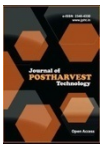

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RESEARCH ARTICLE

Effect of pretreatment on the shelling strength of cashew nut shell

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ABSTRACT

India is the second largest producer of cashew nut in the world. Raw cashew nuts are pre-conditioned either by roasting or steaming before shelling. The specific objective of this study was to evaluate the effect of pretreatment (roasting and steaming) on the shelling strength of cashew nut shell and its effect on whole kernel out turn. The texture analyzer (Model TA-XT plus) with the probe, HDP/BSK blade set with knife, and heavy duty platform was used for the determination of the strength of cashew nut shell and cashew nut kernel. Strength of raw cashew nut shell decreased from 39.2 ± 2.8 kg to 18.6 ± 4.8 kg for roasting and 29.2 ± 10.5 kg for steaming. Manual shelling of roasted cashew nut shell was easy compare with that of steamed cashew nut shell. The WKO was about 98.9±2.65% for roasting and 97.11±1.25% for steaming, whereas it was about 38±3 % for raw cashew nut shell. Pretreatment influenced and decreased the strength of raw cashew nut shell significantly and further improved in WKO and shelling efficiency.

Keywords: Cashew nut, strength of cashew nut, roasting of cashew nut, steaming of cashew nut.

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INTRODUCTION

Cashew nut (*Anacardium occidentale*) is a costly nut like peanut, almond, hazelnut, pistachio and walnut. It is a popular cash crop worldwide with lots of nutritive value. Cashew nut kernel provides fat (46%), protein (21.2%) and carbohydrates (22.3%) and 596 kCal/100 g energy (Ogunsina and Bamgboye, 2014). In India, cashew nut was initially introduced in Goa, and later expanded to western states of India and southern region. Cashew nut is found abundantly in the Maharashtra, Meghalaya, Goa, Kerala, Tamil Nadu, Karnataka and Andhra Pradesh (Borah et al., 2023; Kumar et al., 2012; Mohod, 2010). Total cashew nut produced by India was about 738000 tonnes in the year 2021 whereas total world production was about 3.71 million tonnes in the same year. Top five countries in cashew nut production are Ivory Coast, India, Vietnam, Burundi and Philippines in year 2021 (FAOSTAT 2021).

Actually, cashew nut tree bears cashew apple underneath of which cashew nut is attached. Cashew apple is processed for juice preparation or wine or consumed as fruit (Azoubel, 2005). The main product, cashew nut is collected from the tree and sun dried for 2-3 days before storage. Further raw cashew nuts are processed and cashew nut kernels are obtained as the main

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marketable product. The shell of cashew nut is removed during processing of cashew nut which is very hard because of its structural. The important parts of a cashew nut are its shell, testa and kernel. The cashew nut shell is a layer of three protective tissues namely: the epicarp, the mesocarp, and the endocarp. The Cashew nut shell is about 1/8 inch thick. The mesocarp of cashew shell is designed as a soft honeycomb structure. The cashew nut shell liquid (CNSL) is present in mesocarp of the shell (Das and Ganesh, 2003; Ogunsina and Bamgboye, 2014). Hence, a cashew nut shell can be considered consisting of cashew nut shell solid (CNSS) and cashew nut shell liquid (CNSL) apart from some amount of moisture in CNSS.

The structure of cashew nuts shell, the corrosive liquid in the mesocarp of the shell and the brittleness of the embedded kernel are some of the factors that make cashew nut shelling a challenging process. The general processing steps involved in cashew processing are drying of freshly harvested raw cashew nut in the sun for 2-3 days and storage, soaking of nut, steaming or roasting, shelling, separation, kernel drying, peeling of testa, packaging, storage and marketing. The pre-conditioning of cashew nut makes cashew nut shell solid (CNSS) brittle and amenable to cracking (Kahyaoglu and Kaya, 2006; Shakerardekani et al., 2011). Roasting or steaming of cashew nut also provides other benefits in terms of by-products. The process of roasting and steaming also affect the sensory quality of cashew nut in terms of colour, taste, hardness and mouth feel (Kumar and Kulshrestha, 2023; Borah and Kumar, 2022; Nikzadeh and Sedaghat, 2008; Wanlapa and Jindal, 2006). Roasting of the nut is performed either by open pan roasting or drum roasting or hot oil roasting depending up on the scale of operation (Mohod et al., 2011; Azam-Ali and Judge, 2001). Steaming of cashew nut involves hydrothermal treatment of the dried nuts at about 100 psi for about 25–30 min and cooling it naturally for 12–24 h (Balasubramanian, 2006).

