European Journal of Food Science and Technology
Vol.6, No.1, pp.40-48, February 2018
Published by European Centre for Research Training and Development UK (www.eajournals.org)

EFFECT OF PROCESSING METHODS OF TOASTING, SOAKING, BOILING, SPROUTING ON DIETARY FIBRE AND ANTINUTRIENT CONTENTS OF AFRICAN YAM BEAN AND RED KIDNEY BEAN FLOUR

Ihemeje, A., Nwanekezi, E.C., Odimegwu, E.N. & Ekwe, C.C.

Department of Food Science and Technology, Faculty of Engineering Imo State University, Owerri

ABSTRACT: *The effect of boiling, toasting sprouting and soaking were on dietary Fibre and anti-nutrients in African yam bean and red kidney beans were studied. The samples were grouped into five. The first group was the control (raw). The second, third, fourth and fifth were respectively boiled, toasted, sprouted and soaked. The samples were later subjected to laboratory analysis to evaluate their dietary fibre and antinutrient contents. Results indicate significant ($p<0.05$) increase in dietary fibre of African yam bean (1.95) and red kidney bean (3.11%). Boiling, sprouting and soaking caused increase in dietary fibre (2.39%), 2.17% and 23% respectively while only boiling and sprouting let to significant ($p\leq005$) increase above that of the raw in red kidney bean. Generally all the anti nutrients were significantly reduced by boiling, toasting, sprouting and soaking in both African yam bean and red kidney bean.*

KEYWORDS: Processing Method, Toasting, Soaking, Boiling, Dietary Fibre, Antinutrient Contents, African Yam Bean, Red Kidney Bean Flour**.**

INTRODUCTION

Legumes are good sources of cheap and widely available proteins for human consumption. They are staple foods for many people in different parts of the world. The range between the highly utilized legumes such as soybeans, cowpeas to the lesser known ones like African yam beans. Known legumes together with other conventional legumes can be used for combating protein malnutrition. African yam bean contains different food fractions and minerals that are comparable to other food legumes. The seed is a highly priced food legume in south eastern Nigeria (Asoiro and Ani, 2011) owing to high crude protein content.

Red kidney beans are herbaceous annual plant of the family legumino sae. It is a domesticated independently in ancient Mesoamerica and the Andes. Although widely cultivated in hot climate throughout the world. White and black varieties of these kidney shaped beans are also available but underutilized (Katherine 2002). It is an excellent source of vegetable protein, starch, soluble and insoluble fibres, vitamins (especially B group and minerals, particularly potassium Iron, Zinc, Magnesium and Manganese). They are very low in fat but have not gained wide spread industrial, economic and nutritional importance because of its acceptability and utilization have been limited.

It addition there is presence of complex carbohydrates and dietary fibre which has been proved to be associated to reduce the risk of heart disease, diabetes and obesity. (Anderson et al, 2009). Raw kidney beans also contain large amount of anti nutritional factors such as phytic acid, phyto reamagglutinins, trypsin inhibitors, saponins and tannins which can affect absorption of protein, carbohydrates and certain minerals (Shimelis and Raskshit 2007).

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Traditional processing methods such as hydration, germination, thermal processing (cooking and autoclaving) and fermentation have been proved to be effective in eliminating the anti-nutritional factors present in legumes (Khattab et al, 2009; Nergiz and Gokgoz 2007; Khalil 2001).

Statement of Problem

African yam bean and red kidney beans are good sources of plant proteins, B vitamins and minerals. In addition the presence of complex carbohydrate and dietary fibre contribute to low glycemic index which has been proved to help reduce the risk of heart diseases, diabetes and obesity (Anderson et al, 2009). The effect of processing methods which are said to reduce anti nutritional factors in legumes on the dietary fibre contents of these legumes are not known and has not been reported.

Objective of Study

The major objective of this study is to determine the effect of processing methods on dietary fibre and anti-nutrient contents of African yam bean (Sphenostylis stenocarpa) and Red Kidney beans (Vigna anymyanes) flour.

Specific Objectives

The specific objectives of this study were to:

I. Determine the proximate composition of the red kidney beans and African yam bean based dishes.

II. To determine their reducing sugar

III. To determine the dietary fibre content of African yam bean and red kidney beans.

IV. To produce African yam bean and red kidney bean flours

V. To determine the anti-nutrients content of African yam bean and red kidney beans.

Justification of the Work

The result of this study will help customers to choose the processing methods which will reduce the anti-nutritional factors and at the same time retain most of the dietary fibres of the legumes.

