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Influence of Proecessing Methods on The Nutritional And Anti-Nutritional Composition Of Fluted Pumpkin And African Breadfruit Seeds.

Aaron, H. A.[1], Ukam, U. N.[2] and Markson, A. A.[3]*
[1]*Department of Home Ecocnomics, College of Education, Akamkpa, Cross River State. Nigeria.*
[2]*Department of Nutrition, University of Calabar, Calabar. Cross River State, Nigeria*
[3]*Department of Botany, University of Calabar, Calabar, Cross River State, Nigeria*

Abstract: *Assessment of the influence of three processing methods [fermentation, roasting (dry heat treatment), and boiling (wet heat treatment)] of the seeds of Telfairia occidentalis (fluted pumpkin) and Treculia africana (African breadfruit) was carried out at varying durations. Fermentation for 36 hours led to increases in moisture, protein and carbohydrate of seeds of both plants. Ash, crude fat and fibre declined with increasing duration of fermentation. The levels of the anti-nutrients assessed were also lowered during fermentation. In T. occidentalis, tannins dropped from 221.01mg/100g to 143.29mg/100g; phytate, from 66.59mg/100g to 21.33mg/100g and alkaloid from 18.32mg/100g to 5.23mg/100g. Oxalates followed the same trend. In T. africana, tannins were not affected, but other antinutrients declined with duration of fermentation. Roasted T. occidentalis seeds showed a decline in fat and protein levels. Crude fibre and fat were not affected. Carbohydrate increased in amount with increasing duration of dry heat treatment. In T. africana seeds, moisture, ash and protein declined while fat and carbohydrate increased with longer periods of roasting. All the four anti-nutrients (tannins, phytate, alkaloids and oxalates) assessed in fluted pumpkin seeds dropped in quantity with longer heat treatment periods. Tannins in breadfruit seeds were lowered. Heat treatment in the first 10 minutes did not affect alkaloids and oxalates but longer treatment time effected a decline in their levels. Boiling increased the moisture content of fluted pumpkin seeds, but led to slight reductions in the moisture content of breadfruit seeds. Boiling did not influence the ash and crude fiber content of pumpkin, but led to decreases in protein levels in the seed. In boiled breadfruit seeds, all the nutrients were reduced except carbohydrate. On boiling, the seeds of the two test plants recorded declining levels of all the anti-nutrients except for phytate in T. africana seeds.*
Keywords: *Anti-nutritional, processing methods, bread fruit, Nutritional, Fluted pumpkin*

I. Introduction

In the past two or more decades, there has been a growing level of food insecurity worldwide. The estimation is that by 2050 the world population will be nine (9) billion. That is three (3) billion higher than the current figure of six (6) billion. It has also been estimated that there will be an exponential growth more in the cities in developing countries, especially, in Africa and Asia [1] where food insecurity as well as child mortality due to malnutrition is endemic [2]. Nigerian population is currently estimated to be over one hundred and sixty million (160,000,000) with an annual growth rate of about 2.5 percent [3]. To attain food sufficiency for the growing population, production of more food through cultivation of only the known and commonly eaten staple foods like cassava, yam and cereals cannot by itself constitute the feasible solution. This is partly because most of the available arable lands that would have been used for agriculture have been put to other uses. A more effective approach is necessary to achieve an enduring food security situation for all. One of such strategies is to explore and develop food forms from wild and semi-domesticated crops which are neglected and under-exploited [4].

