Asian Journal of Biological and Life Sciences | Original Research

Extraction of CNSL using screw press

Ashok Pralhad Chaudhari*[1], Nayansingh Jaswantsingh Thakor[2]

1. Principal, Dr. Ulhas Patil College of Agril. Engg. & Tech., Jalgaon-425001, (M.S.), India.
2. Professor and Head, Dept. of Agricultural Process Engineering, and Associate Dean, College of Agril. Engg. & Tech., Dr. BSKKV, Dapoli, Dist. Ratnagiri-415712, (M.S.), India.

E-mail : apchaudhari1@rediffmail.com Contact No. : +91-.....

Submitted : 09.01.2015 Accepted : 10.03.2015 Published : 30.04.2015

Abstract

Liquid from Cashew Nut shell is generally extracted by three methods namely, mechanical, roasting and solvent extraction. The expeller (mechanical) process of oil extraction is more feasible for adoption on industrial scale. The influence of moisture content of cashew nut shells on the extraction of CNSL (Cashew Nut Shell Liquid) by screw press method was studied to find out the role of moisture content in the oil yield and there by optimising the moisture content of shells for the extraction process. The estimation of oil content in the cashew nut shells was carried out using a Soxhlet apparatus. The experiments were conducted at four different levels of moisture (8.12, 10.06, 12.17 and 14.20% (wb)) for the extraction of CNSL by screw press method. 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. The moisture content of the cashew nut shells at the time of extraction (% recovery) of CNSL has a great influence on the oil recovery. It is found that 10.06% moisture content Wet basis(wb)) in cashew nut shells is the optimum moisture content for extraction of oil from cashew nut shells in order to get the maximum oil recovery of 86.68%.

Key words : cashew nut shells, extraction of CNSL, oil content, screw press

INTRODUCTION

Cashew (*Anacardium occidentale)* is an important plantation crop of India. India has the largest area under cashew (9.23 lakh ha (hectare)) and stands as the second largest producer of cashew (7 lakh MT (Metric tones)) in the world [7]. Today, India is the largest processor and exporter of cashew in the world. Maharashtra ranks first in the production (28.78% of the country) and productivity of cashew nut in India [19]. Area under cashew nut in Maharashtra is confined to the Konkan region comprising five districts, namely, Sindhudurg, Ratnagiri, Raigad, Thane and Mumbai. Total production from these five districts is more than 1.98 lakh MT.

Rajapakse [12] reported that the cashew nut consists of kernel, shell and testa and on an average distribution is 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 [3].

The mechanical pressing of oilseed is the common method of edible oil extraction used in the world [11]. Mechanical expression is the oldest method used for obtaining oil from oil-bearing materials. The oil-bearing materials are placed between permeable barriers and pressure is increased by reducing the volume available for the oil-bearing materials. In this way, oil is squeezed from the oil-bearing materials. In practice, this operation can take two shapes, a hydraulic (uni-axial) press or a screw press (extruder or expeller).

Anonymous [3] reported that the expeller method is better than other methods like hot oil bath method, kilning method, etc. as it extracts 90% of the oil. The process is well established as extraction of oil by expeller process is practiced since long. Cashew shells are fed to the expeller to extract remaining oil. Oil thus obtained, is filtered with the help of a filter press and then weighed and packed in M.S. barrels. Recovery of oil is around 90%. This is known as untreated CNSL. Its colour is dark reddish brown when viewed by transmitted light. This oil is further treated to remove metallic impurities and traces of sulphur compounds.

Subbarao [18] cited that by using screw press with the screw speed of 7-13 rpm and feeding rate of 54-95 kg/h, the percentage of CNSL extracted was 20.65-21.04 percent, the percentage of CNSL purity was 85.53-87.80 wt % and the rate of extraction was 11.93-14.90 kg/h.

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 [1] and Baryeh [6]. 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.

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, (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth) 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.

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 [4]. 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 [1] [5]. 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.

Determination of CNSL content of cashew nut shells

The estimation of oil content in 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.

Extraction of CNSL by screw press

Liquid from Cashew Nut shell is generally extracted by three methods namely, mechanical, roasting and solvent extraction. The expeller (mechanical) process of oil extraction is more feasible for adoption on industrial scale. The cashew nut shell liquid was extracted using the screw press available with M/S Metafil Industries Pvt. Ltd., Dapoli. The screw press available was manufactured by Alfa Engineering Company, Chandigarh. The model was of 27-5 type. The length of screw shaft was27 inches and the inner diameter of cage was 5 inches. The CNSL was extracted by varying the moisture content of shells. Pressure and feed rate were maintained constant throughout the tests of oil extraction.

