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INFLUENCE OF CASHEW NUT SHELL SIZE ON OIL EXTRACTION

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ABSTRACT

The influence of size of cashew nut shells on the extraction of CNSL by screw press method was studied to find out the role of size of shells on the oil yield. The estimation of oil content in the cashew nut shells was carried out using a Soxhlet apparatus. The cashew nut shells from the three groups, namely, small, medium and large were used for the extraction of the oil by screw press. Cashew nut shells can be classified based on the sizes in three classes, namely, small (<12 mm), medium (16-20 mm) and large (>20 mm). The medium size cashew nut shells ranging between 16 to 20 mm are having 80% share in the commercially available sample of shells. Average oil content in cashew nut shells was found to be 26.45%. This CNSL content of cashew nut shells implies that there is a good scope for processing the shells for oil. It would be economical instead of directly using as fuel. Size of cashew nut shell has influence on the recovery of oil in screw press extraction. Recovery of oil for large size cashew nut shells is highest (88.54%).

KEYWORDS: Cashew Nut Shells, Oil Content, Extraction of CNSL

1. INTRODUCTION

Cashew (*Anacardium occidentale)* is an important plantation crop of India. It is presently grown in an area of 9.23 lakh hectares with production of about 7 lakh tonnes (CEPC, 2012). This crop was introduced to India during the 16th century. The potential of this crop in the international trade was first realized by India in the early 1900s through the export of cashew kernels. India has the largest area under cashew and stands as the second largest producer of cashew in the world. Vietnam, Ivory Coast and Brazil are the competitors to India for cashew production and export (CEPC, 2012). The cashew nut shell is having a soft feathery outer skin and a thin hard inner skin. Between these skins is the honeycomb structure containing the phenolic material known as Cashew Nut Shell Liquid (CNSL).

Rajapakse *et al* (1977) reported that the cashew nut consists of kernel, shell and testa and on an average distribution are 20 to 25% kernel, 60-70% cashew nut shell and 2-5% testa. It is processed for cashew kernels and cashew nut shell and testa are the two by-products of the cashew processing industry. Cashew nut shell contains 25-30% oil. 100 kg of cashew nut processing generates about 70 to 75 kg of cashew nut shell. The shell of the nut contains a dark reddish brown viscous liquid.

Cashew nut shell liquid is a versatile by-product of cashew processing which has tremendous potentials as a versatile industrial raw material with its diverse applications. It is extensively used in the manufacture of superior type of paints, insulating varnishes in the electrical industry, special types of adhesive cement, friction and brake linings, laminating and epoxy resins, rubber compounding resins, polyurethane based polymers, surfactants, foundry chemicals and as an intermediary of chemicals (Anonymous, 2009).

There are a number of factors or conditions that can be manipulated during extraction in order to maximize yield. These factors include the moisture content of material, size of particles and the temperature of particles. The effect of these factors has been studied by a number of researchers such as Ajibola *et al* (1990) and Baryeh (2001). In all these studies the authors have established that there exists an optimum value of moisture content for each product at which oil yield is highest when other variables are held constant.

2. MATERIALS AND METHODS

The cashew nut shells of about 3.00 MT were procured from the Cashew Processing and Training Centre (CPTC), Department of Agricultural Process Engineering, College of Agricultural Engineering & Technology, Dr. BSKKV, Dapoli. Cashew nut shells were cleaned to remove dust and dirt using the air screen cleaner. Cleaned shells were stored for further use in experimentation.

2.1 Sample Preparation

Cashew nut shells were cleaned to remove dust and dirt using the air screen cleaner. Cleaned shells were stored for further use in experimentation. Initial moisture content of the shells was determined using standard method (AOAC, 1984). Three samples, each weighing 50 g, were placed in an oven set at 105 ^{0}C for 24 hours. The samples were then cooled in desiccators. The dried samples were weighed and the difference in weight before and after drying was taken to be as a moisture loss. Ratio of moisture loss to weight of wet material in percentage was recorded as moisture content wet basis (Ajibola *et al*, 1990; Aremu and Fadele, 2010). The equation employed in calculation of moisture content is as follows:

$$\text{Moisture, \%} = \frac{W_1 - W_2}{W_1} \times 100$$

Where:

W_1 = Initial weight of sample before drying, g.

W_2 = Weight of sample after drying, g.

The principal dimensions of ungraded cashew nut shells were measured using digital vernier caliper with least count of 0.01 mm (Mututoyo, Japan). Cashew nut shells were first classified into three sizes since the practice of grading the cashew nut prior to processing is not followed in the Konkan region of Maharashtra. Also, the cashew nut shells available were of random size obtained from the ungraded cashew nuts of different varieties. However, Cashew nut shells of same size probably may be helpful for better extraction efficiency and better oil recovery.