One of such is the African breadfruit (*Treculia africana* Decne). This forest tree legume is a member of the Mullberry family, Moraceae [6] and is known in Ibibio as 'Ubong Mbakara' and in Igbo as 'Ukwa'. The seed is widely consumed in the South-eastern Nigeria as snacks or pulverized and added to soups as thickener. Findings by several authors have shown that the seed is a healthy source of nutrients and minerals [6, 4, 7]. It is regarded as one of the richest in benefits among plants consumed in the world [8] having been known to be primarily high in its content of aromatic amino acids [9], hence, a veritable source of good quality protein. It is also credited with moderate content of minerals and vitamins. As commonly found in many pulses, breadfruit seeds also contain some anti-nutritional components such as phytate, tannins, cyanide, oxalates and alkaloids [10]. Fluted pumpkin (*Telfairia occidentalis* Hook) is a leafy vegetable commonly used by Nigerians, especially, South-Southerners and South-Easterners to prepare different forms of foods, particularly, porridge and soups. The most popular soups in South-South Nigeria among the Efiks and Ibibios is the thick pumpkin soup known in the local dialect as'Edikang ikong' soup. This soup is prepared with sliced fluted pumpkin leaves with waterleaf (*Talinum triangulare*) with large volume of palm oil and other condiments. The seeds are seldom used. However, when consumed, they are eaten as snacks. Either boiled or roasted. The seeds contain 13% oil and are used for cooking and for other culinary purposes. The oil of *T. occidentalis* seeds has high iodine and a high content of unsaturated fatty acids when compared to palm oil. The seed oil is also suitable for manufacturing of soaps, paints and vanishings [11]. Seed residue after oil extraction is also used as animal feeds. Fluted pumpkin seeds are rich in proteins and other nutrient components [12]. As in many plant seeds, *T. occidentalis* seeds contain anti-nutritional factors such as enzyme inhibitors, allergens, lectins, and other naturally occurring substances. Reports have it that the presence of anti-nutritional factors in foods influences diet intake, digestibility, absorption and metabolic processes in animals and humans [12]. It also limits the bio-availability of nutrients and reduce nutrient utilization, feed efficiency and productivity and hence impedes growth and development in the body [13; 14; 15; 4]. Food processing has been credited with several advantages. According to Food and Agricultural Organization [16], 'value-added through marketing and processing raw products can be much greater than the value of the primary production. To achieve safe levels of these anti-nutritional factors in foods, some form of processing is necessary. This paper seeks to assess the influence of processing and duration of processing (fermentation, roasting, boiling) on nutrient and anti-nutrient levels of breadfruit and fluted pumpkin seeds.

II. Materials And Methods

2.1 Source and preparation of materials

The fresh fruits of *Treculia africana* (breadfruits) were obtained from a stand in College of Education (COE), Akamkpa Local Government Area and *Telfairia occidentalis* fruit was bought from Marian market, Calabar Municipality both in Cross River State, Nigeria. Both fruits were cut open and the seeds manually extracted and washed separately in clean tap water and sun-dried.

2.2 Fermentation of seeds of *Treculia africana* and *Telfairia occidentalis*

Seven hundred and fifty grams (750 g) of each of the test seeds were boiled for 10 minutes using pressure pot and divided into four categories. Seed coats were removed and two hundred grams (250 g) of seeds in each case were tied separately in black polyethylene material and kept in a contaminant- free wooden cup-board for 12, 24 and 36 hours respectively. At the expiration of each fermentation period, the seeds were washed in clean tap water, dried and milled using a warring blender and the powder sieved through a sieve with mesh size of 0.25 mm British standard sieve (Model BS 410) to obtain fine flour. The flour was packaged and kept in air-tight container until required for chemical analysis

2.3 Wet-heat treatment (boiling) of seeds of *Treculia Africana* and *Telfairia occidentalis*

Seven hundred and fifty grams (750 g) of each of the raw test seeds were divided into three portions of 250 g each. Each set was boiled separately in conventional waterbath (MEMMERT) 100^0C for 10, 20 and 30 minutes respectively. The boiled seeds were strained of the water and the seeds dried at 60^0C for 15 minutes and milled using a warring blender and the powder sieved through a sieve with mesh size of 0.25 mm British standard sieve (Model BS 410) to obtain fine flour. The flour was packaged and kept in air-tight container until required for chemical analysis

2.4 Dry-heat treatment of seeds (roasting) of *Treculia Africana* and *Telfairia occidentalis*

The roasted samples were prepared following the methods of [13] where 750 g of the seeds were apportioned into three categories, each with 250 g and subjected to a hot box oven treatment set at 121^0C for 10, 20 and 30 minutes respectively. The roasted seeds were allowed to cool naturally before being milled using a warring blender and the powder sieved through a sieve with mesh size of 0.25 mm British standard sieve (Model BS 410) to obtain fine flour. The flour was packaged and kept in air-tight container until required for chemical analysis while one set of seeds was analyzed raw.

2.5 Proximate and Anti-nutritional Analysis

Determination of the proximate composition (ash, lipid, fibre and moisture) and anti-nutritional components (tannins, phytate, alkaloid and oxalate) of the processed and raw seeds was carried out adopting the methods of the Association of Official Analytical Chemists [17]. Organic nitrogen was determined using Kjeldahl method. Protein content of the seeds was estimated by multiplying the organic nitrogen content by a factor of 6.25. Total carbohydrate was obtained by difference.

