in fibre [19]. Thus, African breadfruit seed may not be an efficient source of dietary fibre, which is important for reducing cholesterol in the body to minimize risks of cardiovascular diseases caused by high plasma cholesterol [17].

Carbohydrate content

The carbohydrate content of the raw sample (46.74%) compares well with that previously reported on breadfruit seeds (46.80%) [26]. Shorter processing time (30mins) resulted in increased yield of carbohydrate when compared to longer processing time (90mins) which reduced the carbohydrate content, this is similar to that reported [27]. The mean values for the carbohydrate content of the African breadfruit seed sample ranged between 45.33 – 52.89%. Boiling for 30mins (B30) had the highest percentage of carbohydrate (52.89%). The ANOVA shows that irrespective of the thermal duration, differences in the values for the raw, roasted and autoclaved samples were not significant ($p < 0.05$) except for sample autoclaved for 30mins (A30). The decrease in the carbohydrate content of the thermally processed samples may be due to heat treatment. The overall result also showed that as the processing time increased, so other properties like the protein content increased hence carbohydrate reduced. This decrease in carbohydrate content could be attributed to the fact that carbohydrate content is calculated by difference.

3.3 Effects of thermal processing methods and duration on the anti nutritional composition of African breadfruit seed flour

The results of the effect of thermal processing method and time on some anti-nutritional compositions of African breadfruit seed is as shown in Table 2.

Hydrogen cyanide content

The result shows a significant ($p < 0.05$) decrease in hydrogen cyanide (HCN) contents for all the samples, irrespective of the thermal processing method and duration. The HCN content of the raw African breadfruit seed in this study is similar to that reported for raw breadfruit seed (1.50mg/100g) [21]. The hydrogen cyanide content of the processed breadfruit seed ranged between 0.48 - 1.49mg/100g. Boiling for 90mins (B90) had the lowest value for hydrogen cyanide (0.48mg/100g). The ANOVA showed that there was a significant difference ($p < 0.05$) between the raw and thermally processed samples. The HCN in the raw seed was 1.49mg/100g, which is higher than the value for cowpea (0.2 mg/100g) and lower than the value

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for Mucuna cochinuiensis (4.0 mg/100g) [20] 28]. The reduction in HCN level during boiling and autoclaving is as a result of leaching, since free cyanides are water soluble [29]. The reduction during roasting is as a result of the free cyanide vapourizing [21]. Ingestion of foods that are high in Hydrogen cyanide can be harmful to the nervous system [30]. The low value of HCN obtained for the thermally processed samples in this study indicates that African breadfruit seed could be safely used in food formulations as the level of HCN is far below the lethal level of 1.40mg/100 mg [31]. Low levels of HCN have been reported for processed cookies from autoclaved blends of sorghum flours, African breadfruit and pigeon pea [32]. Generally, boiling and autoclaving for 90mins were statistically better and a suitable method of eliminating HCN.

Trypsin inhibitors content

The result showed a significant decrease in trypsin inhibitor contents irrespective of the thermal processing methods and duration used. The ANOVA showed that there were significant differences ($p< 0.05$) between the raw and thermally processed samples. The trypsin inhibitor content of the African breadfruit seed reported in this present study was within the range reported for other breadfruit seeds varieties [21]. The trypsin inhibitor content of African breadfruit seed ranged between (0.58 – 1.30TUI/mg), with autoclaving for 90mins (A90) having the lowest trypsin content. There was no significant ($p< 0.05$) difference in the mean values of the autoclave samples. Trypsin inhibitors are reported to be heat-labile in nature this may be the reason for the result obtained in the present study [17]. Roasting was also found to be significantly effective in reducing trypsin inhibitors. Statistically, autoclaving was better and more effective in the removal of trypsin inhibitors when compared to boiling and roasting having the values of 0.77, 0.76 and 0.59 TUI/mg for 30, 60 and 90mins respectively. The, destruction of trypsin inhibitor increases the nutritive value of African breadfruit and allows for its utilization in more food formulations [21].

Tannin content

The result for the tannin contents the African breadfruit seed showed that there was a significant difference in the tannin content between the raw sample and the thermally processed samples. The tannin content in the raw T. africana seeds was found to be 32.03 mg/100g. This result was higher when compared with some plants of leguminous origin such as Brachystegia euryoma seed, having the value 15.15 mg/100g [33]. There were no significant differences ($p< 0.05$) in the tannin contents within the processed samples irrespective of the thermal processing methods and duration except for the roasted samples were significant differences were observed. The results for the tannin content for all the samples ranged between 0.35 – 3.20mg/100g, with the lowest value of 0.35mg/100g being recorded for autoclaving for 90mins (A90). The result also shows that irrespective of the thermal processing methods, increase in thermal duration resulted to a decrease in tannin content. The resulting decrease in tannin contents during boiling and autoclaving is due to the poly-phenolic nature of tannin, hence are water soluble in nature [17]. Major compositions of tannins are situated in the seed coat and the germ, this could be attributed to the dehulling which took place prior roasting, and the temperature for roasting [34]. Autoclaving however was significantly ($p< 0.05$) better and more effective in eliminating tannin, having a mean value of 0.85mg/100g, 1.07mg/100g and 0.35mg/100g at 30, 60 and 90mins respectively.