The influence of moisture content of cashew nut shells on the extraction of CNSL by screw press method was studied to find out the role of moisture content in the oil yield and there by optimising the moisture content of shells for the extraction process.

Considering the importance of the moisture content at the time of pressing, a systematic study was deemed necessary to determine the effects of these parameters on pressing characteristics of cashew nut shells. Moreover, it was observed that the available shells were having the moisture content in the range of 10 to 12% (wb). Hence, the experiments were conducted at four different levels of moisture (8.12, 10.06, 12.17 and 14.20% (wb)) for the extraction of CNSL by screw press method.

The desired moisture content levels were achieved by adding calculated volume of distilled water as obtained from the following equation used by Akinoso[2].

$$Q = \frac{A(b-a)}{(100-b)}$$

Where,

A - Initial mass of the sample, kg.

a - Initial moisture content of the sample, wet basis in per cent,

b - Final (desired) moisture content of sample, wet basis in per cent,

Q - Mass of water to be added, kg.

The flow process diagram of the oil extraction process by screw press is given in Fig. 1.

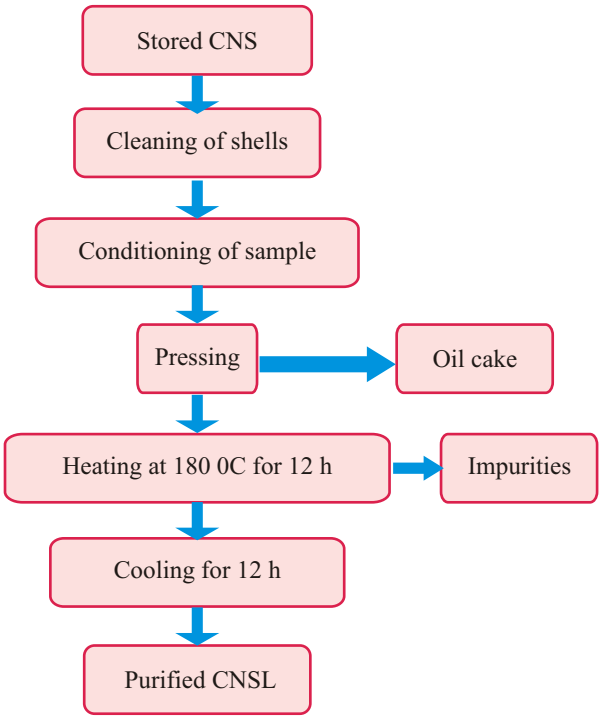

Figure 1: VFlow diagram of CNSL extraction by screw press

A batch of 30 kg was used for the extraction of oil and it was replicated 10 times. Hence, sample of 400 kg for each moisture level was prepared using the moisture conditioning process as explained above. Sample prepared was immediately used for the extraction of oil by screw press to avoid the change in m.c.(

Moisture content) of the prepared sample. Pressure and feed rate were maintained constant throughout the tests of oil extraction for different moisture contents. Test was replicated ten times for each moisture level. Yield of oil was recorded for each test run.

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

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

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

Similar types of formulae were used by Elhassan [9] for the yields of oil from sesame seeds.

RESULTS

CNSL content in the Cashew nut shell

The CNSL content of the shells was determined using Soxhlet apparatus as described in section 2-2 earlier. The data obtained for CNSL content of the shells measured are given in Table 1. 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%.

Table 1: CNSL content (%) of cashew nut shells

Replications	CNSL content (%)
1	26.45
2	26.43
3	26.40
4	26.52
5	26.38
6	26.48
7	26.44
8	26.44
9	26.46
10	26.45
Average	**26.45**
S. D.	**±0.04**

Influence of shell moisture content on oil extraction

The influence of moisture content of cashew nut shells on the extraction of CNSL by screw press method was studied to find out the role of moisture content in the yield of oil and there by optimising the moisture content of shells for the extraction process. Commercially available cashew nut shells were used for these particular experiments. The data obtained for the influence of moisture content of cashew nut shells for the different levels of moisture content (8.12, 10.06, 12.17 and 14.20% (wb)) on the extraction of CNSL by screw press method are given in Table 2.

DISCUSSION

CNSL content in the Cashew nut shell

The CNSL content of cashew nut shells 26.45% 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.