Materials and Methods

African yam beans and kidney beans where obtained frim Eke-ukwu Owerri market in Owerri municipal, Imo State.

Samples Preparation of Flour

The legumes were sorted to remove unwholesome ones while the good seeds were taken to Federal Institute of Industrial Research Oshodi in Lagos State, after which the flour was been packed in a poly bag .

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Proximate Compositional Analysis

All the samples were been replicated three times and the mean results were calculated.

The moisture and ash content of African yam bean and red kidney bean flour samples were determined using the indirect method and furnace incineration method as described by Onwuka (2005).

The protein content of the samples were determined by the semi-micro Kjeldahal method as reported by AOAC (1990), the fat content was determined on wet basis by Soxhlet's method described by Suzanne (2003) while the starch content was determined by sieving method as described by AACC (1999). Reducing sugar was qualitatively determined by using fehling solution test as described by Ramalingam et al., (1993) while dietary fibre content was determined by subtracting sugar and starch contents from the calculated carbohydrates content by difference method described by Okaka and Ikegwu (2011).

Analysis of Antinutritional Constituents

The procedure followed in the determination of total oxalate was as described by Holloway et al., (1989). Phytate content was determined using the method described by Vaintraub and Lapteva (1988) as modified by Salazar et al., (2006). Tannins were analyzed using the method described by Pearson (1976) as modified by Salazar et al., (2006). Saponin content was determined using the method of Birk et al., (1963) and modified by Hudson and El-Difrawi (1979) while Trypsin inhibitor activity was assayed by the procedure described by Smith et al., (1980).

Statistical Analysis

Data obtained was analyzed statistically using analysis of variance (ANOVA) and mean; it was then separated by least significance difference (LSD) procedure as described by Ihekoronye and Ngoddy, (1985).

RESULTS AND DISCUSSION

Table 2: Effects of Processing on Concentration of Proximate Compositional Analysis of African yam bean.

Nutrient(%)	Raw	Boiled	Toasted	Sprouted	Soaked	LSD
Protein	11.24 ±0.12	12.48±0.13	11.00±0.16	11.25±0.06	11.25±0.06	0.3136
M.C	10.55±0.11	11.82±0.16	8.00±0.13	10.57±0.14	10.57±0.14	0.3729
ASH	2.83	2.80±0.05	1.98±0.08	2.84±0.06	2.83±0.01	0.1893
Fat	2.80±0.09	2.07±0.12	1.88±0.12	2.00±0.22	2.8±0.11	0.4090
CHO	70.59±0.21	69.29±0.03	74.21±0.07	71.29±0.03	70.21±0.01	0.2766
Starch	32.96±0.04	30.10±0.05	36.54±0.02	32.71±0.09	31.19±0.05	0.1340
Reducing Sugar	35.68±0.02	36.80±0.12	35.67±15	36.41±0.09	36.75±0.1	0.3129
Dietary Fibre	d 1.95±0.05	ca 2.00±0.12	cd 2.00±0.12	bc 21.17±0.03	ab 2.30±0.02	0.2033

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Effect of Boiling, Toasting, Sprouting and Soaking on Dietary Fibre of African Yam Bean and Red Kidney Bean.

The effect of boiling, toasting, sprouting and soaking on the dietary fibre of African yam bean and red kidney bean was investigated. Results show that fibre the dietary fibre of raw African yam bean (1.95%) was significantly (≤0.05) increased by boiling (2.39) sprouting (2.17%) and soaking (2.30%). But there was no significant difference between that of the raw and toasted African yam bean (2.00%) boiling mostly increased the dietary followed by soaking sprouting and toasting.

Also the result indicated that raw red kidney bean contains 3.11% dietary fibre which was significantly (P<0.05) improved by boiling (3.26), (3.17%) and soaked (3.2o%) were respectively higher than that of the raw sample but not statistically different (P>0.05).

