Int. Agrophysics, 2007, 21, 385-389

INTERNATIONAL
Agrophysics
www.international-agrophysics.org

Effects of pre-shelling treatment on the physical properties of cashew nut (*Anacardium occidentale*)

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Received September 28, 2007; accepted November 2, 2007

A b s t r a c t. Thorough knowledge of the physical properties of cashew nuts in its present form is necessary in the design of its shelling machine. A study was carried out to determine the effects of pre-treatment by hot oil roasting and steam boiling on the physical properties of cashew nut. Samples of cashew nuts obtained from five plantations in Iseyin area of Oyo State and Iwo in Osun State in the South-Western Nigeria were used in this work. About 3kg of nuts were picked from 20 randomly selected trees in each of the plantations. The cashew nuts were subjected to pre-treatment by steam boiling and hot oil roasting. The physical properties of raw and pre-treated cashew nuts were determined using standard methods. The results showed that nuts from South-Western Nigeria, which were used for the experiment, could be classified as medium large and extra large *ie* 22-35 mm. The pre-shelling treatment showed significant difference ($P<0.05$) in the means of length and width of cashew nut, and no significant difference for thickness, aspect ratio and sphericity index. The treatment showed significant difference ($P<0.05$) in true and bulk densities but showed no difference in the porosities of the nuts. The moisture content of raw kernel was significantly different ($P<0.05$) from that of roasted and steam-boiled kernels. The physical properties of cashew nuts were found to be affected by pre-treatment by hot oil roasting and steam boiling.

K e y w o r d s: cashew nut, pre-shelling treatment, steam boiling, hot oil roasting

INTRODUCTION

The cashew tree (*Anacardium occidentale Linn*.) is widely cultivated across the coastal regions of the tropics (Gibbon and Pain, 1985; Naggy *et al*., 1990). It is known to have high utility value; the fruits, the leaves, the bark, the wood and the roots have all been reported to be of valuable commercial uses for food, medicine, industry and environment (Agnoloni and Giuliani, 1977; Ohler, 1979; Nagabhusana and Ravindranath, 1995; Akinwale, 1996a; Olunloyo, 1996; Bisana and Laxamana, 1998; Djarwanto, 2000; Intermediate Technology Development Group, 2005) *etc.* The three main cashew products traded in the international market are: raw cashew nuts, cashew kernels and cashew nut shell liquid (Azam-Alli and Judge, 2001). Cashew kernel is widely consumed as roasted, fried, salted or sugared snacks, as material for confectionery, bakery products and as a food ingredient (Azam-Alli and Judge, 2001), especially because it contains vital minerals which are seldom found in daily diets (Holland *et al*., 1991; Cashew Export Promotion Council, 1992; Davis, 1999). During the last two decades, cashew nut production in Nigeria has increased from 25 000 t in 1980 to over 200 000 t in 2005 (FAO, 2006; Azam-Alli and Judge, 2001). Nigeria is now the leading producer of cashews in Africa. Local consumption of processed cashew nuts and its demand by importing countries keep increasing, thereby providing opportunities for expansion (O'Farrell *et al.*, 2006).

The effects of heat treatment on the behaviour of some agricultural materials during handling and processing have been studied by other researchers (Elmastry *et al.*, 2006; Irtwange, 2006, Akinoso *et al*., 2006). Processing raw cashew nuts into kernel is generally a time consuming and labour intensive operation, involving heat treatment of the nuts, shelling, peeling, grading and packaging; however, shelling has presented the greatest processing problem. This is due to the peculiar kidney-shape of the nut, the presence of a tough, leathery outer shell and the corrosive cashew nut shell liquid it contains (Ohler, 1979; Jain and Sivala, 1997).

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Though some previous work has been done on cashew nut shelling and a number of appropriate technologies have been developed (Ajav, 1996; Thivavarvongs *et al.,* 1995a *etc.*), the quality of yield in terms of whole kernels percentage still remains a major challenge. Consequently, there is a need to understand the effects of pre-shelling heat treatments on the physical properties of cashew nut. This will assist in improving the design of an appropriate machine for shelling with a view to solving problems associated with wholesomeness of cashew kernels during processing. Therefore, the objective of this study was to investigate the influence of pre-shelling treatment on the physical properties of cashew nut.

