Effect Of Heat Processing On The Proximate Composition And Energy Values Of African Walnut (*Plukenetiaconophora*) And African Elemi (*Canariumschweinfurthii*) Consumed As Masticatories In Nigeria

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ABSTRACT: The effects of heat processing on the proximate composition and energy values of the seed kernel flours of African walnut (AW)and pulps of African elemi (AE) used as traditional snacks in most parts of Nigeria were investigated. In the AW, values of moisture, ash, crude fibre and carbohydrate decreased from raw to heat treated samples, while those of crude protein and crude fat generally increased. The increase or decrease in these values was not significant at the 5% level. For instance, ash decreased from 6.05±1.71 in AW_{raw} to 5.45±0.86 in AW_{135}. Crude fat was highest in AW_{45} (52.8±2.70) followed by AW_{90} (51.7±1.61) and was lowest in AW_{raw} (49.8±1.08), while calorific value was highest in AW_{45} (612.2±11.7) followed by AW_{90} (609.3±6.23) and lowest in AW_{raw} (593.4±6.75). Similar trends were observed in proximate composition of raw and macerated African elemi pulp flour, and values between raw and heat processed samples did not generally differ significantly (P>0.05). In $AW_{raw}$the percentage crude protein, crude fat and then energy value in kcal $100g^{-1}$ sample were 26.2, 49.8 and 593.4 respectively, while in AE_{raw} values were 14.6, 41.9 and 568.6 respectively. It can be concluded that both AW and AE are oil-rich seeds and pulps, good nutrient sources that could contribute to the total protein, ash and energy requirements of humans.

Keywords: masticatories, heat processing, proximate composition, energy values.

INTRODUCTION

A significant proportion of the diverse foods available in the environment have been neglected as technological options focus on a few staple foods to address the problem of food security and hunger[1]. There is need to look inwards for locally available foods that are nutritious, cheap and easy to prepare to combat malnutrition. It has been reported that wild seeds and fruits offer a convenient but cheap means of providing adequate supplies of minerals, fat, protein and carbohydrate to people living in the tropics[2]. According to Meregini [3], people of South-eastern Nigeria (across all ages and classes) consume a wide range of fruits and masticatories. Nkafamiya*et al.*[4] reported the consumption of edible wild seeds in the Northern Nigeria. The seed kernels of African walnut and pulps of African elemi are among the widely consumed masticatories in Nigeria.African walnut (*Plukenetiaconophora*) is a climbing and twining tropical plant (Liane) – over 30m long. It is of the family *Euphorbiaceae* and is commonly known in Nigeria as 'Ukpa' (Igbo),'Asala' or 'Awusa' (Yoruba), 'Okhue' or 'Okwe' (Edo) [5], [6]. The fruit is a capsule, 6-10cm long by 3-11cm wide containing sub globular seeds 2-2.5cm long with a thin brown shell resembling the template walnut (Plate I). The seed kernel is edible when roasted or cooked. African elemi or bush candle (*Canariumschweinfurthii*) is a large evergreen tree with a long, clean, straight and cylindrical bole exceeding 50m. It is indigenous to West and Central Africa and is locally known in Nigeria as; 'Ube mgba' (Igbo), 'Atili' (Hausa) or 'Origbo' (Yoruba). It is of the family *Burseraceae* and one of the 75 species that make up the genius, *Canarium*. As shown in Plate II, the fruit is a drupe containing a single triangular shaped seed surrounded by a delicious purplish green pulp [7].Generally, the fruit pulp is eaten either raw or softened by macerating in warm water.

***Plate I**. African walnut seeds*

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Plate II. *African elemi fruits*

Heat-processed seed kernels of African walnut and African elemi pulps are common traditional snacks in Nigeria. According to FAO [8], both composition and nutritional quality of foods can be altered by processing. Audrey *et al.*[9] reported that heating can be both beneficial and detrimental to nutrient content of foods.The present study is designed to determine the effect of wet-heat processing on the proximate composition and energy values of the two Nigerian plant food samples used as masticatories.

