Effects of Blanching on the Proximate Compositions and Antinutritional Factors of Products from African Star Apple (Chrysophyllum albidium) Peels and Cotyledons.

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ABSTRACT

This study focuses on the identification of the proximate compositions and antinutritional factors in the peels and cotyledons of Afrian star apple (Chrysophyllum albidium) and evaluate the effects of processing on the chemical properties of their products. The peels and cotyledons were blanched at 1000C for 2,4 and 6 mins, wet milled with water in 1: 1.5 ratio, sieved with muslin cloth to obtain the extracts which were pasteurized at 800C for 10mins thus giving rise to 8 samples including their control samples coded as follows: peel extract control samples (A1, B1 and C1) of 2, 4 and 6 mins blanching respectively and cotyledons extract control samples (A2, B2 and C2) of 2, 4 and 6mins blanching respectively. The fresh peel and seed contains the following moisture content (22.36%) protein (1.68% and 4.33%), crude fibre (8.21% and 5.99%), ash (0.18% and 0.30%), protein (1.68% and 4.33%), fat (0.50% and 3.05%) and carbohydrate (66.87% and 60.74%), respectively which reduced with increased blanching period. The antinutrients - tannin (0.400% and 0.240%), HCN (1.06% and 1.10%) and phytate (1.21% and 2.73%)- in both peels and seeds respectively also reduced appreciably with increased blanching period.

Key words: antinutritional , blanching, compositions, effects, factors, products, proximate.

INTRODUCTION

Chrysophyllum albidium, from the Sapotaceae family, is commonly found in the Central, Eastern and Western Nigeria, Uganda, Niger, Cameroon, and Cote d'Ivoire (Adewusi, 1997). It is often called the white star apple and distributed throughout the Southern part of Nigeria (Idowu et al., 2006). In Westhern Nigeria, the fruit is called "agbalumo" and popularly referred to as "udara" in South-Eastern Nigeria. C. albidium is a popular tropical fruit tree and widely distributed in the low rain forest zones and frequently found in villages (Madubuike and Ogbonnaya, 2003). The roots, barks and leaves of C. albidium have been employed in folk medicine for the treatment of diseases. The fruit is seasonal (December-March) and has immense economic potentials (Essien et al., 1995), when ripe, ovoid to subglobose, pointed at the apex, and up to 6cm long and 5cm in diameter. The skin or peel is orange to golden yellow when ripe and the pulp within the peel may be orange, pinkish or light yellow. Within the succulent pulp are three to five seeds which are usually eaten. The seed-coats are hard, bony, shiny, and dark brown, and when broken reveal white-coloured cotyledons (Essien et al., 1995).

The peel contain 58.9% moisture, 6.1% protein, 12.4% fat, 4.6% ash, 62.4% carbohydrate and 14.5% crude fibre. The pulp contains 67.5% moisture, 8.8% protein, 13.1% fat, 68.7% carbohydrate, 40% crude fibre and 3.4% ash (Table 1). Anti-nutrients contents include; total oxalate content in the peel, 211 mg/100g and in the pulp, 167 mg/100g. Tannins content in the peel 264 mg/100g and the pulp 627 mg/100g while the hydrocyanic acid content is 5.4 mg/100g in the peel and 6.8 mg/100g in pulp. The phytic acid content is 0.8 mg/100g in the peel and 1.6 mg/100g in the pulp (Edem et al., 2003). The seed has high content of crude protein

18.34%, 6.48% fat and 4.63% crude fibre. The seed is low in minerals and also contains significant amount of anti-nutrients such as saponnins, tannins and flavonoids but has no alkaloids and an thraquinone (Odo et al., 2005) as shown in Table 2.

Table 1: Proximate composition and vitamin C of peel and pulp of African star apple

	Moisture %	Protein %	Fat %	Ash %	CHO %	Crude Fibre %	Ascorbic Acid mg/100g
Peel	58.9	6.1	12.4	4.6	62.4	14.3	239.1
Pulp	67.5	8.8	15.1	3.4	68.7	8.0	446.1

Source: Edem et al.,(2003)

Table 2: Antinutrients compositions of peel and pulp of African star apple (in mg/100g)

	Tannins	Total oxalate	Hydrocyanic acid	Phytic acid
Peel	264	211	5.4	0.8
Pulp	627	167	6.8	1.6

Source: Edem et al., (2003)

MATERIALS AND METHODS

MATERIALS

Procurement of Raw Materials

The healthy fruits of Chrysophyllum albidum were collected from uncultivated and cultivated farmlands respectively, located at South Eastern part of Nigeria.