2.2 Classification of Cashew Nut Shells

Classification of the cashew nut shells was done by sieving the cashew nut shells using different sieves. The four sieves having perforation sizes 25, 20, 16 and 12 mm size based on the dimensions of the cashew nut shells were used. Two kg of cashew nut shells were used for each test with ten replications for sieving. The sieves were shaken for 10 minutes using the manual sieve shaker. The sieves were arranged from top to bottom with decreasing perforation size. The weights of samples retained on each sieve were measured and recorded. After the sieving, the cashew nut shells were

classified into three categories. The cashew nut shells retained on 20 mm sieve were considered as Large (L) size shells. The shells retained on 16 mm sieve were considered as Medium (M) size shells. The shells retained on 12 mm sieve were classified Small (S) size shells. Thus, the shells were classified into three groups based on size, namely, small (S), medium (M) and large (L).

2.3 Determination of CNSL Content of Cashew Nut Shells

The estimation of oil content in different sized cashew nut shells was carried out using a Soxhlet apparatus. It is based on the principle that lipids in sample are dissolved in organic non-polar solvents like petroleum ether, spirit, benzene, hexane etc. Lipids/ Fat dissolved in solvent can be extracted by heating and cooling simultaneously in a condenser. Three hundred and fifty milliliters (350ml) of hexane was charged into the round bottom flask of soxhlet apparatus. Subsequently, 20g of crushed cashew nut shell was charged into the thimble and fitted into the soxhlet extractor. The apparatus was assembled. The solvent in the set-up was heated to 68 ^{0}C and the vapor produced was subsequently condensed by water flowing in and out of the extraction set-up. This process of heating and cooling continued until a sufficient quantity of CNSL was obtained. At the end of the extraction, the thimble was removed while the remaining solvent in the extractor was recharged into the round bottom flask for a repeat of the process. Finally, the set-up was then re-assembled and heated to recover the solvent from the oil.

2.4 Extraction of CNSL by Screw Press

The influence of size of cashew nut shells on the extraction of CNSL by screw press method was studied to find out the role of size of shells on the oil yield. The cashew nut shells from the three groups, namely, small, medium and large were used for the extraction of the oil by screw press. The results obtained were compared with the control. Pressure and feed rate were maintained constant through out the tests of oil extraction for different sizes of the cashew nut shells. Yield of oil was recorded for each test run.

The yield of CNSL was carried out using the following formulae:

$$CNSL\ (\%) = \frac{Weight\ of\ CNSL}{Weight\ of\ moisture\ free\ sample} \times 100$$

$$Yield\ of\ CNSL\ (\%) = \frac{CNSL\ \%}{CNSL\ content\ in\ sample} \times 100$$

Similar types of formulae were used by Elhassan (2009) for the yields of oil from sesame seeds.

3. RESULTS AND DISCUSSIONS

3.1 Classification of the Cashew Nut Shells (m.c. 10.16%, wb)

The cashew nut shells used for the extraction of oil are generally not graded. Efforts were made to determine the size of the shells available in the market and classification was made to know the sizes of cashew nut shells and to see the influence of size on the oil extraction process by screw press. Mean values of the weight of shells retained on different sieves are given in Table 1.

Table 1: Classification of Cashew Nut Shells Based on Size

Sr. No.	Size of Sieve (mm)	Mass of Shells (g)	Share (%)	Class of Shells Designated
1	20	1549.24	12.80±3.81	Large
2	16	256.06	77.46±4.58	Medium
3	12	194.70	9.74±7.08	Small
	TOTAL	**2000.00**	**100.00**	**….**

The cashew nut shells were classified into three classes as per the procedure given in the section 2.2. It is found that 9.74% of the cashew nut shells were having size of 12 to 16 mm, 77.46% of the shells were having size in the range of 16 to 20 mm and 12.80% of the shells were having size larger in the range of 20 to 25 mm.

Shells were classified based on the sizes in three classes, namely, small, medium and large. Shells having dimensions smaller than 16 mm were classified as small, in between 16 and 20 mm are classified as medium shells and shells having dimensions larger than 20 mm are called as large shells. As seen from the Figure 1, the classification of cashew nut shells shows the normal distribution. It is also observed that the shells of the medium size (i.e.16-20 mm) shares about the 80% and represents the equivalence of commercial ungraded shells.