	Raw	Boiled	Toasted	Sprouted	Soaked	LSD
M.C	2.41±0.09	3.82±0.08	2.38±0.12	3.09±0.19	4.40±0.5	0.1906
ASH	4.39±0.01	3.00±0.15	4.02±0.11	2.40±0.08	4.37±0.18	0.6925
PAT	15.68±0.12	11.00±0.18	14.22±0.1	11.28±0.14	12.50±12	0.5334
Protein	15.27±0.03	22.71±0.19	23.03±0.14	20.81±0.30	15.26±0.04	0.4595
Fibre	3.54±0.1	2.26±0.05	465±0.12	3.58±0.13	3.52±0.08	0.3002
CHO	58.71±0.20	57.2±0.06	51.70±0.25	58.84±0.25	59.95±0.05	0.3987
Starch	35.51±0.09	31.78±0.13	27.00±0.15	33.44±0.08	34.56±0.00	0.1703
Reducing Sugar	20.08±0.04	22.17±0.03	21.53±0.09	22.16±0.04	22.19±0.03	0.1572

Table 3: Effects of Processing on Concentration of Proximate Compositional Analysis of Red kidney bean.

Table 4: Effects of Processing on Concentration of antinutrient in African yam bean.

Sample Parameters	Raw	Boiled	Toasted	Sprouted	Soaked	LSD
Saponin (mg/100g)	2.2^{a}±0.06	1.70^{a}±0.35	1.08^{a}±0.08	2.00^{a}±0.5	2.00^{a}±0.94	-
Trysin	1.84^{a}±0.46	0.72^{b}±0.28	0.86^{b}±0.05	0.97^{b}±0.02	1.04^{b}±0.17	0.5841
Oxalate (mg/100g)	20.81^{a}±2.64	16.09^{b}±0.51	17.00^{b}±0.72	18.03^{b}±0.21	17.77^{b}±0.61	2.6662
Phylate (mg/100g)	4.07^{a}±.19	2.06^{b}±0.12	2.12±0.12	2.16^{b}±0.18	3.05^{b}±0.95	1.3184
Tannin (mg/100g)	11.86^{a}±0.87	7.56^{c}±0.069	7.08^{c}±0.01	9.23^{b}±0.23	10.07^{b}±0.25	1.661

Mean with same superscripts along the same row are significantly different (p≤0.05) means were separated using L.S.D

ISSN 2056-5798(Print), ISSN 2056-5801(online)

Effect of Different processing methods on the concentration of anti-nutrients in African yam bean.

The effect of boiling, toasting, sprouting and soaking on trypsin inhibitor, oxalate phylate and tannin concentration of African yam bean is shown in table 2.

Saponin

The results of saponin concentration of both raw and processed African yam bean were shown in table 2 as 2.2±0.5mg/100g, for raw sample, 1.70±0.35mg/100g for boiled, 1.08±0.08mg/100g for soaked. The processed African yam bean acquired 22.7%, 50.90% and 9.1 reduction in their saponin content and it was observed that the roasted sample had the highest percentage, reduction of saponin content was significantly different ($p \leq 0.05$) among all the samples analyzed. The result for the heat processing methods (boiling and toasting) which obtained the highest percentage of reduction were in agreement with Balogun et al (2001), who reported that most anti-nutrient factors in legume seeds can be reduced by proper heat application.

Tryposin Inhibitor

Tryosin inhibitor is a type of serine protease inhibitor that reduces the biological activity of tryposin which is responsible for the breakdown of proteins. The concentration level of trypsin in the African yam bean sample were reduced from 1.84±0.46 (raw) to 0.71±0.28 (boiled), 0.86±0.05 (toasted 0.97±0.02 (sprouted) and 1.04±0.17 (soaked). The percentage reductions were 60.09, 53.3, 47.3 and 43.5 for boiled, toasted, sprouted and soaked respectively. From the results it can be concluded that boiled samples contain more amino acid in consumption than other samples. The results obtained from boiled and toasted sample once again agreed with the report made by Farris and Singh (1990) and Balogun et al (2001), who reported that most anti-nutrient factor in legume seeds can be reduced by proper application of heat. The processed samples were not significantly different ($p \leq 0.05$) from each other.

Oxalate

The oxalate content of raw African yam bean was found to be 20.81±2.64mg/100g as presented in table 2. The subjection of the raw sample to boiling, toasting, sprouting and soaking reduced the oxalate content to about 22.7, 18.03, 13.4 and 14.6 percent respectively. There were no significant differences among the processed sample ($p \leq 0.05$). Oxalate forms a strong chelate with dietary calcium and other dicalent metals at certain concentration (Abara et al., 2000). The strong complexes of calcium is limited, unavailable for absorption and sometimes becomes precipitated as insoluble salts that accumulate in the renal calculi (Hui, 1992). The oxalate content of both raw and processed AYB obtained from the study do not pose any health problems when compared to 59% or more intake of oxalic acid reported by (Hui, 1992) too fatal to humans.