2.6 Statistical Analysis
Data were subjected to one –way Analysis of Variance (ANOVA) using SPSS version 21.0. Duncan's Multiple Range Test (DNMRT) was used to separate the means at the 5 % level of probability.

III. Results
Fermentation as a form of processing had a significant influence on the nutrient content of the starch obtained from the seeds used (Table 1).

Table 1: Influence of fermentation on the nutritional content of Fluted pumpkin (*Telfairia occidentalis*) seeds

Proximate values	Proximate composition (%)					
	Moisture	Crude fat	Ash	Crude protein	Crude fibre	Carbohydrate
Unfermented (raw) pumpkin seeds	49.01[c]	18.48[a]	1.63[b]	27.23[b]	0.92[a]	2.52[b]
Pumkin seeds fermented for 12 hours	50.23[b]	18.22[a]	1.82[a]	27.02[c]	0.75[ab]	3.12[a]
Pumkin seeds fermented for 24 hours	53.12[a]	16.11[b]	1.84[a]	28.29[b]	0.68[b]	4.02[a]
Pumkin seeds fermented for 36 hours	53.45[a]	16.01[b]	1.93[a]	30.25[a]	0.62[b]	3.98[a]
DNMRT	1.02	0.93	0.11	1.10	0.25	1.20

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

The moisture content of pumpkin seeds increased with increasing period of fermentation. However, the moisture level (50.23 %) obtained in the seeds after 24 hours was not significantly different from the value obtained following 36 hours of fermentation. Crude fat declined with increased period of fermentation. Similar trend was observed with crude fibre. During the period of fermentation, protein increased with increasing duration of fermentation. This was also the case with carbohydrate until after 24 hours where there was a slight decline in the level of the nutrient. The level of decline was not, however, significantly (P<0.05) different from the values obtained for other samples fermented.

Table 2: Influence of fermentation on the nutritional content of African breadfruit (*Treculia africana*) seeds

Treatment/Duration	Proximate composition (%)					
	Moisture	Crude fat	Ash	Crude protein	Crude fibre	Carbohydrate
Unfermented (raw) Breadfruit seeds	3.35[a]	14.98[a]	4.37[a]	25.74d	4.60[a]	46.77[c]
Breadfruit seeds Fermented for 12 hours	3.44[a]	13.66[b]	3.31[ab]	26.10c	4.40[a]	47.21[a]
Breadfruit seeds Fermented for 24 hours	4.11[b]	12.93[b]	2.88[b]	28.34b	4.31[a]	46.98[b]
Breadfruit seeds Fermented for 36 hours	4.18[b]	8.22[c]	2.45[b]	29.91a	3.90[b]	44.32[d]
DNMRT	0.59	0.92	1.14	1.01	0.51	0.24

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

Seeds of breadfruit subjected to fermentation exhibited various patterns of nutrient dynamics (Table 2). As obtained in *Telfairia* seeds, there was increment in the moisture content of the seeds with increasing duration of fermentation, with the highest value (4.18 %) obtained after 36 hours of fermentation when compared with 3.35% which was the moisture yield of raw seedsFat, ash and fibre declined with progressive fermentation, while protein recorded increases with longer duration of fermentation increasing from 25.74% in unfermented seeds to 29.91% after 36 hours of fermentation. However, in carbohydrate, increases in quantity was observed after 12 hours of fermentation but declined thereafter with the lowest value (44.32%) observed after 36 hours of fermentation.

Table 3: Influence of dry heat treatment (Roasting) on the nutritional content of Fluted pumpkin (*Telfairia occidentalis*) seeds

Treatment/Duration	Proximate composition (%)					
	Moisture	Crude fat	Ash	Crude protein	Crude fibre	Carbohydrate
Raw Pumpkin seeds	49.01[d]	18.48[a]	1.63[a]	27.23[a]	0.92[a]	2.52[d]
Pumpkin seeds Roasted for 10 minutes	48.23[b]	18.68[a]	1.66[a]	26.95[a]	0.89[a]	2.63[c]
Pumpkin seeds Roasted for 20 minutes	46.10[a]	17.02[b]	1.59[a]	26.01[b]	0.89[a]	3.96[b]
Pumpkin seeds Roasted for 30 minutes	43.21[c]	17.23[b]	1.61[a]	25.67[b]	0.85[a]	4.10[a]
DNMRT	0.34	1.22	0.12	0.61	0.43	0.02

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

The quantity of crude fibre and ash was not affected by dry heat (roasting) of pumpkin seeds. However, all other nutrients in the seed were affected (Table 3). Fat and Protein declined from 18.48% to 17.23% and from 27.23% to 25.67% respectively after 30 minutes of heat treatment while carbohydrate recorded increases (from 2.52% to 4.10%) within the same duration. In breadfruit seeds, all the nutrients recorded decline in amounts except crude fat and carbohydrate that showed evidence of increment with increasing heat treatment (Table 4). Moisture was reduced from 3.35% to 2.89% while ash and protein declined from 4.37% to 2.98% and 4.60% to 2.54% respectively. Carbohydrate was recorded progressive increment till the 20 minutes heat treatment but dropped slightly with additional 10 minutes treatment.