Characteristics of cashew nut shell changes considerable after pre-treatment. The shell of cashew nut becomes brittle that depend on the selection of pretreatment method. Further shelling efficiency and whole kernel out turn (WKO) depends on many factors. The specific objective of the paper was to evaluate the effect of pretreatment (roasting and steaming) on the shelling strength of cashew nut shell and its effect on whole kernel out turn.

MATERIALS AND METHODS

Collection of raw cashew nut

Raw cashew nut, steamed cashew nut and roasted cashew nut were collected from the industries operating in Selsella and Mankachar block of Meghalaya and Assam for the present study. The collected samples were stored in air tight container in order to prevent any moisture change in the samples.

Shelling of cashew nut

The Cashew nut samples, collected from the industries, were shelled using hand cum pedal operated cashew nut shell cutter into two half of cashew nut shell and one piece cashew nut kernel (Mohod, 2010). The design of the cutter and preconditioning of cashew nut facilitates mechanical shelling of cashew nut to remove the kernel without damage or contamination from the cashew nut shell liquid (CNSL). A cashew nut was placed and held with proper orientation in between a pair of knives, each shaped in the contour of half a cashew nut. A sufficient amount of force was applied by means of a foot operated lever that cut open the shell of cashew nut longitudinally into two half of cashew nut shell, leaving the kernel untouched. The separation of cashew kernel from the cut shell was carried out manually by using the sharp knife. This unit operation produced the cashew shell as by-product and cashew nut kernel a main product. Further cashew nut kernels were dried in the air dryer at 65–70 ˚C in perforated tray for 6–8 h. and testa of the kernels were removed manually. The final product, cashew nut kernels, was stored in air tight container for further analysis.

Determination of whole kernel out turn

The hand cum pedal operated cashew nut shell cutter was operated by a trained operator. The value of Whole kernel out turn (WKO) was determined as the percent ratio of the weight of whole kernels (W_w) to the total weight of kernels recovered (W_T) that was measured by shelling of 500 g of the particular type of cashew nut (Ogunsina and Bamgboye, 2012). The Eq. 1 was used for calculation of WKO.

$$\mathrm{WKO} = \frac{\mathrm{W_W}}{\mathrm{W_T}} \times 100\% \quad (1)$$

Measurement of moisture content of cashew nut

The moisture content of cashew nuts and shell of cashew nuts were measured using instruments following the standard method. Moisture content of cashew nut and cashew nut shell were measured by heating the samples in hot air oven at 105 ± 1 °C for 24 hours. The Eq. 2 was used for calculation of moisture content (MC).

$$MC = \frac{\text{Initial weight of cashew nut} - \text{Dry weight of cashew nut}}{\text{Dry weight of cashew nut}} \times 100\% \quad (2)$$

Measurement of colour of cashew nut

A tristimulus colorimeter (Chroma Meter CR – 400, Konica Minolta, japan) was used to measure and compare the colour (L, a, b) of cashew nut samples. The instrument was calibrated with white and black tiles before measurement of the colour of cashew nut. The sensor of the colorimeter was allowed the touch the sample for recording the colour parameter of the cashew nut.

Measurement of strength of cashew nut

The texture analyzer (Model TA-XT plus) was used for the determination of the strength of cashew nut shell and cashew nut kernel. The probe, HDP/BSK blade set with knife, and heavy duty platform were used to measure force required to cut cashew nut shell. The knife edge of the probe was attached to the load cell carrier of texture analyzer and lowered into the slotted insert. The heavy duty platform was repositioned so that there should not be any contact between the blade and slot surface. A blank test was conducted to check for any contact force between blade and slot. Cashew nut shell was kept on slotted portion of heavy duty platform and the probe was allowed to move downward at test speed of 2 mm/s and strain of 20 % was applied on cashew nut. The force required to break/cut cashew nut shell was plotted with the distance.