Reagents for Laboratory Analysis

All reagents used for this study were obtained from the Department of Food Science and Technology University of Nigeria, Nsukka and Ogige Market in Nsukka respectively and they are all of analytical quality.

METHODS

Sample Preparation

The fruits were thoroughly washed with water, to remove extraneous materials such as dirt, separated into pulp, peel and seeds which were further cracked to reveal the white cotyledon. Different processing methods were applied as shown in Fig. 1.

Production of Extracts from Blanched Seeds and Peel Pulps

The cotyledon and peel were divided into three equal parts each and steam blanched at 100oC for 2mins, 4mins and 6mins, wet milled to produce their respective pulps which were blended with water in 1:1.5 ratios producing their extract yield respectively. These extracts were pasteurized at 800C for 10mins and thereafter bottled for analyses thus giving rise to 8 samples including their control samples coded as follows: blanched peel extract samples (A1, B1 and C1) of 2, 4 and 6 mins blanching respectively and blanched cotyledons extract samples (A2, B2 and C2) of 2, 4 and 6mins blanching respectively.

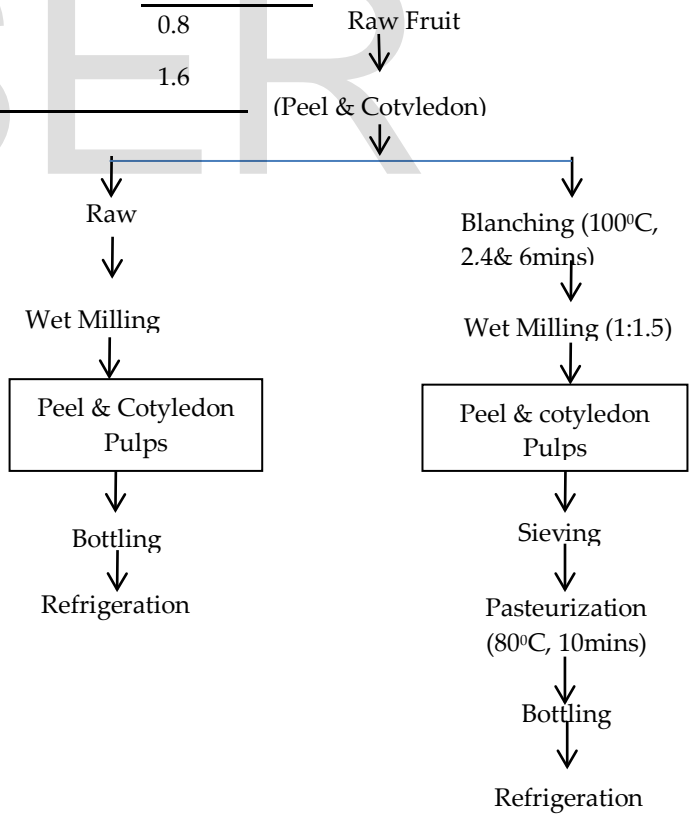

Fig. 1: Production of udara products.

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SAMPLE ANALYSIS

Proximate Analysis

Determination of Moisture Content

Moisture content of samples were determined using hot air oven method (Gallenkamp, VWR 1730 England) in duplicate as described by AOAC (2010). Five grammes (5g) of the test sample (ginger peels) was weighed using weighing balance (Electronic kitchen scale SF-400 China) in duplicate into already weighed sterilized and cooled petri dishes. The dishes were then put into an air oven (Gallenkamp, VWR 1730 England) at 150±20C for 15 minutes before weighing. The dishes were returned to the oven and re-weighed until constant weights were obtained. The loss in weight was regarded as moisture content. The percentage moisture content was then calculated as thus:

$$Percentage\ Moisture\ Content = \frac{W_2 - W_1}{W_1} \times \frac{100}{1}$$

Where;