MATERIALS AND METHODS.

Samples: Fresh fruit capsules of African walnut (AW) were purchased from a farmer at Ojoto, Idemili South Local Government Area of Anambra State, Nigeria. The capsules were cut open with a sharp knife and the seeds were collected. Fresh fruits of African elemi (AE) were purchased from NgwaRoad market in Aba, Aba South Local Government Area of Abia State, Nigeria. The wholesome seeds and fruits were sorted.

Sample processing: The wholesome plant samples were washed in several changes of deionised water and divided into four (4) lots. The first lots were used raw and labelledAW_{raw} and AE_{raw} for African walnut and African elemi samples respectively. The other lots were given different wet-heat treatments. Trial cooking using their respective traditional cooking methods showed that accepted eating tenderness was obtained for African walnut by boiling in water (99±1^{o}C) for 90 min and, for African elemi by macerating in hot water (55^{o}C) for 30 min. The 2nd, 3rd and 4th lots of African walnut were boiled in water (99±1^{o}C) for 45, 90, and 135 min and labelled AW_{45}, AW_{90}, and AW_{135} respectively. While the 2nd, 3rd and 4th lots of African elemi were macerated in hot water (55^{o}C) for 15, 30 and 45 min and labelled AE_{15}, AE_{30}, and AE_{45} respectively. The water used was discarded. The shell of AW_{raw}, AW_{45}, AW_{90} and AW_{135} were cracked with a hammer and the kernels collected. The fruit pulps of AE_{raw}, AE_{15}, AE_{30}, and AE_{45} were scrapped from the "stones" with a knife. Both kernels and pulps were sliced thinly with a knife (to facilitate drying) and dried for 48 hr in an air-circulatory oven (50^{o}C) (Universalwärmeschrank, UNB 100). The oven-dried samples were ground in a mill (Model BL357. Kenwood, Birmingham UK), passed through a 60-mesh size screen and used in the analyses.

Determination of proximate composition and energy values of raw and heat processed samples

All the analyses were carried out in triplicates using the recommended methods of the Association of Official Analytical Chemists [10]. Moisture was determined using Oven-drying/Evaporation method [10]. Three grams of the sample was dried at 105^{o}C for 2 hr to a constant weight in an air-circulatory oven (Universalwärmeschrank, UNB 100). Loss in weight was taken as a measure of moisture content of the sample, and calculated as percentage of the sample weight. Ash was determined using Incineration (Combustion) method [10]. Three grams of the dried sample was incinerated at 550^{o}C for 4 hr in a muffle furnace until ash was obtained. The non-combustible residue represented the ash and was calculated as percentage of the weight taken. Crude protein was estimated by a process developed by Kjeldahl (1883) as described in the Official Methods of Analysis (No.2.057) of AOAC [10] in which Kjeldahl nitrogen was determined. The method involved the digestion of 2.0g sample with 20ml concentrated H_2SO_4, distillation of the digest to liberate ammonia which was trapped into 2.0% boric acid solution, followed by titration with 0.10MHCl. The % nitrogen was multiplied by a factor of 6.25 to obtain % protein, since proteins on the average, contain 16% nitrogen i.e. 100/16, [11].Crude fat was determined by the gravimetric semi-continuous solvent extraction method contained in the Official Methods of the Association of Official Analytical Chemists [12] as described by [11]. The method involved exhaustively extracting 5.0g sample in a Soxhlet apparatus using petroleum ether (40-60^{o}C) as extractant. Crude fibre was evaluated following the gravimetric method as described in the AOAC method [10]. Three grams of the sample (pre-dried at 105^{o}C) was extracted with 200ml boiling 1.25% H_2SO_4 and 1.25% KOH leaving the non-digestible organic (fibre) and inorganic (ash) matter as residue. Incineration eliminated the fibre which was estimated as weight lost upon incineration of the residue and expressed as percentage of the weight taken. Total carbohydrate was obtained by the difference method as described by Onyeike and Omubo-Dede [13].That is, total carbohydrate (%) = 100 – (%Moisture + % Ash + %crude protein + %crude fat). The energy content was calculated by multiplying the mean values of crude protein, crude fat and total carbohydrate by the Atwater factors of 4, 9 and 4, respectively, summing the products and expressing the results in kilocalories per 100g sample (kcal $100g^{-1}$) as reported by Onyeike and Nkwuzor [14].