Phytate

The phytate content of raw African yam bean sample were found to be 4.07±0.19mg/100g as presented in table 2. The value is higher than 2.16mg/100g reported by Ugwu and Oranye (2006) on African breadfruit. The effect of processing on the bean was illustrated in table 2 and it showed that processed AYB received 49.4, 47.9, 46.9 and 25.1 percent decrease in the phylate concentration. According to Boulter (1982) phylate lead to hard to cook phenomena in

ISSN 2056-5798(Print), ISSN 2056-5801(online)

pulses, which increased the cooking time of legume grains. However, the apparent reduction in phytic acid during processing could be attributed to the formation of insoluble complex between phylate and other components, such as phylate potein and phylate mineral complexes (Vijayakumari et al., 1997). There was insignificant difference among the processed samples (≤0.05/100g).

Tannin

The tannin concentration of raw and processed AYB as presented in table 2 were between 7.08±0.01mg/100g and 11.86±0.087mg/100g. There were significant difference between raw and processed AYB (≥0.05). Toasting recorded the least value for tannin (7.08±0.01mg/100g) followed by boiling (7.56±0.06mg). The least values obtained for the heat treated samples could be attributed to proper application of heat (Balogun et al, 2001). For boiling, tannin are said to be phylhenols, and phyphenols, and polyphenolsie compounds are water soluble in nature (Kumar et al, 1979) meaning that reduction during boiling could be attributed to leaching out of phenols into cooking water.

Table 5: Effects of Processing on the Concentration of anti-nutrients in red kidney bean.

Sample Parameters (mg/100g)	Raw	Boiled	Toasted	Sprouted	Soaked	LSD
Saponin /1	1.55^{a}±0.05	1.24^{b}±0.14	1.02^{b}±0.06	1.38^{b}±0.06	1.35^{b}±0.05	0.224
Trysin	1.20^{a}±0.11	0.18^{b}±0.02	0.34^{b}±0.08	0.42^{b}±0.11	0.96^{b}±0.16	0.2518
Oxalate	18.32^{a}±0.11	16.09^{b}±0.05	15.10^{c}±0.05	16.02^{a}±0.12	15.28^{c}±0.08	0.2464
Phylate	3.20^{a}±.0.09	1.77^{c}±0.23	1.80^{c}±0.05	1.75^{c}±0.05	2.15^{b}±0.06	0.3141
Tannin	78^{a}±0.22	5.61^{d}±0.19	52.28^{e}±0.03	7.64^{c}±0.08	8.7^{b}±0.07	0.3258

Mean along the row with similar superscripts are insignificantly different (p≤0.05) means were separated using Least Significant Difference L.S.D

Effects of different processing methods on the concentration of anti-nutrients in red kidney bean

The red kidney bean were subjected to boiling toasting sprouting and soaking and effect of these processing methods on concentration of antinutrients in red kidney bean were analyzed and vales presented in table 3.

Saponin

The saponin content of the red bean was presented in table 3 as 1.55±0.05mg/100g. The value is low 2.2±0.6mg/100g compared to what was reported for African yam bean. The concentration of saponin in red kidney bean decreased in the processed sample by 20%, 34.2%, 11% and 13% for boiled, toasted, sprouted and soaked red kidney bean. The toasted sample was significantly lower (p≤0.05) in saponin than other samples could be attributed to temperature and processing time plus method owing to the fact that saponins are heat labile.

Trypsin Inhibitor level of concentration was drastically reduced especially by boiling and is in conformity with the work done by Prathiba (1995). This reduction maybe attributed to its great solubility in cooking water apart from being heat labile. The raw red kidney bean trypsin

ISSN 2056-5798(Print), ISSN 2056-5801(online)

inhibitor concentration is 1.20±0.11 (Table 3). Boiling decreased it to about 85% and toasting (71.7%), sprouting (65%) and soaking (2%). There was no significant difference between the raw and soaked sample at ($p \leq 0.05$).