W2 = Constant weight of sample

W1 = Original weight of sample

Determination of Crude Fat Content

The soxhlet extraction method of AOAC (2010) was used in determining the fat content of the sample. About 2g of the sample (A) was weight out using electronic kitchen scale (SF-400 China) and put in the extraction thimble and plugged. It was then placed back in the soxhlet apparatus. A weighed flat bottom flask (B) was thereafter filled to about three-quarter of its volume with petroleum ether of 40-600C boiling point range. The apparatus was then set up and the experiment was carried out for a period of 4-8 hours after which complete extraction was made. The petroleum ether was recovered by evaporation using water bath (Technicol, SE-20 England) and the remaining portion in the flask was dried in the oven (Gallenkamp, VWR 1730) at 800c for 30 minutes and cooled in a dessicator and finally weighed using Mettler HAS balance (P-163 England). The difference in the weight of the empty flask and the flask with oil (C) gave the oil content which was calculated as the percentage fat content.

$$Percentage\ Fat\ Content = \frac{C - B}{A} \times \frac{100}{1}$$

Where;

A = weight of sample

B = weight of empty flask

C = weight of flask and oil

Determination of Crude Protein Content

The crude protein content of the sample was determined by the semi-micro kjeldahl technique described by AOAC (2010). About 1g of the sample was put into a kjeldahl flask and 3g of hydrated cupric sulphate (catalyst) was added into the flask. Twenty millilitres (20ml) of anhydrous sodium sulphate and 1g of concentrated sulphuric acid (H2SO4) were added to digest the samples, stoppered and swirled. The flasks and its content was then swirled occasionally until the liquid was clear and free from black or brown colour. The clear solution was then cooled and made up to 100ml with distilled water and a digest of about 5ml was collected for distillation. Five milliliters (5ml) of 60% sodium hydroxide solution was put into the distillation flask and distilled for five minutes. The ammonia that was distilled-off was absorbed by boric acid indicator which was titrated with 0.1ml hydrochloric acid. The titre value of the end point at which the colour changed from green to pink was taken. The crude protein was calculated as percentage crude protein.

$$Crude\ protein\ (percentage) = \frac{0.0001410 \times 6.25 \times 25 \times T}{W \times 5} \times \frac{10}{1}$$

Where,

W = weight of sample (g)

T = Titre value

Determination of Crude Fibre Content

The crude fibre content of the sample was determined using the method described in AOAC (2010). About 2g (w1) of sample was weighed using Mettler HAS balance (P-163 England) and put in a 250ml beaker, then boiled for 30 minutes with 100ml of 0.12M H2SO4 and filtered through a funnel. The filtrate was washed with boiling water until the washing was no longer acidic. The solution was boiled for another 30 minutes with 100ml of 0.012M NaOH solution; filtered with hot water and methylated spirit three times. The residue was transferred into a crucible and dried in the oven (Gallenkamp, VWR, 1730 England) for 1 hour. The crucible with its content was cooled in a dessicator and then weighed (W2) using Mettler HAS balance (P-163 England). The residue was then taken into a furnace for ashing at 6000C for 1 hour. The ashed sample was removed from the furnace and put into the dessicator to cool and later weighed (W3) using Mettler HAS balance (p-163 England). The percentage crude fibre was calculated thus;

$$Percentage\ Crude\ Fibre\ Content = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

Where;

W1 = weight of original sample

W2 = weight of crucible and residue

W3 = weight of final ashed sample

Determination of Crude Ash Content

The method described by AOAC (2010) was adopted for ash content determination. A silicon dish was heated to 6000C in muffle furnace cooled in a dessicator and weighed using Mettler HAS balance (P-163 England). About 5g of the sample was put into the silicon dish and transferred to the furnace. The temperature of the furnace was then allowed to reach about 5250C before placing the dish in it. The temperature was maintained until whitish grey colour was obtained indicating that all the organic matter content of the product had been destroyed. The dish was brought out from the furnace and placed in the dessicator, cooled and weighed. The percentage ash content was calculated as:

$$Percentage\ Ash\ Content = \frac{C - A}{B - C} \times \frac{100}{1}$$

Where;

A = weight of empty dish

B = weight of empty dish and sample before ashing

C = weight of dish and ash

Determination of Carbohydrate

Carbohydrate content of the samples was determined by the difference described by Oyenuga (1968) using the equation below.