RESULTS AND DISCUSSION

Strength of raw cashew nut shell

Raw cashew nut shell was brownish in colour with moisture content of 18.22 ± 2.1 %. The mean values of the measured moisture content and colour attributes of cashew nuts and cashew nut shells are given in Table 1. Statistical analysis showed that the moisture content of raw cashew nut was statically different (α = 0.05) from roasted and streamed cashew nut. Moisture content of raw cashew nut was slightly higher than that of roasted and steamed cashew nuts.

The measured value of cutting strength for raw cashew nut shell was 36.4± 5.8 kg at the moisture content of 18.22 ± 2.1 %. Hence, it was very difficult to cut the raw cashew nut shell compared with preconditioned cashew nut shell. Raw cashew nut shell solid (CNSS) was spongy and tough. When the nut was compressed between the blades of the shell cutter, intracellular pressure was developed within the CNSL bearing cells in the mesocarp of the shell that might have offered resistance to fracture.

The cells of CNSS ruptured and some amount of CNSL discharged out. As more force was applied, the entire cashew nut was compressed damaging the wholesomeness of the kernel in the process. Hence, most of the broken cashew nut kernel was obtained which was contaminated with some CNSL. Thus cashew nut kernel obtained from shelling of raw cashew nut was not fit for human consumption. The WKO was about 38±3 % more effort was required to break cashew nut shell. Hence, shelling of raw cashew nut was not suitable. A kind of thermal processing of raw cashew nut was essential for increasing shelling efficiency and WKO, and reducing the cutting strength of cashew nut shell.

Table 1: Moisture content and colour attributes of cashew nut shells and cashew nut kernels

	Raw cashew nut kernel	Roasted cashew nut kernel	Steamed cashew nut kernel	Raw cashew nut shell	Roasted cashew nut shell	Steamed cashew nut shell
Moisture content (% db)	18.22 ± 2.1	12.13 ± 0.63	12.68 ± 0.54	11.45 ± 2.11	9.26 ± 2.3	8.56 ± 2.4
Colour attributes (L^*)	72.32 ± 2.14	64.92 ± 2.99	70.15 ± 4.58	37.41± 3.54	28.5± 2.75	32.76± 2.29
Colour attributes (a^*)	1.63 ± 0.13	2.57 ± 0.30	1.77 ± 0.08	3.5± 1.12	0.66± 0.92	4.79± 1.28
Colour attributes (b^*)	20.56 ± 2.11	21.12 ± 2.12	21.74 ± 2.52	9.7± 2.92	-2.9± 1.23	3.59± 2.09

Effect of roasting on the strength of roasted cashew nut shell

The colour of cashew nut shell was influenced by the roasting process of condition. Whole cashew nuts used in this study are shown in Figure 1. Cashew nut shell collected after shelling of various types of cashew nut (raw, steamed and roasted cashew nut) is presented in Figure 2. Comparison of hue angle of roasted cashew nut shell and steamed cashew nuts shell indicated that the roasted cashew nut shell was blackish and the steamed cashew nut shell was brownish because of processing treatment. Surface of shell of raw cashew nut turned blakish due to burning of nut in percolated CNSL. Hence, the colour of raw cashew nut shell and roasted cashew nut shell was statistically different (α = 0.05).