DATA ANALYSIS

Data were analyzed by analysis of variance (ANOVA) and means were compared by the Duncan's multiple range test[15]. Significance was accepted as 5% level ($p < 0.05$) or 95% confidence limit.

RESULTS AND DISCUSSION

The results of proximate composition of raw and cooked African walnut (AW) are shown in Table I, while those for African elemi (AE) are presented in Table II. The magnitude of the effect of heat treatment on the proximate composition which is represented as difference between the raw and cooked samples is shown in Tables III and IV respectively for the two plant foods.The moisture content of African walnut flour (Table I) was significantly ($p < 0.05$) decreased at all levels of cooking, ranging from 3.0% (in AW_{raw}) to 1.52% (in AW_{135}). The reduction in moisture level was progressive ranging from 37.9% at 45min to 49.5% at 135 min of cooking (Table III). In contrast, the moisture content of African elemi was significantly increased at all levels of processing, ranging from 2.66% to 4.45% (Table II). The effect of cooking on dry matter content of the samples followed the same pattern as its effect on moisture contents. The range was 97.0 - 98.5% (1.13 - 1.55% increase) in African walnut and, 97.3 - 95.8 (1.75 - 1.54% reduction) in African elemi. In both AW and AE, crude fibre decreased with time of cooking, but the decrease was not significant at the 5% level (Tables I & II). The crude protein content was generally increased in African walnut (Table I) and decreased in African elemi (Table II). The crude fat contents of raw AW and AE were 49.8 and 41.9g/100g respectively and were not significantly ($p>0.05$) affected by heat processing. The total carbohydrate contents of the samples (Tables I and II) were not significantly ($p>0.05$) affected by processing. African elemi had relatively higher totalcarbohydrate content than AW. In both samples (AW and AE) heat processing did not affect significantly ($p>0.05$) the energy contents.The moisture content of the two plant foods at all levels of processing were generally lower than the values reported by other researchers for comparable plant foods (Table V). Moisture occurs in food in form of bound, adsorbed or free water. The free water is easily lost on drying (heating) unlike the bound and adsorbed water that appear to be associated with proteins present [16]. Cooking (maceration), according to Sefa-Dedeh *et al.*[17] is a form of hydrothermal processing that involves hydration and heating. The higher moisture contents of African elemi may be due to the lower processing temperature (55^{o}C) compared to that of African walnut, (99±1^{o}C).Moisture content is of significance as it is one of the determinants of shelf-life of processed foods [18]. Water is required for microbiological growth and biochemical reactions that underline deterioration [16]. Consequently, the quality of African walnut kernel flour with lower moisture content, would keep longer than that of African elemi pulp. Cooking decreased the ash contents of the two samples (Tables I and II). Earlier reports have shown that heat processing decreased the concentration of ash in foods (Table V). The value of 6.05–5.45g/100g sample for AW was high but comparable to the values of 4.48-4.20g/100g sample obtained for jack beans [19]. The ash content is a measure of the total amount of non-combustible inorganic minerals [20]. The results showed that the two plant foods at all levels of processing are good sources of dietary minerals needed for most of the physiological processes taking place in the body. The observed reduction in the ash contents with time of cooking may be due to leaching of minerals into the water used for the wet-heat processing.