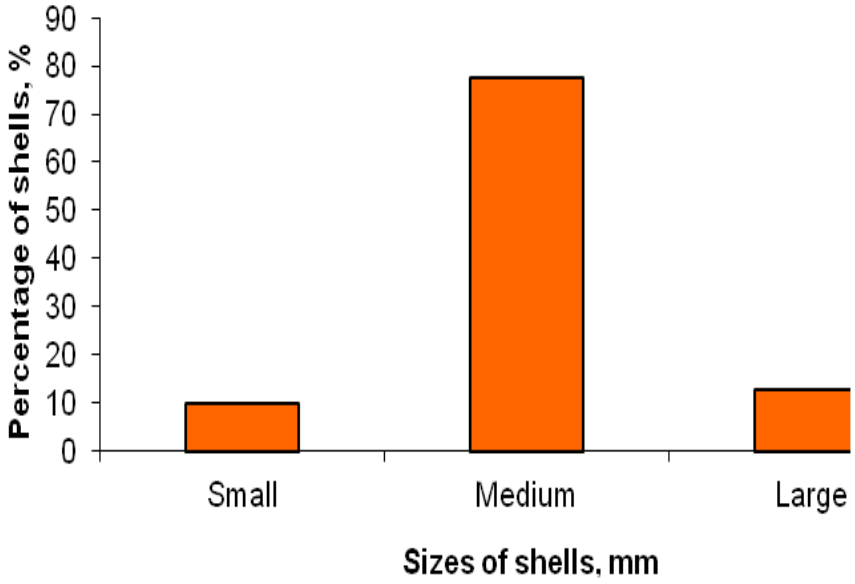

Figure 1: Size Distribution of Cashew Nut Shells

3.2 CNSL Content in the Cashew Nut Shell

The CNSL content of the shells was determined using Soxhlet apparatus as described in section 2.3 earlier. The data obtained for CNSL content of the shells measured are given in Table 2. The variation in the CNSL content at various sizes of cashew nut shells at moisture content of 10.16% (wb) is shown in the Figure 2. Cashew nut shell liquid of control sample was found to be 27.18%. It was in the range of 22.20 to 28.7% for experimental classified shells samples. Average oil content in cashew nut shells was found to be 26.45%. This CNSL content is considered throughout this research work and all other results for the recovery of oil were compared using the oil content of cashew nut shell as 26.45%.

This CNSL content of cashew nut shells implies that there is a good scope for processing the shells for oil. It would be economical instead of directly using as fuel. When one tonne of cashew nut is processed, 750 kg cashew nut shells are available. About 200 kg CNSL can be extracted from these shells, considering 26.45% CNSL content in it, having the value of about Rs. 6000 with the average price of Rs. 30 per kg. After the extraction of CNSL, the residual material available of shells can be also used as fuel. This would be more profitable, for the cashew nut processors than directly burning the shells as fuel without extracting the CNSL.

Table 2: CNSL Content (%) of Cashew Nut Shells

Sr. No.	Control	Small	Medium	Large
1	27.20	22.25	27.70	28.65
2	27.16	22.20	27.65	28.70
3	27.15	22.20	27.70	28.55
4	27.24	22.25	27.80	28.80
5	27.22	22.10	27.74	28.45
6	27.12	22.25	27.75	28.80
7	27.14	22.20	27.68	28.75
8	27.18	22.15	27.70	28.74
9	27.21	22.20	27.72	28.72
10	27.20	22.15	27.67	28.79
Average	**27.18**	**22.20**	**27.71**	**28.70**
S. D.	**±0.04**	**±0.05**	**±0.04**	**±0.12**