% Carbohydrate = 100 – (% moisture + ash + % protein + % crude fiber+%crude fat)

Analysis of Anti-nutritional Factors

Determination of Tannin

The Folin– Denis spectrophotometric method as described by Pearson (1976) was used. One gram of the sample was dispersed in 10ml distilled water and agitated. This was left to stand for 30mins at room temperature and shaken every 5mins. After this, it was centrifuged at 3000rpm for 5mins to obtain the extract. A quantity of 2.5ml of standard tannic acid solution was dispersed into a separate 5ml flask. A quantity of 0.1ml folin– Denis reagent was measured into each flask, followed by 2.5ml of saturated Na2CO3 solution. The mixture was diluted to the mark in the flask (50ml) and incubated for 90mins at room temperature. The absorbance

was measured at 250nm. The reading was taken, with the reagent blank at zero.

Tannin content was given as follows

Tannin (g/100g) = Conc. of standard × Absorbance of sample

Determination of Phytate

Phytate content was determined according to the method described by Pearson (1976). A quantity of 0.5g of the sample was weighed into a 500ml flat bottomed flask. The flask with the sample was placed in a shaker and extracted with 100ml 2.4 % HCL for 1hr at 250C, it was decanted and filtered. Five milliliters of the filtrate was diluted to 25ml with distilled water. Fifteen milliliters of 0.1M sodium chloride was added to10ml of the diluted sample and passed through Whatman No.1 filter paper to elute inorganic phosphorus, and 15ml of 0.7M sodium chloride was also added to elute phytate. The absorbance was read at 520nm.

Determination of cyanide

Cyanide content was determined according to the method described by Onwuka (2005). A quantity of 5g of the sample was weighed into a conical flask, 50ml of distilled water was added and allowed staying overnight, filter. About 1ml of the sample filtrate was weighed into a test tube, and then 4ml of alkaline picrate was added and allowed to stand for 5min. the absorbance was read at 490nm. The reading was taken, with the reagent blank at zero.

Determination of Alkaloids

The gravimetric method of Harbone (1980) was adopted. Five gram (5.0g) of the sample was dispersed into 50ml of 10% acetic acid solution in ethanol. The mixture was shaken well and allowed to stand for 4hr before filtering. The filtrate obtained was evaporated to one quarter (1/4) of its original volume. Concentrated ammonium hydroxide was added drop wise to precipitate the alkaloids. The precipitate was filtered with a weighed filter paper and washed with 1% NH4OH solution. The precipitate in the filter paper was dried in the oven at 600C for 30mins and reweighed:

% Alkaloid = $\frac{W_2 - W_1}{W} \times \frac{100}{1}$

Where

W = Weight of sample

W1 = Weight of empty filter paper

W2 = Weight of filter paper plus precipitate.

Data Analysis and Experimental Design

The results were laid out in a completely randomized design (CRD) using a statistical programme SPSS/PC+, Version 17.0 (SPSS Inc., Chicago, IL, USA). A one-way ANOVA was employed for comparison among the groups. Duncan's new multiple range test (DNMRT) was used to compare the treatment means and significance level was accepted at 5%.

RESULTS AND DISCUSSION

Proximate Composition (%) of African star apple samples

The proximate composition of udara peel and cotyledon samples is presented in Table 3. The fresh peels and cotyledons had the moisture content of 22.56% and 23.39% respectively which significantly ($P<0.05$) increased to 14.83% and 96.04% after 2mins blanching peel and cotyledon samples respectively, (95.22% and 97.45%) in 4 mins, and 93.61% and 98.59% respectively after the 6th minute of their blanching. These increase were possible due to formulation of the products with water which is in agreement with report of Frazier and Westhoff (1978), that moisture content of any food is an index of its water activity and is used as a measure of stability and

susceptibility to microbial contamination (Scott, 1980). The extracts therefore may have very brief shelf life due to their high moisture contents and thus adequate preservative measures are recommended to prevent their spoilage. This informed adequate processing measures taken (pasteurization and bottling) in preparation of the extracts. Traces of crude fiber were observed only in fresh samples and absent in all the blanched extracted samples, as a result of dilution effect and filtration technique applied that removed the fiber.