Figure 1: whole cashew nut: raw cashew nut (a), roasted cashew nut (b), and steamed cashew nut (c)

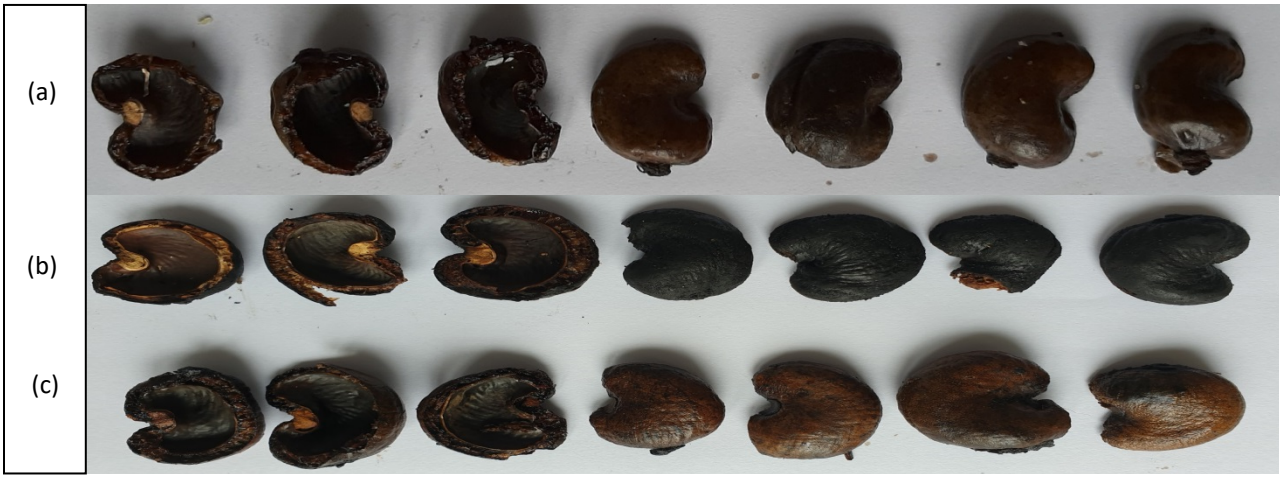

Figure 2: Cashew nut shell only: raw cashew nut shell (a), roasted cashew nut shell (b), and steamed cashew nut shell (c)

Statistical analysis showed that the moisture content of roasted cashew nut and steamed cashew nut were not significantly different at α = 0.05. However, moisture content of raw cashew nut was statically different (α = 0.05) from that of roasted and streamed cashew nuts. The difference in the value of moisture content of raw cashew nut with that of roasted and streamed cashew nuts was due to the processing treatment given to the raw cashew nuts.

The Figures 3 and 4 show the cutting strength of raw cashew nut shell, roasted cashew nut shell and steamed cashew nut shell, which were measured using the texture analyzer. Raw cashew nut shell was hardest with 36.4± 5.8 kg cutting strength when compared with that of roasted and steamed cashew nut shells. Thermal treatment (roasting and steaming) reduced the cutting strength of cashew nut shell. The mean values of cutting strength of roasted and steamed cashew nut shells were 25.3 ± 5.9 kg and 30.8 ± 7.0 kg, respectively. Statistical analysis of data showed that the strength of raw cashew nut shell, roasted cashew nut shell and steamed cashew nut shell were significantly different at 0.05 level of significant. The CNSS turned brittle which caused significant reduction of strength of CNSS. Hence, processing steps like roasting of cashew nut influenced the cutting strength of cashew nut significantly.