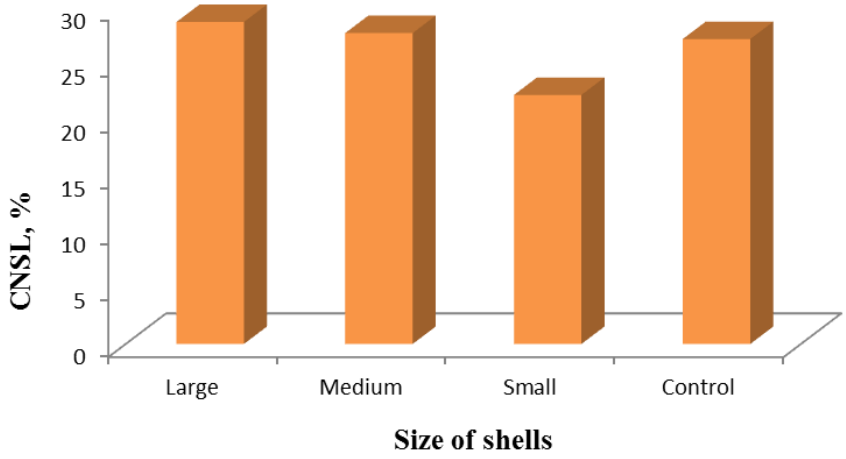

Figure 2: CNSL Content of Cashew Nut Shells

3.3 Influence of Shell Size on Oil Extraction

The influence of size of cashew nut shells available at optimum shell moisture content of 10.06% (wb) on the extraction of CNSL by screw press method was studied as discussed in the section 2.4. The shells from the three groups namely, small, medium and large were used for the extraction of the oil by screw press. The results were compared with the commercially available shells, i.e. control sample. Yield of oil was recorded for each test run. Test was replicated ten times for each size of the shells. The results of recovery of CNSL at various sizes of shells are shown in Table 3. Size of cashew nut shell has influence on the extraction of oil.

Table 3: Recovery of CNSL by Screw Press at Different Sizes of Shells of 10.06% (wb) M. C

Sr. No.	Class	CNSL Yield (%)	Recovery of CNSL (%)	S. D.*
1	Large	26.20	88.54	±0.39
2	Medium	25.83	87.29	±0.62
3	Small	24.13	81.55	±1.04
4	Control	23.29	86.68	±1.01
	Mean	**24.86**	**86.02**	**±0.77**

*n = 10

Recovery of oil was highest (88.54%) in case of large sized shells when extracted at optimum shell moisture content of 10.06% (wb). It was followed by the medium sized shells (87.29%), control sample (86.68%) and small sized shells (81.55%). This may be due to

- The surface area of the shells exposed to screw press would be more in case of large and medium sized shells in comparison with small sized shells. Due to the more availability of the surface area more number of oil bodies get ruptured when pressure is applied on the shells during the expression by screw press.
- Also the original CNSL content is more (28.70%) in large sized shells as compared to that in medium (27.71%) and small (22.20%) sized shells.

Recovery of oil for both the medium sized shells and commercially available cashew nut shells (control) when extracted at optimum shell m. c. of 10.06% (wb) was quite close.

The Figure 3 shows that although there is an increase in the CNSL yield as the size of shell increases, however the increase is very small (< 1%) in case of medium and large sized shells. Commercially available shells constitute about 80% of these as the medium size.

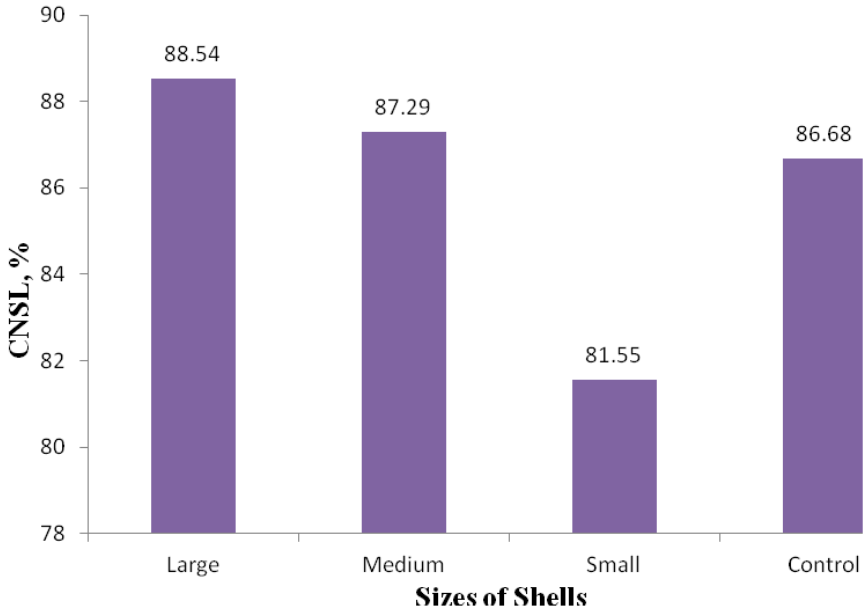

Figure 3: Influence of Size of Shells on Oil Extraction

4. CONCLUSIONS

- Cashew nut shells can be classified based on the sizes in three classes, namely, small (<12 mm), medium (16-20 mm) and large (>20 mm). The medium size cashew nut shells ranging between 16 to 20 mm are having 80% share in the commercially available sample of shells.
- Average CNSL content in cashew nut shells is **26.45%**. This CNSL content of cashew nut shells implies that there is a good scope for processing the shells for oil.
- Size of cashew nut shell has influence on the recovery of oil in screw press extraction. Recovery of oil for large size cashew nut shells is highest (88.54%).

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