MATERIAL AND METHOD

Raw cashew nuts (from yellow apples) were obtained from plantations in Iseyin area of Oyo state and Iwo in Osun state in South-Western Nigeria. Five plantations with ages ranging from 10 to 15 years (when cashew trees should be producing at maximum capacity under favourable conditions) were randomly selected in each area. About 3 kg of nuts per tree were picked from 20 randomly selected trees in each of the plantations.

The equipments used were: moisture dishes made of heavy gauge aluminium; desiccator, oven (gallenkamp); micrometer (Canon Instrument, Japan); chemical balance -Mettler Toledo PB153 Electronic Balance, 1000 g maximum, accuracy 0.001 g; others were a baby steam boiler for steam-boiling and an oil-bath of cashew nut shell liquid for hot oil roasting.

The pre-shelling treatments used were steam boiling and roasting in a bath of cashew nut shell liquid; raw samples of cashew nuts were reserved for use as the control. The samples were prepared according to the methods described below.

i) Three batches of 5 kg weight of raw cashew nuts were drawn from the lot. Each of the three batches was steam boiled in a laboratory autoclave at 7 bar for 30 min, one after another, after which they were allowed to cool naturally for 18 h (Balasubramanian, 2006).

ii) Three batches of 5 kg weight of raw cashew nuts were drawn from the lot. Each of the three batches was roasted one after another by heating cashew nut shell liquid to 190-200°C and dipping the nuts in the hot liquid for 5 minutes. The roasted nuts were allowed to cool naturally for 18 h (Andrighetti *et al*., 1994).

The following physical properties were determined for each of the three categories of pre-treated cashew nut *ie* raw, roasted and steam boiled – dimensions, sphericity index, aspect ratio, density, bulk density, moisture content and porosity using standard methods (Mohsenin, 1978; Asoegwu *et al*., 2006).

i) For each replicate of the heat treated cashew nuts, 100 nuts were picked randomly from each replicate of the heat treatment and the principal axes *ie* a – length, b – width, and c – thickness, were determined as shown in Fig. 1. The width and thickness were measured perpendicular to the major axis. The sphericity index (S_p) and aspect ratio (R_a) were calculated as documented by Mohsenin (1978):

$$S_p = \frac{(abc)^{1/3}}{a} 100\% , \tag{1}$$

$$R_a = \frac{b}{a} 100\% . \tag{2}$$

ii) The true density (ρ_t) of the nuts was determined by the water displacement method. A nut of known mass was immersed inside a known volume of water inside a measuring cylinder; the ratio of the mass of the nut to the volume of water displaced due to the immersed nut gave the density (equation 3) of the nut. For each replicate of the heat treatment this was repeated 10 times:

$$\rho_t = \frac{mass}{volume} . \tag{3}$$

iii) A cylindrical container of known weight and volume was filled with cashew nuts and weighed. The weight of the nuts was calculated by the difference between the weight of the empty cylinder and the weight after it was filled with nuts. The ratio of the weight of the nuts to the volume of the cylindrical container gives the bulk density (ρ_b). The process was repeated 10 times for each replicate of the heat treatment.

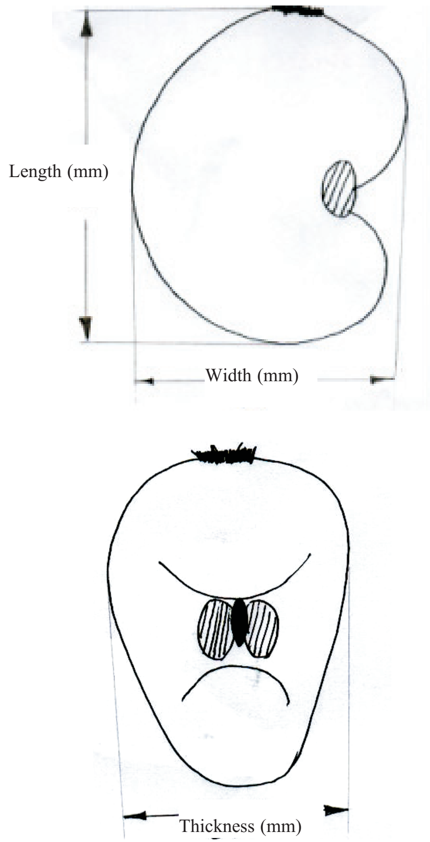

Fig. 1. Schematic diagram showing the characteristic dimensions of cashew nut.