Table 4: Influence of dry heat treatment (Roasting) on the nutritional content of African breadfruit (*Treculia africana*) seeds

Treatment/Duration	Proximate composition (%)					
	Moisture	Crude fat	Ash	Crude protein	Crude fibre	Carbohydrate
Raw Breadfruit seeds	3.35^a	14.98^b	4.37^a	25.74^b	4.60^a	46.77^b
Breadfruit seeds Roasted for 10 minutes	3.30^a	15.01^b	3.43^b	26.11^b	3.12^b	47.23^a
Breadfruit seeds Roasted for 20 minutes	3.27^b	15.34^a	3.05^c	27.21^a	3.02^b	48.11^a
Breadfruit seeds Roasted for 30 minutes	2.89^c	15.08^b	2.98^c	22.04^c	2.54^c	47.62^a
DNMRT	0.08	0.17	0.24	0.58	1.15	1.03

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

Table 5: Influence of wet heat treatment (Boiling) on the nutritional content of Fluted pumpkin (*Telfairia occidentalis*) seeds

Treatment/Duration	Proximate composition (%)					
	Moisture	Crude fat	Ash	Crude protein	Crude fibre	Carbohydrate
Raw Pumpkin seeds	49.01^c	18.48^a	1.63^a	27.23^a	0.92^a	2.52^b
Pumpkin seeds Boiled for 10 minutes	49.45^b	17.28^b	1.61^a	26.97^{ab}	0.87^a	3.02^b
Pumpkin seeds Boiled for 20 minutes	49.97^a	16.55^c	1.60^a	26.84^b	0.83^a	4.87^a
Pumpkin seeds Boiled for 30 minutes	50.21^a	15.18^d	1.59^a	26.80^b	0.80^a	5.06^a
DNMRT	0.36	0.56	0.47	0.33	0.41	0.79

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

When pumpkin seeds were boiled for 10 to 30 minutes, the moisture and carbohydrate content increased. Boiling within the same time span did not influence the quantity of ash and crude fibre in the seeds. The range of values obtained for fat in boiled pumpkin seeds was 17.28 – 15.18%. These values were however, significantly (P<0.05) lower than 18.48g/100g recorded for the raw seeds. There was also a decline in protein values obtained in boiled pumpkin seeds. Further reduction in the protein level of the seed was not significant (P<0.05) between 10 and 30 minutes of boiling (Table 5).

Table 6: Influence of wet heat treatment (Boiling) on the nutritional content of African breadfruit (*Treculia africana*) seeds

Treatment/Duration	Proximate composition (%)					
	Moisture	Crude fat	Ash	Crude protein	Crude fibre	Carbohydrate
Raw Breadfruit seeds	3.35^a	14.98^a	4.37^a	25.74^b	4.60^a	46.77^d
Breadfruit seeds Boiled for 10 minutes	3.17^a	13.68^{bc}	3.95^b	26.11^a	3.82^{ab}	49.31^c
Breadfruit seeds Boiled for 20 minutes	3.11^a	13.78^b	3.67^b	25.98^a	3.07^{bc}	51.10^b
Breadfruit seeds Boiled for 30 minutes	3.10^a	12.96^c	3.09^c	26.01^a	2.36^c	54.34^a
DNMRT	0.67	0.91	0.32	0.17	0.88	0.76