Blanching treatment caused a significant reduction ($P<0.05$) in the protein content of 6mins blanched fresh peels and cotyledons extract as shown in Table 7, which agrees with the reports of Kuti and Torres (1997) that heat treatments (blanching, pasteurization) may decrease the relative compositions of protein. This reduction could also be attributed to dilution effect of the formulation.

There were significant differences ($P<0.05$) in the fat contents of the samples. The fat composition of the cotyledon and peel were appreciably low with that of the fresh cotyledon (3.10%) being higher than that of the fresh peel (0.30%). However, both were found to reduce gradually with increase in blanching time as shown in Table 7 which may be as a result of dilution effects. Fats are concentrated source of energy, and they supply more than twice as many calories per gram, that is, 9kcal/g (27.7kJ/g) compared with proteins and carbohydrates.

There were also appreciable significant differences ($P<0.05$) in the carbohydrate composition of the peel and cotyledon of udara samples, where as the fresh peel and cotyledon recorded the highest values of 66.87% and 60.74% respectively the carbohydrate content reduced drastically in extracted samples as a result of high moisture content of the extract, resulting from the water addition during formulations. Carbohydrates provide the major sources of energy in these products, while the cellulose form cannot be digested but thus contributes to the bulk quantity and aids digestive processes. Carbohydrate had been reported to provide many other health benefits and its recommended daily intake (RDA) values for people within 4 years or older consuming 2,000 calories per day is 300g (Nestle, 2002), which implies that carbohydrate values of the udara peel and cotyledon products can assist to maintain the daily requirements when consumed.

The ash composition represents minerals quantities present in a plant or animal matter. The ash composition of fresh cotyledon was higher (0.40%) than that of the fresh peel (0.18%). However, the ash content of the extracted cotyledon samples reduced, while the peel samples increased with increase in blanching duration. Thus, 6mins blanched peel extract had the highest ash value of 0.40% while 6mins blanched cotyledon extract had lowest value of 0.10%.

Table 3: Effects of blanching on the proximate composition of African star apple (udara) peel and cotyledon extracts (%).

Parameter	Peel	Seed	A1	A2
Moisture content	22.56±0.03h	25.39±0.01g	94.83±0.01f	96.04±0.06
Crude fiber	8.21±0.03a	5.99±0.34b	ND	ND
Ash	0.18±0.04de	0.50±0.07a	0.20±0.03de	0.26±0.03c
Protein	1.68±0.03b	4.33±0.06a	1.04±0.04c	0.90±0.06c
Fat	0.50±0.03b	3.05±0.01a	0.15±0.04c	0.05±0.03c
Carbohydrate	66.87±0.13d	60.74±0.47c	3.78±0.11b	2.75±0.06b

Values are means± SD (n= 3). Mean values with the same superscript in a row are not significantly different ($P>0.05$). ND=Not detected.

Key

A1- 2mins blanched extract of udara peel.

B1- 4mins blanched extract of udara peel.

C1- 6mins blanched extract of udara peel.

A2- 2mins blanched extract of udara cotyledon

B2- 4mins blanched extract of udara cotyledon.

C2- 6mins blanched extract of udara cotyledon.

Effects of blanching on antinutritional factors of udara sample

The result of the evaluation of the antinutrient in udara is presented in Table 4.

It shows that fresh sample of peel and cotyledon had the highest anti-nutrients when compared with their respective blanched extract samples. Tannin significantly ($P<0.05$) reduced from 0.400 to 0.080% and 0.240 to 0.030% for both peel and cotyledon samples respectively. Hydrogen cyanide (HCN) significantly ($P<0.03$) reduced from 1.060 to 0.030% and 1.100 to 0.210% for both peel and seed samples respectively, while phytate reduced significantly ($P>0.05$) from 1.210 to 0.520% and from 2.750 to 0.590% for both peel and cotyledon samples respectively. Tannin and phytate contents were highest in fresh cotyledon when compared with fresh peel but the reverse was the case for HCN where there was no significant difference ($P>0.05$) when fresh peel was compared with fresh cotyledon sample. These reductions in antinutritional contents are in accordance with the observation of Egbe and Akinyele (1990), that anti-nutrients can be reduced drastically by employing longer blanching periods of time. However, the percentage level of reduction is dependent on the duration of blanching as observed in Table 10, blanching at 2, 4, and 6min had remarkable reduction effect on tannin, phytate and HCN. This agrees with the report of Udensi et al. (2004) that since most of the antinutritional factors are heat labile, blanching could therefore inactivate the heat sensitive antinutritional factors. Again since water was involved in the heating process, some soluble compounds could be removed with the discarded boiling solution.