Phytate content

The results showed a significant ($p< 0.05$) decrease in phytate contents for all the samples, irrespective of the thermal processing method and duration. The phytic acid constituents of the boiled African breadfruit seed in this study is similar to that reported for other breadfruit seeds [21]. The phytate content in the raw T. africana seeds was found to be 2.07 mg/100g. The value is lower than the 888 mg/g reported for moth beans and the value 51.6 mg/g reported for Prospis chilenisi [22].The result for phytate ranged between 0.57 – 2.07mg/100g, with the lowest value (0.57mg/100g) being recorded for autoclaving for 90mins. Soaked pigeon pea seeds that were boiled showed further reduction in phytate constituents [35]. Lower phytate content in African breadfruit seed indicates that the nutritional values of the processed seeds would be beneficial. This decrease may be attributed to insoluble complex being formed amid phytates and other component [22]. Phytates reduces the digestibility of starches, fats, and protein. They are usually excreted in the waste once they are bound. Roasting also significantly reduced the phytates. The heat-labile character of phytates may be attributed to its reduction during roasting [21]. Before phytates are absorbed, they can influence digestive enzymes and can also bind mineral in the gut. Inside the intestine, they can also bind the minerals zinc, iron and manganese [36].

Alkaloid content

The ANOVA showed that there were significant **(**$p< 0.05$) decreases in the alkaloid content of all the samples, irrespective of the thermal processing method and duration. The alkaloid contents of the raw and processed breadfruit seed samples ranged between 4.00 – 1.33% with autoclaving for 90mins having the lowest mean value of 1.33%. The alkaloid constituents of the African breadfruit seed reported in this present study is similar to that reported for other breadfruit seeds, it had been observed that alkaloids and oxalic acid were eliminated to a very low level when legume samples were autoclaved [21] [37]. The decreasing effect of roasting on the alkaloids content of African breadfruit seed may be due to the heat applied and also their destruction during roasting [21]. Alkaloids, including oxalates, are commonly found in legumes and often result in bitter taste and flatulence in humans. Low level of these anti-nutrients would reduce flatulence in humans. Generally, the thermal processing methods significantly ($p< 0.05$) decreased the alkaloid content of African breadfruit seed flour. Autoclaving was found to be very efficient in the elimination of alkaloids from African breadfruit seed having a mean value of 2.83%, 2.33% and 1.33% for 30, 60 and 90mins respectively.

Oxalate contents

The ANOVA showed that there were significant ($p< 0.05$) decrease in oxalate contents of all the samples of the African breadfruit seed, irrespective of the thermal processing method and duration. The results are similar to the work on anti-nutrients in breadfruit seed flours [18]. The values of the oxalate contents for the raw and thermally processed breadfruit seeds ranged between 3.23 – 1.93 mg/100g, with 1.93mg/100g as the lowest mean value, reported for autoclaving at 90mins. However, statistical analysis shows that, autoclaving and boiling was significantly more effective in the reduction of the oxalate. The decrease in oxalates of the

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boiled and autoclaved samples could be as a result of heat hydrolysis of the oxalates [38]. The decreasing effect of roasting on the oxalate content of the African breadfruit seed may be due to the heat applied and also their destruction during roasting [21]. The result for this present study indicated that autoclaving at 30, 60 and 90 minutes, with the values (2.61, 2.21 and 1.93) mg/100g was significantly ($p< 0.05$) better and a more effective means of eliminating oxalate when compared to boiling and roasting.

4.0 Conclusion and recommendation

Thermal processing and duration of processing generally reduced the anti-nutritional content of African breadfruit seed (Treculia africana) flour. Either of the thermal processing methods used in this study would be a safe processing method for African breadfruit seed. However, autoclaving and boiling of breadfruit seed prior to consumption or conversion into flour destroys most anti-nutritional factors. Because of the reduced anti-nutrient composition of African breadfruit seeds flour and its staple nature, it could be further processed into different food products. Further work should be carried out on the mineral and pharmaceutical compositions of African breadfruit (Treculia africana) seeds. This will provide more insight into the commercial exploitation of this seed since some anti-nutrient like alkaloids could be beneficial to man and farm animals at low doses.

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Table 1: The Effects of Thermal Processing Method and Duration on some Nutritional Compositions of African Breadfruit Seed Flour.