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

Boiling slightly reduced the level of moisture (from 3.35% to 3.10%) of breadfruit seeds, though not significant (P<0.05). However, varying levels of decline were observed in all other nutrient components at significant levels except carbohydrate. Crude fibre dropped in quantity from 14.98% to 12.96%. Ash declined significantly from 4.37 to 3.09%. Fat also decrease slightly within the processing time from 14.88% to 12,96%. Carbohydrate was significantly raised in amount from 46.77% to 54.34% within 30 minutes of wet treatment (Table 6). Result on influence of fermentation on the anti-nutrient content of *T. occidentalis* seed is presented in Table 7. All the anti-nutrient components of the seed were lowered following fermentation. Tannins dropped from 221.01mg/100g to 143.29 mg/100 g and phytate from 66.59 mg/100 g to 21.33 mg/100 g while alkaloid declined from 18.32 mg/100 g to 5.23 mg/100 g within 36 hours of fermentation. The level of reduction in the quantity of oxalate (7.11 mg/100 g) within 12 hours of fermentation was not, however, significant (P<0.05) when compared with the quantity (8.12 mg/100 g) found in the unfermented (raw) seed. Further drop to a value of 4.96 was achieved in 36 hours, which was not, however, significantly different from 5.21 obtained after 24 hours of fermentation.

Table 7: Influence of fermentation on the anti-nutritional content of Fluted pumpkin (*Telfairia occidentalis*) seeds

Treatment	Anti-nutrients (mg/100g)			
	Tannins	Phytate	Alkaloid	Oxalate
Unfermented (raw) Pumpkin seeds	221.01[a]	66.59[a]	18.32[a]	8.12[a]
Pumpkin seeds Fermented for 12 hours	201.02[b]	62.13[b]	13.22[b]	7.11[a]
Pumpkin seeds Fermented for 24 hours	188.32[c]	40.78[c]	11.02[c]	5.21[b]
Pumpkin seeds Fermented for 36 hours	143.29[d]	21.33[d]	5.23[d]	4.96[b]
DNMRT	11.25	4.22	2.16	1.54

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

Table 8: Influence of fermentation on the anti- nutritional content of African breadfruit (*Treculia africana*) seeds

Treatment	Anti-nutrients (mg/100g)			
	Tannins	Phytate	Alkaloid	Oxalate
Unfermented (raw) Breadfruit seeds	20.98[a]	2.15[a]	3.98[a]	3.43[a]
Breadfruit seeds Fermented for 12 hours	18.32[a]	2.11[a]	2.93[b]	2.14[b]
Breadfruit seeds Fermented for 24 hours	16.05[a]	1.92[b]	1.43[c]	1.02[c]
Breadfruit seeds Fermented for 36 hours	11.03[a]	0.82[c]	1.00[c]	0.95[c]
DNMRT	6.21	0.11	0.72	0.38

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

Tannin content of *T. african*a seeds was not affected even after 36 hours fermentation. Phytate declined in quantity to 0.8 from 2.15 found in the raw seed. Alkaloid dropped from 3.98 to 1.00 within the same duration while a value of 0.95 of oxalate remained of the 3.43 found in raw seed. The possible alteration of the anti-nutrient component of pumpkin seed by dry heat treatment was assessed and the findings are presented in Table 9. Dry heat treatment of the seed resulted in a decline in the four anti-nutrient components assessed. Tannins dropped from 221.01 to 125.01, phytate from 66.59 to 56.13, alkaloids from 18.32 to 2.17 and oxalate from 8.12 to 1.38.

Table 9: Influence of dry heat treatment (Roasting) on the anti-nutritional content of Fluted pumpkin (*Telfairia occidentalis*) seeds

Treatment/Duration	Anti-nutrients (mg/100g)			
	Tannins	Phytate	Alkaloid	Oxalate
Raw Pumpkin seeds	221.01[a]	66.59[a]	18.32[a]	8.12[a]
Pumpkin seeds Roasted for 10 minutes	183.21[b]	59.12[b]	12.89[b]	5.11[b]
Pumpkin seeds Roasted for 20 minutes	142.09[c]	58.87[b]	4.33[c]	3.27[c]
Pumpkin seeds Roasted for 30 minutes	125.01[d]	56.13[c]	2.17[c]	1.38[d]
DNMRT	13.44	1.02	3.16	0.43

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

Tannins in breadfruit seeds were observed to drop progressively as the duration of heat treatment increased. This was also true for other anti-nutrient assessed. However, the alkaloid content of seeds roasted for 10 minutes did not differ from the ones roasted for 20 minutes and the value obtained after 30 minutes of heat treatment was not significantly different from the ones treated 10 minutes less. Oxalate in seeds roasted for 10 minutes was similar to the content of raw seeds but differed significantly from seeds treated for 20 and 30 minutes duration which were not, however, significantly (P<0.05) different from each other.