Influence of shell moisture content on oil extraction

The moisture content of the shell at the time of oil extraction has a great influence on the extraction recovery of the oil. The average recovery of CNSL at shell moisture of 8.12% (wb) was 80.57% and that at shell moisture of 12.17% (wb) and 14.20% (wb) was 85.54% and 84.01%, respectively. It was highest (86.68%) when the shell moisture content was 10.06% (wb).

The oil yield increased with increase in moisture content, up to levels between 8.12% (wb) (80.57%) and 10.06% (wb) (86.68%) as evident from the Fig. 2. The reason for this can be the assistance of the moisture for the displacement of oil from the surface of shells (oil bearing materials of the cashew). Further increase in the moisture content from 10.06 to 14.20% (wb) led to a decrease in oil yield from 86.68 to 84.01%. This may be due to moisture levels above 10.06% (wb) i.e. the optimum, there is swelling of the mucilage over the cashew nut shells, this produces a cushioning effect on the shells. The swelled mucilage can be the hurdle to oil flow during expression while the cushioning effect on the shells reduces the rupturing of the particles and internal tissues during pressure application [10]. Similar trend was also observed by Dedio and Dorrell [8] for flax seeds. For the increase of moisture content of flaxseeds from 8 to 16%, there is a dramatic decrease in oil recovery from 54.7 to 4.4%. Another reason for the decrease in oil yield with increase in moisture content of shells probably may be when the excess moisture is present, the liquid phase takes the entire load, itself being incompressible, and does not exert any pressure on the oil bearing particles, thus showing an adverse effect on oil recovery [11][17].

The moisture content was reported to be the most important factor affecting cake residual oil content. Screw pressing of the oil bearing materials showed that the residual oil content decreased as the moisture content of the material decreased; low moisture content was particularly important, but further reduction in

Table 2: Recovery of CNSL by screw press at various moisture contents of shells.

Sr. No.	Moisture content (wb) of Shells, (%)	CNSL Yield (%)	Recovery of CNSL (%)	S. D.
1	8.12	23.84	80.57	±1.06
2	10.06	25.65	86.68	±1.01
3	12.17	25.31	85.54	±1.03
4	14.20	24.86	84.01	±0.91

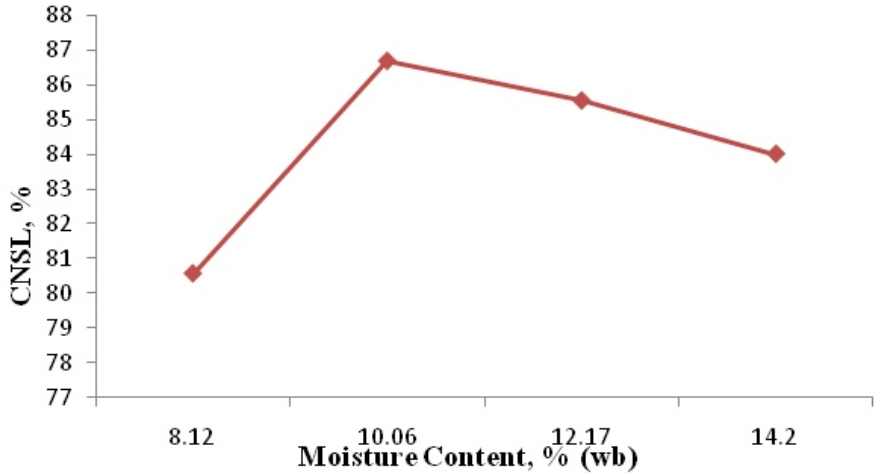

Figure 2: Influence of shell moisture content on oil extraction.

moisture content was not beneficial and resulted in more sediment in the oil [16] [13] [20] [15]. In screw pressing of soaked and sun-dried flaxseed, oil recovery increased from 78 to 88% as moisture content increased from 5 to 7%, and thereafter it decreased to 76% at 9% moisture content. Higher moisture content increased plasticity and thereby reduced the level of compression and contributed to poor oil recovery [14]. Moisture acted as a lubricant in the barrel; therefore, higher moisture content resulted in insufficient friction during pressing [13].

Thus, for each oilseed, there is optimum moisture content such that when, under compression, it just reaches the saturation point, any additional load applied is transmitted throughout the body of the solid phase exerting pressure on the particles. Therefore, in the present study, 10.06% (wb) is the optimum moisture level at which we obtained maximum yield of CNSL 86.68%. At this stage the cells are easily deformable without rapturing [11] and oil is released [17]. Similar results were also observed for melon seeds [1] and other vegetable oil seeds.