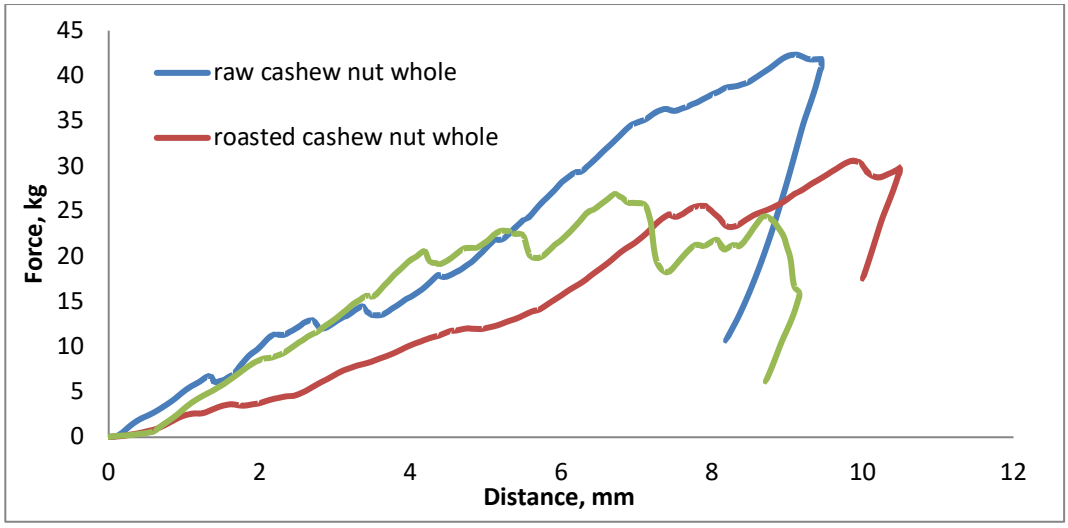

Figure 3: Force required to cut shell of whole cashew nut

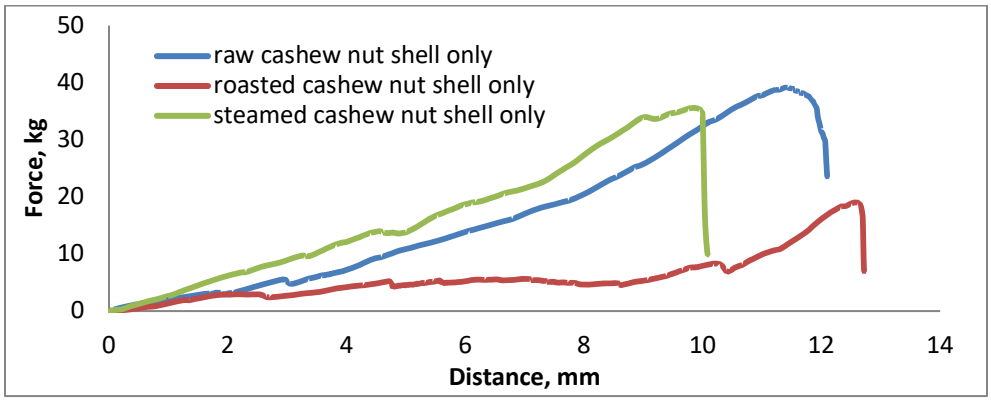

Figure 4: Force required to cut cashew shell only

The values of shelling strength of cashew nut shells are shown in the Table 2. There was 98.9±2.65% WKO in case of shelling of roasted cashew nut which was very high compared with that of raw cashew nut. The higher value of WKO was due to the development of brittleness in CNSS which caused huge reduction of strength of CNSS. The strength of CNSS decreased from 39.2 ± 2.8 kg to 18.6 ± 4.8 kg after roasting. The conventional practice of roasting of nuts is at 15 – 20% moisture content and roasting for 1.5 min (Oloso and Clarke, 1993). Ogunsina and Bamgboye (2012) reported that highest significant ($p < 0.05$) WKO (99.64%) was obtained when moisture content of nuts was 16.84% and roasted for 1.5 min but optimum WKO of 96.96% was obtained at 12.57% MC and 1 min roasting time, considering the time, energy and labour requirement. However, it makes no difference if nuts are processed at any of the MC and roasting time interactions (Ogunsina and Bamgboye, 2012).

Table 2: Cutting strength of cashew nut shell

	Raw cashew nut whole	Roasted cashew nut whole	Steamed cashew nut whole	Raw cashew nut shell	Roasted cashew nut shell	Steamed cashew nut shell	Raw Cashew nut kernel	Roasted Cashew nut kernel	Steamed Cashew nut kernel
Cutting strength (kg)	36.4± 5.8	25.3 ± 5.9	30.8 ± 7.0	39.2 ± 2.8	18.6 ± 4.8	29.2 ± 10.5	2.2 ± 0.55	2.3 ± 0.56	2.1±0.54