Table 10: Influence of dry heat treatment (Roasting) on the nutritional content of African breadfruit (*Treculia africana*) seeds

Treatment/Duration	Anti-nutrients (mg/100g)			
	Tannins	Phytate	Alkaloid	Oxalate
Raw Breadfruit seeds	20.98[a]	2.15[a]	3.98[a]	3.43[a]
Breadfruit seeds Roasted for 10 minutes	15.33[b]	1.73[b]	2.91[b]	3.04[a]
Breadfruit seeds Roasted for 20 minutes	13.02[c]	1.42[c]	2.19[bc]	2.90[ab]
Breadfruit seeds Roasted for 30 minutes	9.19[d]	1.10[d]	1.65[c]	2.07+
DNMRT	1.15	0.21	0.94	0.87

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

Anti-nutrients of boiled pumpkin seeds were massively reduced with increasing duration (Table 11). Tannins dropped to 12.98 from the initial value of 221.01 in raw seeds. Phytate declined to 18.23 from 66.59 in raw seeds while alkaloids and oxalate dropped to3.25 and 1.76 from 18.32 and 8.12 respectively.

Table 11: Influence of wet heat treatment (Boiling) on the nutritional content of Fluted pumpkin (*Telfairia occidentalis*) seeds

Treatment/Duration	Anti-nutrients (mg/100g)			
	Tannins	Phytate	Alkaloid	Oxalate
Raw Pumpkin seeds	221.01[a]	66.59[a]	18.32[a]	8.12[a]
Pumpkin seeds Boiled for 10 minutes	185.22[b]	45.47[b]	12.16[b]	6.21[b]
Pumpkin seeds Boiled for 20 minutes	123.78[c]	26.79[c]	6.33[c]	3.21[c]
Pumpkin seeds Boiled for 30 minutes	99.25[d]	18.23[d]	3.25[d]	1.76[c]
DNMRT	12.98	7.42	3.44	2.01

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

The declining phytate values evident in *T. africana* following 30 minutes of boiling did not differ statistically (P<0.05) from the values obtained for raw seeds. However, tannins, alkaloids and oxalate were evidently lowered in amounts following 30 minutes wet heat treatment (Table 12). The tannin content of the seeds boiled for 10 minutes did not differ statistically from those subjected to 30 minutes; however, boiling significantly lowered the levels of tannin in all the treated seeds. Alkaloids and oxalate were consistently lowered in amounts with increasing duration of boiling (Table 12).

Table 12: Influence of wet heat treatment (Boiling) on the nutritional content of African breadfruit (*Treculia africana*) seeds

Treatment	Anti-nutrients (mg/100g)			
	Tannins	Phytate	Alkaloid	Oxalate
Raw Breadfruit seeds	20.98[a]	2.15[a]	3.98[a]	3.43[a]
Breadfruit seeds Boiled for 10 minutes	3.78[b]	2.01[a]	3.64[b]	2.65[b]
Breadfruit seeds Boiled for 20 minutes	3.23[b]	1.99+	3.32[c]	2.04[c]
Breadfruit seeds Boiled for 30 minutes	2.42[b]	1.84[a]	3.21[d]	1.83[d]
DNMRT	3.17	0.31	0.04	0.13

Values are means of triplicates. Value in the same column with similar letters are not significantly different at P<0.05.

IV. Discussion

Fermentation as a form of processing had a significant influence on the proximate composition of the seeds assessed (Table 1). The moisture content of pumpkin seeds increased with increasing period of fermentation. However, the moisture level (50.23%) obtained in the seeds after 24 hours was not significantly different from the value obtained following 36 hours of fermentation. Similar reports have been given by several authors on the influence of fermentation on moisture content of some selected seeds. [18 ; 19] in separate researches reported increases in the moisture content of Jack fruit (*Artocarpus heterophyllus*) seeds on fermentation. Fermentation of millet (*Pennisetum glaucum*) and Soyabeans (*Glycine max*) flour blends have also resulted in high moisture content of the samples [15]. However, [20] gave a contrasting report on cocoyam (*Colocasia esculenta*). The contrasting result obtained for cocoyam may stem from the behaviour of corms on fermentation. The decline in crude fat reported in this work with increased period of fermentation corroborates the findings of some earlier researchers, [15] on *Pennisetum glaucum* and *Glycine max* and [14] on African breadfruit (*Treculia africana*) kernel . The reduction in crude fibre from 4.06% to 2.54% recorded in this study is likely as a result of breakdown of the fibre by the micro-organisms involved in the fermentation process or through conversion of carbohydrate and lignocelluloses into protein [20]. Protein increased in both breadfruit and pumpkin seeds assessed with increasing duration of fermentation. Similar results were also obtained by [21]) in pumpkin seed flour, [15] in millet and soyabeans. [22] attributed this increment to synthesis of amino acids in excess of the amounts required during protein synthesis hence they accumulate in free amino acid pool. They also suggested that the increases in protein observed during fermentation might result from degradation of stored proteins and other materials during fermentation. The rise in the amount of carbohydrate with increasing fermentation time until after 24 hours where there was a slight decline. The level of decline in carbohydrate content was not, however, significantly (P<0.05) different from the values obtained for other samples fermented. The quantity of crude fibre and ash was not affected by dry heat (roasting) of pumpkin seeds. However, all other nutrients in the seed were affected. Fat and Protein declined from 18.48% to 17.23% and from 27.23% to 25.67% respectively after 30 minutes of heat treatment while carbohydrate recorded increases from 2.52% to 4.10% within the same duration.