Table I. *Proximate composition of raw and cooked African walnut (AW) seed kernel flour*

	Proximate composition (g/100g sample)			
Constituents	AW_{raw}	AW_{45}	AW_{90}	AW_{135}
Moisture	3.01 ± 0.03^{a}	1.87 ± 0.27^{b}	$1.62\pm0.41^{b,c}$	1.52 ± 0.8^{c}
Dry matter	97.0 ± 0.26^{b}	$98.1\pm0.27^{a,b}$	98.4 ± 0.41^{a}	$98.5\pm1.31^{a,b.}$
Crude protein	26.2 ± 0.61^{b}	26.2 ± 0.74^{b}	$26.9\pm61^{a,b}$	27.7 ± 0.68^{a}
Ash	6.05 ± 1.71^{a}	5.57 ± 1.01^{a}	5.48 ± 0.77^{a}	5.45 ± 0.86^{a}
Crude fat	49.8 ± 1.08^{a}	52.8 ± 2.70^{a}	51.7 ± 1.61^{a}	51.4 ± 4.82^{a}
Crude fibre	5.85 ± 0.55^{a}	5.47 ± 0.62^{a}	5.21 ± 0.37^{a}	5.26 ± 0.17^{a}
Total carbohydrate	10.1 ± 0.98^{a}	8.04 ± 2.91^{a}	9.11 ± 2.69^{a}	8.71 ± 4.53^{a}
Energy value (kcal/100g sample)	593.4 ± 6.75^{a}	612.2 ± 11.7^{a}	609.3 ± 6.23^{a}	608.2 ± 23.1^{a}

Values are means ± standard deviations of triplicate determinations. Values in the same row bearing the same superscript letters are not significantly different at the 5% level ($p> 0.05$).

The recommended dietary allowance (RDA) for fibre is 38g and 25g/day for adult male and female respectively [21].Thus, 100g of AW could provide 14 – 15% and 21 – 23%; and AE 10% and 15% of daily dietary requirements of fibre for adult male and female respectively. Crude fibre is the amount of indigestible sugars present in a food sample which has the physiological role of adding bulk to stool, and thus contribute to the maintenance of internal distensions for a normal peristaltic movement [22]. By facilitating peristalsis, dietary fibre helps to reduce many gastrointestinal diseases, serum cholesterol, risk of coronary heart disease, colon and breast cancer and hypertension [23]. Most fibres are carbohydrates with varying degree of solubility in water. The decrease in crude fibre content during processing could be attributed to solubilization as increase in temperature leads to breakage of weak bonds between polysaccharide chains and glycosidic linkages in dietary fibrepolysaccharides[24]. These result in a decreased association between fibre molecules and/or a depolymerization of the fibre bringing about solubilization[8]. The crude protein value of the raw AW (26.2g/100gsample) is comparable to the value of 25.7g/100sample obtained by Akintayo and Bayer [25]. Cooking has been reported to decrease the protein levels of African yam beans [13], cowpea [26], African bread fruit [27] and groundnut seeds [28]. The crude protein content of AW which ranged from 26.2g/100g in AW_{raw} to 27.7g/100g in AW_{135} was comparable to the values of 23.1 - 40.0g/100g sample reported for some protein – rich plant foods such as soybeans, cowpea, melon, pumpkin seeds, gourd seeds, Jack beans, cashew nut and groundnut [29], [13], [26], [30], [31], [19].

Table III: *Differences in proximate compositions and energy values between raw and cooked African walnut (AW) seed kernel flour.*

Constituents	Difference (percentage difference)		
	$AW_{45} – AW_{raw}$	$AW_{90} – AW_{raw}$	$AW_{135} – AW_{raw}$
Moisture	-1.14(37.87)	-1.39(46.18)	-1.49(49.50)
Dry Matter	1.10(1.13)	1.40(1.44)	1.50(1.55)
Crude protein	0.00	0.70(2.67)	1.50(5.73)
Ash	-0.48(7.93)	-0. 57(9.42)	-60(9.92)
Crude fat	3.0(6.02)	1.90(3.82)	1.6(3.21)
Crude fibre	-0.38(6.50)	-0.64(10.94)	-0.59(10.09)
Total carbohydrate	-2.06(20.40)	-0.99(9.80)	-1.39(13.8)
Energy value	19(3.20)	16(2.70)	14(2.36)

[a]Values in parentheses are percentage changes after cooking.