Effect of steaming on the strength of steamed cashew nut shell

It is evident from Figure 1 and 2 and Table 1 that colour of raw cashew nut shell and steamed cashew nut shell was not statistically different ($\alpha = 0.05$). The colour of cashew nut was not much changed after steaming, whereas roasting caused drastic change in the colour of cashew nut. It is evident from Table 2 that steamed cashew nut shell was stronger than the roasted cashew nut shell but weaker than the raw cashew nut. Hence, manually shelling of steamed cashew nut shell required more force compared to with that of roasted cashew nut shell. Ogunsina and Bamgboye (2013) also have reported that fracture strength of roasted and steamed cashew nut shell depended on roasting and steaming, respectively. There was 97.11±1.25% WKO in case of shelling of steamed cashew nut which was very high compared with that of raw cashew nut but little lower than the roasted cashew nut. The average values strength of cashew nut shell were 342 N for raw nuts, 321 N for roasted nuts, and 341 N for steam boiled nuts during longitudinal loading at 2.5 mm/min strain rate (Ogunsina and Bamgboye, 2013).

Strength of cashew nut kernel

The mean values of hardness of raw cashew nut kernel, roasted cashew nut kernel and steamed cashew nut kernel were 2.2 ± 0.55, 2.3 ± 0.56 and 2.1 ± 0.54 kg, respectively. Statistical analysis of data showed that the hardness of raw cashew nut kernel,

roasted cashew nut kernel and steamed cashew nut kernel were not significantly different at 0.05 level of significant. All types of cashew nut kernels were further dried under same condition after shelling. Hence, moisture content of all types of cashew nut kernels was not significantly different, which is the most important factor for strength of kernel. The roasting and streaming of cashew nut did not influenced the hardness of cashew nut kernel but influenced the cutting strength of cashew nut shells. Ogunsina and Bamgboye (2012) also reported that short roasting time influenced shell leaving kernel unaffected. The shelling of cashew nuts was challenging and difficult because shell was very hard and kernel was very soft. Hence, manual shelling of cashew nut is still being used in many cashew nut processing units.

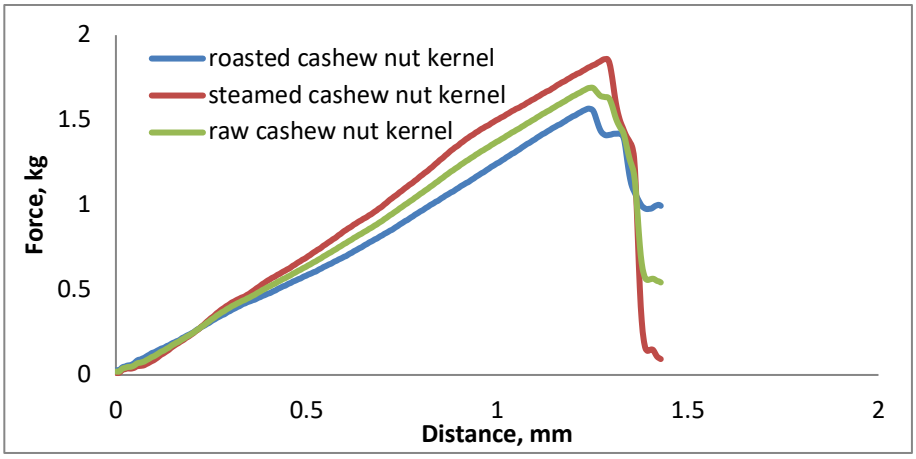

Figure 6: Force required to break cashew nut kernel

CONCLUSION

The processing steps like roasting and streaming of cashew nut influenced the shelling strength of cashew nut shells. Strength of raw cashew nut shell decreased from 39.2 ± 2.8 kg to 18.6 ± 4.8 kg for roasting and 29.2 ± 10.5 kg for steaming. Roasted cashew nut shell was easy to shell compare with that of steamed cashew nut shell. The WKO was about 98.9±2.65% for roasting and 97.11±1.25% for steaming, whereas it was about 38±3 % for raw cashew nut shell. Hence, cashew nut industries operating in Meghalaya and Assam were using roasted cashew nut for manual shelling.

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