The presence of tannins in seed cotyledon and peel extracts have been reported by Dharmanda (2001) and Hayashi et al., (1993) to have anti-inflammatory effect that helps to control all indications of gastritis, esophagitis, enteritis and irritating bowel disorders. This also conforms with the report by Idowu et al., (2003) and Faleyimu et al. (2008) that seed cotyledon contains tannins. These products can also be used in treatment of fibroid when ground, mixed with water and potash or alcohol and potash (Faleyimu et al., 2008). Adewusi (1997) also reported that high tannin content of this fruit may be responsible for its ethno-medicinal usage. This also confirms the efficacy of these products against vaginal infections and dermatological infections (Idowu, et al., 2003). Adisa (2000) also stated that these chemical elements in the seed cotyledon are used as a remedy for fever and as emollients for treatment of skin eruptions, diarrhea and stomach ache, which is as a result of infections and inflammatory reactions. This further explains the therapeutic and medicinal properties of these products and supported their use as an external application for skin eruptions diseases. The medicinal values of these products are supported by Enzo (2007) that tannins are responsible for anti-diarrheal activity. Faleyimu, et al., (2008) also confirmed that evaluation of potentials of Chrysophyllum abidium in wound care showed that the cotyledon extract exhibited haemostatic antimicrobial and wound healing activities. The report of Lotito et al., (2006) also stated that the seed extract mixed with shear butter oil arrested bleeding from fresh wound by reducing bleeding

and blood clothing time, and suppressing inflammatory reaction involved by injured tissues.

Nwadinigwe (1982) also stated that the antibacterial activity of Chrysophylum albidium supported it use as an antiseptic after birth. Phytate was the highest of all antinutrients analyzed in both peel and cotyledon followed by HCN and lastly tannin. Alkaloid was absent in both fresh peel and cotyledon.

Table 4: Effects of blanching on antinutrient contents of African star apple (udara) samples (%).

Antinutrient	Peel	Seed	A1	A2	B1	B2	C1	C2
Tannin	0.40±0.03a	0.24±0.04b	0.25±0.04b	0.21±0.03bc	0.15±0.01cd	0.08±0.01de	0.08±0.01e	0.03±0.01e
HCN	1.06±0.03a	1.10±0.03b	0.73±0.05b	0.68±0.07b	0.33±0.06cd	0.48±0.09bc	0.05±0.01e	0.21±0.01de
Phytate	1.21±0.04b	2.75±0.06a	1.15±0.06b	0.80±0.03cd	1.00±0.03bc	0.70±0.04de	0.52±0.03e	0.39±0.06de

Values are means± SD (n=3). Mean values with the same superscript in a row are not significantly different (P>0.05).

ND=Not detected.

Key

A1- 2mins blanched extract of udara peel.

B1- 4mins blanched extract of udara peel.

C1- 6mins blanched extract of udara peel.

A2- 2mins blanched extract of udara cotyledon.

B2- 4mins blanched extract of udara cotyledon.

C2- 6mins blanched extract of udara cotyledon.

CONCLUSIONS

Data obtained from this study on the proximate compositions and antinutritional contents of African star apple's cotyledon and peel products indicates that food processing by blanching and pasteurization considerably reduces the quantities of these nutrients with increase in processing time from 2mins to 4mins and finally to 6mins when compared with those of raw/fresh samples.

REFERENCES

Adewusi, H.A. (1997). The African Star Apple (Chrysophyllum albidium) indigenous knowledge from Ibadan, South Western Nigeria. In: Proceedings of a National Workshop on the Potentials of the Star apple in Nigeria pp. 25-33.

Adisa, S.A. (2000). Vitamin C, protein and mineral content of Africa apple (Chrysophyllum albidium).A conference proceedings of the 18th Annual Conference of NIFST, Garba, S.A., Ijagbone, I.F., Iyagba, A.O., Iyamu, A.O., Killani, A.S. and Ufarunu, N.(eds), pp. 141-146.