Table IV: *Differences in proximate compositions and energy values between raw and macerated African elemi (AE) pulp flour.*

Constituents	Difference (percentage difference)		
	AE_{15} - AE_{raw}	$AE_{30} – AE_{raw}$	$AE_{45} – AE_{raw}$
Moisture	1.79(67.3)	1.56(58.7)	1.24(58.7)
Dry Matter	-1.70(1.75)	-1.50(1.54)	-1.50(1.54)
Crude protein	-1.40(9.59)	-2.01(13.8)	-2.04(14.0)
Ash	-0.67(17.05)	-0.68(17.3)	-0.41(10.4)
Crude fat	0.68(1.62)	0.77(1.84)	0.91(2.17)
Crude fibre	-0.07(1.84)	0.09(2.39)	0.09(2.39)
Total carbohydrate	-0.42(1.27)	0.36(1.08)	0.04(0.12)
Energy value	-1.2(0.21)	0.30(0.05)	0.2(0.04)

[a]Values in parentheses are percentage changes after cooking.

Table V: *Proximate composition of selected plant foods.*

	Proximate composition (g/100g sample)						Energy value (kcal)	Plant food[a][Reference]
	Moisture	Crude Protein	Ash	Crude fat	Crude fibre	Total carbohydrate		
R:	5.92	26.3	3.85	53.23	--	10.7	521.83	Melon seeds [29]
C:	4.43	28.0	3.75	53.03	--	10.8	632.43	
R:	11.4	24.1	3.50	2.95	--	58.1	355.4	Cowpea [26]
C:	8.77	18.4	2.63	4.10	--	66.2	354.4	
R:	11.25	18.32	1.62	1.31	1.31	77.44	394.8	African bread fruits [27]
C:	10.91	14.12	1.27	1.03	1.17	82.41	395.4	
R:	9.67	18.87	4.94	49.23	6.17	11.12	539.68	Beniseed [35]
C:	10.34	14.12	2.26	56.78	4.45	12.05	575.71	
R:	6.15	35.55	5.80	20.25	7.12	31.28	449.6	Soybean [38]
C:	6.75	38.20	4.00	17.50	9.75	30.55	432.5	
R:	3.76	24.50	3.04	47.90	9.49	11.31	574.34	Groundunt seeds [41]
C:	5.70	16.11	2.70	38.81	18.64	18.04	493.6	
R:	8.41	29.8	4.48	4.20	7.37	50. 80	372.9	Jack beans [19]
C:	6.45	30.3	4.20	4.06	6.73	47.13	377.7	
R:	2.40	15.30	4.40	15.80	3.60	49.0	401.1	Red kidney beans [42]
C:	2.90	18.40	2.70	10.20	4.70	61.10	424.3	

R:	9.69	22.50	3.86	3.76	--	60.19	364.6	Brown African yam bean [13]
C:	9.90	20.40	2.55	2.13	--	65.02	360.9	
R:	5.70	25.3	4.40	36.7	1.20	26.8	536.0	Cashewnut [32]
R:	8.0	11.5	0.5	40.3	7.3	32.9	_	*Cordiasebestena*[18]

[a]R: = Raw sample, C:= cooked / boiled sample.