In breadfruit seeds, all the nutrients recorded decline in amounts except crude fat and carbohydrate that showed evidence of increment with increasing heat treatment Moisture was reduced from 3.35% to 2.89% while ash and protein declined from 4.37% to 2.98% and 4.60% to 2.54% respectively. [13] reported loss of moisture and reduction in the amount of ash and protein in seeds of *Treculia africana* treated to heat by roasting. Their report indicated that all roasted samples did not differ statistically from the other but they however, differed from the raw (control) seeds. [10] made similar findings on African breadfruit seeds. Progressive increment of carbohydrate was observed within 20 minutes of heat treatment but dropped slightly on additional 10 minutes treatment. Increment in carbohydrate content of roasted African breadfruit seeds was also reported [10]. The rise in the quantity of carbohydrate may be attributed to increased dry matter accumulated with loss of moisture.
When pumpkin seeds were boiled for duration of 10 to 30 minutes, the moisture and carbohydrate content increased. Boiling within the same time span did not influence the quantity of ash and crude fibre in the seeds. [12] also made similar findings but added fat as one of the nutrients not affected by boiling. Contrary to the findings of [12] concerning fat, the present study revealed that there a decline in the fat content of boiled pumpkin seeds in the range of 17.28 – 15.18% when compared to a significantly ($P<0.05$) higher value of 18.48% recorded for the raw seeds. They also reported increase in protein content of pumpkin seeds following cooking. This present study recorded a slight decline in protein values in boiled pumpkin seeds after 10 minutes of boiling. Further reduction in the protein level of the seed was not significant ($P<0.05$) between 10 and 30 minutes of boiling. The contrasting findings may be related to the duration and temperature applied during. Boiling slightly reduced the level of moisture (from 3.35% to 3.10%) of breadfruit seeds, though not significant ($P<0.05$). [13] reported decrease in moisture of boiled breadfruit seeds. However, significant levels of decline were observed in all other nutrient components except carbohydrate. Crude fibre dropped in quantity from 14.98% to 12.96%. Ash declined significantly from 4.37% to 3.09 %. There was a slight decrease in fat after 30 minutes of boiling. Similar decreases have been reported [13], however, they added that beyond 30 minutes duration of boiling, the quantity of fat increased. The present study did not assess the level of fat in breadfruit seeds beyond 30 minutes duration. Decreases recorded for crude fibre and ash observed in this study is in concert with the findings of [18]. However, they differed in their result on protein level observed in boiled breadfruit seeds. They observed raised levels of protein but the present study revealed slight increases in protein. The difference may stem from the duration of wet heat treatment. It is likely that the long duration of boiling may have leached and denatured the protein therein. Carbohydrate was significantly raised in amount from 46.77% to 54.34% within 30 minutes of wet treatment. Increases in the level of carbohydrate in boiled seed samples of breadfruit have also been reported in African breadfruit [14; 13; 18], in fluted pumpkin seeds [12]. [13] asserted that shorter processing time results in higher carbohydrate yields. Decreasing carbohydrate levels have been reported in breadfruit seeds on boiling [10].