Treatment time (min)	Moisture (%)	Ash (%)	Fat (%)	Fibre (%)	Protein (%)	CHO (%)
RW	3.33^{bc}±1.15	4.33^{b}±0.58	15.67^{b}±0.76	4.64^{b}±1.47	25.62^{a}±1.83	46.74^{b}±1.47
B 30	3.00^{ab}±0.00	2.33^{a}±0.58	13.00^{a}±1.73	2.54^{a}±0.20	26.23^{a}±0.46	52.89^{c}±2.17
B 60	3.67^{cd}±0.58	2.00^{a}±0.00	13.17^{a}±0.29	1.81^{a}±0.22	28.63^{b}±0.03	50.72^{c}±0.92
B 90	2.00^{ab}±0.00	3.67^{b}±0.58	18.50^{c}±0.50	1.29^{a}±0.22	31.06^{d}±0.09	43.49^{a}±1.10
R 30	3.33^{b}±1.15	2.33^{a}±0.57	15.67^{b}±0.29	2.54^{a}±1.20	28.54^{b}±0.14	47.59^{b}±2.19
R 60	2.67^{a}±1.15	2.33^{a}±0.58	15.17^{b}±0.29	2.39^{a}±1.04	30.90^{c}±0.58	46.54^{b}±1.51
R 90	1.67^{a}±0.58	2.67^{a}±0.58	15.83^{b}±0.29	1.94^{a}±0.08	31.74^{a}±0.05	46.15^{b}±0.76
A 30	2.67^{ab}±0.58	2.00^{a}±0.00	13.50^{a}±0.87	2.47^{a}±0.42	28.80^{b}±0.07	50.56^{c}±1.49
A 60	2.67^{ab}±0.58	2.33^{a}±0.58	16.00^{b}±1.32	2.06^{a}±0.21	29.28^{b}±0.09	47.66^{b}±1.62
A 90	4.33^{d} ±1.15	2.33^{a}±0.58	16.16^{b}±1.15	1.53^{a}±0.07	30.30^{c}±0.04	45.33^{b}±0.62

Means in the same column not followed by same superscript are significantly different (p< 0.05). Data are means ± SEM of triplicate result assessed by Duncan multiply range test. ***RW****=Raw,* ***B****=Boiled (30, 60 and 90mins),* ***R****=Roasted (30, 60, and 90mins),* ***A****=Autoclaved (30, 60 and 90mins).*

Table 2: Effect of Thermal Processing Methods and Time on Some Anti-nutritional Compositions of African Breadfruit Seed flour

Treatment (mins)	Cyanide (mg/100g)	Trypsin (TUI/mg)	Tannic (mg/100g)	Phytate (mg/100g)	Alkaloid (%)	Oxalate (mg/100g)
RW	1.49^{f}±0.03	1.30^{f}±0.03	32.03^{e}±1.06	2.07^{g}±0.15	4.00^{f}±0.50	3.23^{e}±0.07
B 30	0.98^{c}±0.13	1.12^{e}±0.07	2.38^{a}±0.48	1.79^{ef}±0.08	3.17^{e}±0.29	2.84^{d}±0.17
B 60	0.71^{b}±0.09	1.02^{de}±0.14	1.50^{a}±0.31	1.28^{cd}±0.11	2.17^{bc}±0.29	2.48^{c}±0.20
B 90	0.48^{a}±0.03	0.80^{bc}±0.03	2.66^{a}±0.56	0.79^{b}±0.14	1.67^{a}±0.29	1.97^{a}±0.07
R 30	1.39^{ef}±0.07	0.88^{bc}±0.20	17.13^{d}±2.41	1.87^{f}±0.16	2.83^{d}±0.29	3.00^{d}±0.04
R 60	1.09^{cd}±0.07	0.97^{cd}±0.10	13.16^{c}±1.63	1.39^{de}±0.03	2.33^{c}±0.29	2.82^{d}±0.13
R 90	0.81^{b} ±0.02	0.87^{bc}±0.03	6.83^{b}±3.14	1.23^{cd}±0.05	1.83^{b}±0.29	2.25^{c}±0.10
A 30	1.23^{de}±0.13	0.77^{ab}±0.16	0.85^{a}±0.14	1.62^{e}±0.04	2.83d^{e}±0.58	2.61^{c}±0.07
A 60	1.12^{cd}±0.02	0.76^{ab}±0.03	1.07^{a}±0.61	1.19^{c}±0.08	2.33^{cd}±0.29	2.21^{b}±0.11
A 90	0.51^{a} ±0.06	0.59^{a} ±0.08	0.35^{a}±0.11	0.57^{a}±0.04	1.33^{a} ±0.29	1.93^{a}±0.13

Means in the same columns not followed by same superscript are significantly different (p< 0.05). Data are means ± SEM of triplicate result assessed by Duncan multiply range test. ***RW****=Raw,* ***B****=Boiled (30, 60 and 90mins),* ***R****=Roasted (30, 60, and 90mins),* ***A****=Autoclaved (30, 60 and 90mins).*