iv) From the values obtained for true and bulk density, the porosity (p) of each sample was calculated as documented by Mohsenin (1978):

$$p=\frac{\rho_t-\rho_b}{\rho_t}100\%, \tag{4}$$

v) Moisture measurement was carried out following the ASAE Standards (2003). The test samples for which moisture content was determined were the nut, the kernel and the shell. Three moisture dishes were obtained and approximately 100 g of each of the test samples weighed to the nearest 0.01 g was spread evenly over the base of each of the moisture dishes. The initial weight of each of the moisture dishes plus the sample was taken. The dishes with their lids beside them were placed in an oven at 103°C for 6 h. At the end of oven-drying, the three dishes were removed quickly and covered with their lids and placed in desiccators. The final weight of each of the moisture dishes plus the oven dried sample it contained was taken after they reached room temperature. The moisture content (wet basis) for each sample was calculated by dividing the loss in weight due to oven drying by the initial weight of the sample (ASAE, 2003). The experiment was repeated thrice per test sample for each replicate of the heat treatment:

$$m=\frac{100w_m}{w_i}, \tag{5}$$

where: m = moisture content, wet basis (%), w_m = moisture loss, w_i = initial weight of test sample.

vi) A regular cylindrical container open at both ends and placed on a galvanized steel surface was filled with cashew nuts to the brim. Afterwards the container was lifted gradually and finally emptied to form a conical heap with the nuts. This was repeated 10 times for each replicate of the heat treatment. The tangent of the angle of inclination to the hirizontal ($\tan\theta$) was calculated from the height (h) and base radius (r) of the formed heap as:

$$\tan\theta=\frac{h}{r}. \tag{6}$$

vii) Coefficient of static friction is the tangent of the angle of inclination at which a material begins to slide on a surface. Using the method described by Dutta *et al*. (1988), five nuts were placed on an inclined plane apparatus with mild steel, galvanized steel and plastic surfaces. The plane portion of the apparatus was raised. The angle of inclination to the horizontal, as soon as the nuts began to slide, was measured from the protractor, the tangent of which is the coefficient of static friction. This was repeated 10 times for each replicate of the heat treatment.

The results obtained were analysed using Duncan's multiple range grouping (Statistical Analysis Software).

RESULTS AND DISCUSSION

The dimensions of cashew nut as influenced by pre-shelling heat treatment are shown in Table 1. With raw cashew nuts as control, it was observed that the physical dimensions of the pre-treated cashew nuts varied considerably. For all the nut sizes considered, a decrease in the dimensions was observed when the nuts were roasted. This was due to loss of moisture from the cashew nuts and shrinkage during roasting. An increase in the physical dimensions was observed when the nuts were steam boiled. This was due to addition of moisture during steam boiling. The two pre-treatments provided for moisture removal and moisture addition. The size distribution for raw cashew nuts compared reasonably with Balasubramanian (2001) who had earlier carried out similar work on raw India-grown cashew nuts. From Table 2, the differences in the means of length and width are significant ($P<0.05$), however there was no significant difference in the means of thickness, aspect ratio and sphericity index.

Though the porosity of roasted nuts was numerically higher than that of raw and steamed nuts (Table 2), the difference indicated by the pre-shelling treatment is not significant. Table 3 shows the densities of cashew nut as influenced by the treatments. The treatments showed a significant difference ($P<0.05$) in the true and bulk densities. The heat applied during roasting caused release of cashew nut shell liquid and moisture loss from the raw cashew nut. This obviously accounts for the decrease in the nut weight and, consequently, the density of roasted nuts.