Oxalate

Oxalate is known to have similar effect with phylate (Morozumi et al., 2006). Noonan and Savage (1999) added that oxalate aids in formation of kidney stones by decreasing absorption of calcium. The concentration of oxalate in red kidney bean were presented in table 3 as 18.32±0.11mg/100g for raw, 14.13±0.11mg/100g for raw, 14.13±0.05mg/100g boiled, 15.10±0.05mg/100g for toasted, 16.02±0.12mg/100g for sprouted and 15.28±0.08mg/100g for soaked. Boiling among all the processing method had the highest percentage reduction (22.9%) and is significantly lower ($p \geq 0.05$) in terms of oxalate concentration.

Phylate

The processing methods reduced the phylate content of the red kidney bean by 44.7% for boiled, 43.8% for toasted, 45.3% for sprouted and 32.8% for soaked. The sprouted sample had the highest percentage reduction of phylate and this also observed during germination of soybeans, where there was an increase in phylate activity which is accompanied by a corresponding decrease in phylate content. There was insignificant difference between boiled, toasted and sprouted and at ($p \leq 0.05$). The values were low compared to 343.0 and 543.0 mg/100g reported by Ruchi and Sheel (2013) on red kidney beans (raw and processed).

Tannin

The tannin content of the raw red kidney bean (9.78±0.22mg/100g) was high compared to leguminous plant like brachytegia eurycomo seed which is 5.15mg/100g (Amah et al., 2001). The concentration reduced after processing to 5.61±0.19mg/100g for boiled, 5.23±0.03mg/100 for toasted, 7.64±0.08mg/100g for sprouted and 8.07±0.07mg/100g for soaked with the toasted sample having the least value which could be attributed to the severity of the temperature of the processing method which might have disrupted the coats of the bean were tannins exist. There were significant differences ($p \geq 0.05$) among all the samples analyzed. The tannin content was low compared to 3833-4533/100g reported by Ruchi and Sheel (2013) on red kidney beans.

CONCLUSION

The processing methods (boiling, toasting, sprouting and soaking) were found to improve the dietary fibre of both African yam bean and red kidney beans. Also their inherent anti-nutrients were significantly ($p < 0.05$) reduced by the processing methods adopted. These results proved that the processing methods are very effective and could lead to increase in nutritional qualities of African yam bean and red kidney bean respectively especially in terms of mineral contents due to reduction in anti-nutrients (phylate, oxalate, trypsin, tannins etc) known to bind and form complexes with minerals thereby reducing their bioavailability.

ISSN 2056-5798(Print), ISSN 2056-5801(online)

RECOMMENDATION

From the results obtained it is recommended that further investigation will be carried on both African yam beans and red kidney beans where two or more of these processing methods could be applied simultaneously. This practice would probably further improve their dietary fibre and also reduce the concentrations of many inherent anti-nutrients. The functional properties of their flours should also be investigated to increase their economic importance and lead to possible industrial application.

REFERENCES

AACC .(1999). Approved Methods of Analysis, 11th Edition. American Association of Cereal Chemists. ISBN 978-1-891127-68-2

Abara, A., Udosen, E. and Eka, O. (2000). Estimation of calcium, zinc, hydrocyanate, oxalate and phylate in doscorea bulbifera tuber. Global J. pure App. Sci 10:79-84.

Anderson, J.W., Baird, P., Davis, R., Ferreri, S., Knudtson, M., Korayam, A., Waters, V and Williams, C.L. (2009) Health benefits of dietary Fibre. Nut. Rev. 67:188-205.

Asoiro, F.,U., Ani A.O., (2011). Determination of some Physical Properties of' African Yam Beans, Pac J Sci Tech, 12: 374-380.

AOAC (1990) Official Methods of Analysis, 15th Edition. Association of Official Analytical Chemists, Washington D.C.

Balogun, T., Kaakuka, F. & Bawa, G. (2001). Effect of boiling full fat soyabeans on its amino acid profile and on performance of pigs. Nig. J. Anim. Food 28 (1):45-51.

Birk, Y., Bondi, A., Gestner, B. and Ishaya, I.A. (1963). Thermostable hemolytic factor in Soya beans. Natural. 197:1089-1090.

Boulter, D.(1982). The post-translational proteolysis of the subunits of vicilin from pea (Pisum sativum L.). Biochem J, 207, 629–632.

Farris, D. and Singh, U. (1990) Pigeon pea. In:L Nene et al (eds). The pigeon pea, pantanchru, A.P. pp467.

Holloway. W.D., Argall, M.E., Jealous, W.T., Lee, J.A. and Bradbury, J.H. (1989). Organic acid and calcium oxalate in tropical root crops. J. of Agric and Food Chem. 37:337-341.