The crude protein range of (12.6-14.6g/100g sample) for AE is comparable to the value of 11.5g/100g sample obtained for *Cordiasebestena* [18]. The recommended dietary allowance (RDA) of protein for men and women are 56 and 46g respectively [21], and 23-36g for children [32]. A 100g of raw and cooked AW can thus provide 46.8-49.5%, and 57.0-60.2% of the RDA of protein for men and women respectively and adequately supply that of children, while 100g of AE on the other hand can provide 22.5 - 26.1% and 27.3 - 31.7% of the RDA of protein for men and women respectively, and 42.6 - 49.5% for children. These levels of crude protein may qualify the samples as good sources of dietary protein if bio-available and easily digestible by the body. Protein serves as the major structural components of all cells in the body, and functions as enzymes, transport carriers, and some hormones. Dietary protein is an important macronutrient in human nutrition being the source of essential amino acids for the synthesis of the body's proteins. According to Hu*et al.* [33], there is an inverse relationship between protein intake and risk of coronary heart disease(CHD). The decrease in crude protein content of AE due to cooking could be attributed to leaching of nutrients into the cooking water and may also have resulted from Maillard reaction [34], [28] or protein denaturation [35]. The progressive increase in protein in AW as time of heat treatment increased may be due to progressive loss of moisture with increased cooking time. Based on the values obtained for crude fat, the food samples may be classified as oil-rich. The recommended daily energy allowance is 2100 - 2550kcal for male and 1800 - 2000kcal for female [21]. The crude fat for AW (49.8 - 52.8g/100g sample), and AE (41.9 - 42.8g/100gsample) could provide 448.2 - 475.2kcal and 377.1 - 385.2kcal of energy respectively. Hence, while the crude fat of AW could provide over 21% and 25% of the daily energy need for male and female respectively, that of AE can provide 18% and 21% respectively. The two plant foods could be adjudged good sources of dietary fats since the RDA of fat requires that the fat component of the food provides 20 - 35% of the daily calorific need [36].Fats (lipids) are structural components of all tissues and are indispensable for the assembly of membranes of cells and cell organelles. They are sources of essential fatty acids for the body's fat synthesis, and serve as vehicles for the absorption of fat–soluble vitamins and other precursors. Dietary fats slow gastric emptying and intestinal motility thereby prolonging the length of time food is left in the stomach – increasing the satiety values of meals. This is particularly important for infants and children due to their small stomach size [37]. Increase in the crude fat content of the samples with processing time may be attributable to the disruption of the cell structure and membrane partitions of the seeds by heat during boiling which also caused the fat to melt and then be easily extractable. AW gave low total carbohydrate content that was decreased by cooking giving the range 8.04-10.10g/100g sample. This value is comparable to the values 10.7 - 10.8, 11.12 - 12.05 and 11.31 - 18.04g/100g sample reported for melon, beniseed and groundnut seed respectively (Table V). The decrease in the total carbohydrate due to boiling was highest (20.4%) when the sample was cooked for 45min. The decrease in total carbohydrate had been reported on Jack beans [19], and soybean [38]. Dietary carbohydrate is the primary source of energy for the brain and important for the maintenance of glycemic homeostasis and, for gastrointestinal integrity and function. The recommended daily allowance for carbohydrate for adult men and women is 130g [21]. With the total carbohydrate value ranging from 8.04-10.1g per 100g sample, AW is a poor source of carbohydrate being able to provide only 6 - 8% of the RDA for carbohydrate per 100g. AE is relatively a good source of dietary carbohydrate having carbohydrate value ranging from 33.2 - 33.56g/100g sample. During cooking, a hydrothermal processing that involves heat hydrolysis of carbohydrate, there is gelatinization of starch. This refers to the disruption of granular structure, hydration, swelling and solubilization of starch molecules [39]. The relatively soluble simple disaccharides and monosaccharide produced increase the availability of detectable carbohydrate. The leaching of the simple sugars into the cooking water could lead to reduction in the total carbohydrate contents of samples [40]..The energy density of each of the two plant foods, which is the amount of energy stored in a specific food per unit volume or mass (usually in 100g), was not appreciably affected by processing. The least energy values of 593.4kcal/100gsample for rawAWcould account for 23-28% and 30-33% of the recommended daily energy allowance of 2100 - 2550kcal for male and 1800 - 2000kcal for female respectively [21],while568.6kcal/100gsample for raw AE could provide 22-27% and 28-32% of the RDA of energy for male and female respectivelyThe two samples, at all levels of processing, could therefore be adjudged good sources of energy.

Conclusion:

It can be concluded that heat-processing did not considerably affect the nutrient values of African walnut and African elemi. The two masticatories hitherto consumed as snacking items have high energy and nutrient contents and could be exploited to enhance the nutritional status of the consumer. Due to low moisture contents, the observed quality of the processed samples could keep for a long time and therefore have the potential for incorporation in the weaning/complimentary feeding for children.

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