T a b l e 1. Physical dimensions of cashew nut as influenced by pre-shelling heat treatment

Principal axes of cashew nut	Number of observations	Raw nuts	SD	Roasted nuts	SD	Steam boiled nuts	SD
Length (mm)	100	30.3	2.4	29.4	1.9	31.2	1.8
Width (mm)	100	23.4	1.9	22.1	1.7	23.9	1.6
Thickness (mm)	100	17.7	2.5	16.8	2.2	17.7	2.5
Sphericity (%)	100	77.26	4.14	75.45	3.54	75.87	4.51
Aspect ratio (%)	100	77.38	6.50	75.33	3.94	76.72	7.00
Porosity (%)	10	43.59	4.27	54.74	3.97	43.59	5.77

T a b l e 2. Effects of pre-shelling treatment on the physical dimensions of cashew nut

Response*	Treatment			
	R	R_{RO}	R_{ST}	SEM
L	30.297^{b}	29.542^{c}	31.198^{a}	0.0144
W	23.379^{a}	22.334^{b}	23.911^{a}	0.0121
TH	17.681	16.760	17.710	0.0157
AR	77.400	75.329	76.097	0.4127
SI	76.457	75.308	75.871	0.2743
PO	43.59	54.74	43.59	1.87

*L – length, W – width, TH – thickness, AR – aspect ratio SI – sphericity index, PO - porosity; R – raw cashew nut, R_{RO} – roasted cashew nut, R_{ST} – steamed cashew nut; a, b, c – means on the same row with different letters are significantly different (P<0.05); SEM – standard of mean.

T a b l e 3. Effects of pre-shelling treatment on the density of cashew nut

Response*	Treatment			
	R	R_{RO}	R_{ST}	SEM
TD	1076.09a	747.13c	968.10b	27.77
BD	596.67a	368.29c	523.79b	17.85

*TD – true density, BD – bulk density. Other explanations as in Table 2.

T a b l e 4. Effects of pre-shelling treatment on the moisture content of the structural components of cashew nut

Response*	Treatment			
	R	R_{RO}	R_{ST}	SEM
KNL	12.8000^{a}	10.7467^{b}	11.2500^{b}	0.3708
SHL	15.6630^{a}	12.1400^{b}	15.5167^{a}	0.6768
NUT	13.8000^{a}	11.1067^{b}	9.4567^{b}	0.6855

*KNL – kernel, SHL – shell, NUT – entire nut. Other explanations as in Table 2.

The pre-shelling heat treatment showed a significant difference (P<0.05) in the moisture content of the structural components on cashew nuts as shown in Table 4. The moisture content of the kernel of the raw nut was significantly different (P<0.05) from that of roasted nut and steam-boiled nut. In contrast, there was no significant difference in the moisture content of the shell of the raw and steamed nut; however, these were significantly different (P<0.05) from that of the roasted nut. For the entire nut, the moisture content of the steamed and roasted nut was significantly different (P<0.05) from that of the raw. This trend can be further seen in Fig. 2. The reduction in moisture content of pre-treated nuts is attributable to shrinkage due to moisture loss when subjected to cooling. More moisture was lost in the roasted cashew due to the rupture and release of the contents of the cashew nut shell liquid bearing cells. This consequently caused a decrease in the weight and density of roasted nuts.

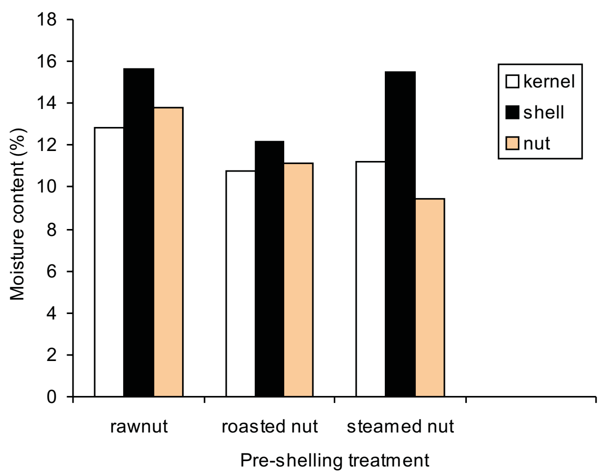

Fig. 2. Effects of pre-shelling treatment on the moisture content of structural components of cashew nut.

CONCLUSIONS

1.The physical properties of cashew nuts were found to be affected by pre-treatment by roasting and steam boiling.

2. The properties increased with steam boiling and reduced with roasting.

3. Change in moisture level due to pre-treatment was found to have significant effects on the physical properties of cashew nuts.

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