Hudson, B.J.F. and E.A. El-Difrawi, 1979. The Sapogenins of the seeds of four Lupin species. J. Plant Foods, 3: 181-186.

Hui, Y. (1992). Oxalates in encyclopedia of food science and technology. John Wiley and Sons, Inc. Vol 3. Pp58.

Ihekoronye, A.I. and Ngoddy, D.O. (1985). Integrated Food Science and Technology for the tropics , London Macmillan Publisher pp:235-240.

Katherine, W. (2002).Healing Foods. New Lanark M. LII9DJ. Scotland.

Khalil, M.M. (2001). Effects of soaking, germination, autoclaving and cooking on chemical and biological value of guar, compared with faba bean. Nahrung-food, 45:246-250.

Khattab, R.Y., Amitfield, S. and Nyachoti, M. (2009). Nutritional quality of legume seeds as affected by some physical treatments part I. Protein quality evolution. LW T-Food Sci. Technol. 42:1107-1112.

Kumar A., Maurya B. R., Raghuwanshi R. (1979). Isolation and characterization of PGPR and their effect on growth, yield and nutrient content in wheat (Triticum aestivum L.). Biocatal. Agric. Biotechnol. 3 121–128.

Morozumi, M., Nakayama, E., Iwata, S., Aoki, Y., Hasegawa, K. and Kobayashi, R. (2006). Simultaneous detection of pathogens in clinical samples from patients with community-

ISSN 2056-5798(Print), ISSN 2056-5801(online)

acquired pneumonia by real-time PCR with pathogen-specific molecular beacon probes. J Clin Microbiol.44:1440–1446.

Nergiz, C. and Gokgoz, E. (2007). Effects of traditional cooking methods some anti-nutrients and in vitro protein digestibility of dry bean varieties (Phaseolus vulgaris L.) grown in Turkey. Int. J. Food Sci. technol 42:868-873.

Noonan, S.C. and Savage, G.P. (1999) Oxalate Content of Foods and Its Effect on Humans. Asia Pacific Journal of Clinical. Nutrition, 8, 64-74.

Okaka, J.C., and Ikegwu .F. (2011). Dietary fibre and encouraging the use of monogastric nutrition Journal of science and techn. 17 (2), p2.

Onwuka, G.J. (2005) Food Analysis and Instrumentation theory and practice. Napthli prints. Lagos Nigeria. Pp:64-76.

Pearson, D. (1976). The Chemical Analysis of Food, 2nd Edition. Longman Group Ltd. Edinburg, London and New York.

Prathibha, S. B. (1995). Enzyme inhibitors in tuber crops and their thermal stability. Plant Foods for Human Nutrition, Dordrecht, 48(3), 247-257.

Ramalingam, J.R., Marichamy, R., Lipton, A.P. and Ganapathy, A.(1993). Large scale exploitation of sea horse (Hippocampus kuda) along the Palk Bay Coast of Tamil Nadu. Mar. Fish. Info. Serv. 119:17-20.

Ruchi, C and Sheet, S. (2013) Conventional nutrients and antioxidants in real kidney beans (phaselus vulgaris L). An explorative and product development endeavor. Annels. Food Sci. Technol14(2):275-285.

Salazar, E., Ferreira, M.A.R. and Migon, H.S. (2006). Objective Bayesian analysis for exponential power regression models. Sankhya -Series B. 74, 107–125.

Shimelis, E and Rakshit, S. (2007). Effect of processing on antinutients and vitro protein digestibility of red kidney bean (Phaseolus Vulgaris L) Varieties grown in East Africa. Food Chem. 103:161-172.

Ugwu, F. M. and Oranye, N. A. .(2006). Effects of some processing methods on the toxic components of African breadfruit (Treculia africana). African Journal of Biotechnology. Vol.5(22), pp. 2329-2333.

Vaintraub, I.A. and Lapteva, N.A. (1988). Colorimetric determination of phylate in Unpurified extracts of seed and the products of their processing. Analytical Biochemistry. (175:227-230.

Vijayajumari, K., Siddjuraji, P.N and Janardhanan, K(1997). Effect of domestic processing on the levels of certain antinutrients in proposes chilensis (Molina) Stunz seeds. Food Chemistry 59 (3):367-371.

ISSN 2056-5798(Print), ISSN 2056-5801(online)