AOAC(2010). Official Methods of Analysis Association of Official Analytical Chemists, 15th Ed. Washinton D.C., USA.

Chamunanda, S. (2001). Gallnuts and the uses of tannins in Chinese medicine. Institute for Traditional Medicine, Portland, Oregon.

Edem, E.O., Eka, O.U. and Ifon, E.T. (2003). Chemical Evaluation of Nutritive Value of the Fruit of African Star apple (Chrysophyllum albidium). J. Fd. Chem., 14(4): 303-311.

Egbe, A. A. and Akinyele, I. O. (1990).Effect of cooking on the anti-nutritional factors of Lima beans (Phaseolus lunatus).Fd. Chem., 35: 81 – 87.

Enzo, A. P. (2007). Traditional plants and herbal remedies used in the treatment of diarrheal disease. Model of action, quality, efficacy and safety considerations.Modernphytomedicine Turning Medicinal Plants in to Drugs. Wiley-VCL verlag GmbH & Co. KGaA, Weinheim, pp. 248 – 260.

Essien, E.U., Esenowo, G.J. and Akpanabiata, M.I. (1995). Journal of Plant Foods for Human Nutrition.Springer Netherlands. Vol. 48:135-140.

Faleyimu, O. I. and Oluwalana, S. A., (2008). Medicinal value of forest plant seeds in Osun State, Nigeria. Medicinal value of plant seeds.

Frazier, W. C., and Westhoff, D. C. (1978). Food microbiology, (3rd ed). McGraw Hill Book Company, New York, pp. 293 – 303.

Harbone, J. B. (1980). The Biochemistry of natural Pigments, Cambridge University Press.p.128.

Hayashi, M. Oychev, E. V. Okamura, K. A., Sugeta, Hongo, C. Okuyam, K. and Ebisu, S., (1993). Heat treatment strengthens human dentine. J. Dent. Res., 3: 309 – 314.

Idowu, T.O., Iwalewa, E.O., Aderoga, M.A., Akingelu, B.A., Ogundaine, A.O. (2006). Biochemical and behavioural effects of eleagnine from Chrysophyllum albidium. J. Biol. Sc. 6:1029-1034.

Idowu, T.O., Onawunmi, G.O., Ogundaini, A.O. and Adesanya, S.A. (2003).Antimicrobial constituents of Chrysophyllum albidium cotyledons. Nig. J. Nat. Prdts. and Medicine 7:33-36.

Kuti, J. O. and Torres, E. S. (1997). Potential Nutritional and Health Benefit of Tree Spinach. Texas A. & M. University, Kingsville, South Texas.

Lotito, S. B. and Frei, B. (2006).“Consumption of flavonoid rich foods and increased plasma antioxidant capacity in humans: cause, consequence or epiphenomeno” free Radical.Biol. Med., 41(2): 1727 – 46.

Madubuike, F.N., Ogbonnaya, O. (2003). The Potential Use of White Star Apple Seed (Chrysophllum albidium) and Physic Nut (Jatropha curcas) as Feed Ingredients for Rats .J. Fac. Agric. Vet. Med. 1:97-105.

Nestle (2000). Food politics. Berkeley: University of California Press, p. 21.

Nwadinigwe, C. A. (1982). Nutritional Value and Mineral Contents of Chrysophyllum albidium Fruit. J. Sci., Fd. and Agric.,1932.33, 283-285.

Odo, M.O., Ngele, S. and Okezue, I.E. (2005). Evaluation of nutritional composition and anti-nutrients in Africa white apple. Nig. Fd. J. Crop Sci. Assoc., Uganda.Vol. 23: 252-255.

Onwuka, G.I., 2005. Food Analysis and Instrumentation: Theory and Practice. 1st Edn., Napthali Prints, Surulere, Lagos-Nigeria, pp: 140-160.

Pearson, D. (1976). The Chemical Analysis of Foods, Churchhill Livingstone, Edinburgh.

Scott, W. S. (1980). Water relations of food spoilage micro-process during baking of African bread fruit seed. J.Fd. Proper, 7: 585 – 602.

Udensi, E.A, Onwuka, G. I. and Okoli E. G. (2004).Effect of Processing on the levels of some antinutritional factors in Mucanalitilis. Plant Pdts. Res. J., 8(1): 16.

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