All the anti-nutrient components of *T. occidentalis* seed were lowered following fermentation. Tannins dropped from 221.01 mg/100 g to 143.29 mg/100 g and phytate from 66.59 mg/100 g to 21.33 mg/100 g while alkaloid declined from 18.32 to 5.23 within 36 hours of fermentation. Fermentation of pumpkin seeds for 12 hours did not significantly ($P<0.05$) lower the quantity of oxalate when compared with the content of the unfermented (raw) seed. However, at 24 and 36 hours, fermentation resulted in a significant decline in oxalate content of the seed. Fermentation as a method of processing is known to add value to the processed food materials. One of such value-added contributions of fermentation is the reduction in the anti-nutrients components in food materials. Fermentation has resulted in lower levels of phytate and tannins in *Pennisetum glaucum* (millet) and *Glycine max* (soyabeans) [15]; decline in oxalate, phytate and tannins has been reported in *T. Africana* (breadfruit) seedsubjected to fermentation [23; 4; 10; 14]. The levels of oxalate, phytate, saponins, Hydrocyanide (HCN) and tannins have been lowered in cocoyam through fermentation [20]. In breadfruit, tannin seeds were not affected even after 36 hours fermentation. Phytate declined in quantity to 0.8 mg/100 g from 2.15 mg/100 g found in the raw seed. Alkaloid dropped from 3.98 mg/100 g to 1.00 mg/100 g within the same duration while a value of 0.95 mg/100 g of oxalate remained of the 3.43 mg/100 g found in raw seed. The indifference of tannins and oxalate to fermentation may be attributed to the short time span of fermentation. It is likely that these components would have been lowered significantly with increased duration of fermentation such successes have been achieved other food materials at 48 and 72 hours [20].

Dry heat treatment (roasting) of seeds of *T. occidentalis* resulted in a decline in the four anti-nutrient components assessed. Tannins dropped from 221.01 mg/100 g to 125.01 mg/100 g, phytate from 66.59 mg/100 g to 56.13 mg/100 g, alkaloids from 18.32 mg/100g to 2.17 mg/100g and oxalate from 8.12 mg/100 g to 1.38 mg/100 g. [23)] also reported reduction in tannin and phytate content of Telfairia seeds treated to heat by roasting. Tannins in breadfruit seeds were observed to drop progressively as the duration of heat treatment (roasting) increased. Decrease in tannin content with increasing duration of roasting was also reported in African breadfruit seeds by [13)]. Reduction in the amount of tannins in the roasted seeds was attributed to the high temperature which led to the breakdown of the anti-nutrient component [24]. While alkaloid in pumpkin seeds showed a clear-cut decline in amount in treated seeds, the alkaloid content of breadfruit seeds roasted for

10 minutes did not differ from the ones roasted for 20 minutes and the value obtained after 30 minutes of heat treatment was not significantly different from the ones treated 10 minutes less. Reports of decreasing quantity of ant-nutrient components in breadfruit seeds have been put forward (13; 14)]. Oxalate in seeds roasted for 10 minutes was similar to the content of raw seeds but differed significantly from seeds treated for 20 and 30 minutes duration which were not, however, significantly ($P<0.05$) different from the other. The findings in this present study agrees with the report by [14] but is in contrast with the report by [10] who reported an increase of 5 mg/100 g of oxalate in roasted samples when compared with the raw samples. This difference may be because of different method of heat application and duration of heat treatment.

Anti-nutrients in boiled pumpkin seeds were massively reduced with increasing duration. Tannins dropped to 12.98 mg/100 g from the initial value of 221.01 mg/100 g in raw seeds. The tannin content of breadfruit seeds boiled for 10 minutes did not differ statistically from those subjected to 30 minutes; however, boiling significantly lowered the levels of tannin in all the treated breadfruit seeds. Phytate declined to 18.23 mg/100 g from 66.59 in pumpkin raw seeds while alkaloids and oxalate dropped to 3.25 mg/100 g and 1.76 mg/100 g from 18.32 mg/100 g and 8.12 mg/100 g respectively. There was also a decline in phytate content of *T. African* seeds after 30 minutes of boiling. Alkaloids and oxalate were consistently lowered in amounts with increasing duration of boiling. Reports of reduction in anti-nutrients in food materials have been put forward [6; 21]. Decline in the levels of these substances in processed food materials have been attributed to the leaching of the anti-nutrient component (phytate, tannins and oxalates) into the boiling water [14]. They noted that the ease of leaching of phytate in particular is due to its hydrophilic nature.

V. Conclusion

Processing method is considered acceptable when it retains or leads to increases of nutrients and lowers toxic components in the food materials processed. From the findings of this study, fermentation has proved the best method of processing of both seeds for consumption as it has led to retention of higher amounts of some of the nutrients and leading to increases of others. However, considering the effectiveness in reducing the levels of anti-nutrients, boiling is better. It is hereby recommended that for optimum nutritional delivery, pumpkin and breadfruit seeds should be fermented for a minimum of 24 hours and boiled for at least 30 minutes before consumption.

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