CONCLUSION

The 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. The moisture content of the cashew nut shells at the time of extraction (% recovery) of CNSL has a great influence on the oil recovery. It is found that 10.06% moisture content (wb) in cashew nut shells is the optimum moisture content for extraction of oil from cashew nut shells in order to get the maximum oil recovery of 86.68%.The screw press method of extraction of CNSL is efficient.

REFERENCES

1. Ajibola O. O., Eniyemo S. E., Fasina O. O., Adeeko K. A. Mechanical expression of oil from melon seeds. Journal of Agric. Engr. Res. 1990:45: 45-53.

2. Akinoso R., Igbeka J., Olayanju T., Bankole L. Modeling of oil expression from palm kernel (*Elaeis guineensts jacq*.). Agricultural Engineering International: the CIGR Ejournal. Manuscript F, P 05016. Vol. VIII. 2006.

3. Anonymous. Cashew Nut Shell Liquid. 2009. http://www.anacardium.info/IMG/cashew_nut_shell_iquid. pdf

4. AOAC. *Official methods of analysis* (14th Ed.) Arlington, VA: Association of Official Analytical Chemists, 1984.

5. Aremu A. K., Fadele O. K. Moisture Dependent Thermal Properties of Doum Palm Fruit (*Hyphaene Thebaica*). Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS). Scholarlink Research Institute Journals. 2010:1(2): 199-204. http://www.jeteas.scholarlinkresearch.org

6. Baryeh E. A. Effects of palm oil processing parameters on yield. Journal of Food Engineering. 2001:48(1): 1-6.

7. CEPC. About Cashew and Cocoa-statistics. Cashew nut Exports Promotion Council of India. 2012. http://www.cashew india.org/php/cepcContents.php?CatID=29

8. Dedio W., Dorrell D. G. Factors affecting the pressure extraction of oil from flax seed. Journal of American Chemists' Society. 1977:54(8): 313-320.

9. Elhassan S. H. A. R. Mechanical expression of oil from Sesame (*sesamum indicum* L.) seeds. 2009. A Thesis Submitted to University of Khartoum in Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Agriculture. Department of Agricultural Engineering. Faculty of Agriculture. University of Khartoum.

10. Fasina O. O., Ajibola O. O. Mechanical express ion of oil from conophor nut (*Tetracarpidium Conophorum).* Journal of Agric. Engr. Res. 1989:44: 275-287.

11. Mrema G. C., McNulty P. B. Mathematical model of mechanical oil expression from oilseeds. Journal of Agricultural Engineering Research. 1985:31(5): 361-370.

12. Rajapakse R. A., Gunatillake P. A., Wijekoon K. B. A Preliminary study on processing of cashew nuts and production of cashew nut shell liquid (CNSL) on a commercial scale in Sri Lanka. J. Ntn. Sci. Coun.Sri Lanka. 1977:5 (2): 117-124.

13. Reuber, M. New Technologies for Processing *Crambe abyssinica*, M.S. Thesis, Iowa State University, Ames, 1992.

14. Singh J., Bargale P. C. Mechanical expression of oil from linseed (*Limum usitatissimum* L.). Journal of Oilseeds Research, 1990:7: 106

15. Singh K. K., Wiesenborn D. P., Tostenson K., Kangas N. Influence of Moisture Content and Cooking on Screw Pressing of Crambe Seed. *JAOCS.* 2002:*79,* 165-170.

16. Singh M. S., Farsaie A., Stewart L. E., Douglass L. W. Development of mathematical models to predict sunflower oil expression. Transactions of the American Society of Agricultural Engineering, 1984:27(4): 1190.

17. Sivala K., Bhole N. G., Mukheiliee R. K. Effect of Moisture on Rice Bran Oil Expression. *J. agric. Engng Res.* 1991:50, 81-91.

18. Subbarao CH. N. V., Krishna Prasad K. M. M., Prasad V. S. R. K. Review on Applications, Extraction, Isolation and Analysis of Cashew Nut Shell Liquid (CNSL). The Pharma Research Journal. 2011:6(1):21-41. www.thepharmaresearch.info

19. Swain S. K., Gupta J. P., Sahoo P. K. Scope for modernization of cashew nut processing in Orissa. National seminar on Research, Development and Marketing of Cashew, 20th 21st November, 2007: 98-99.

20. Vargas-Lopez, J. M., Wiesenborn D., Tostenson K., Cihacek L. Processing of Crambe for Oil and Isolation of Erucic Acid, *J. Am. Oil Chem. Soc*. 1999:*76:*801809. In: Singh K. K., Wiesenborn D. P., Tostenson K., Kangas N. Influence of Moisture Content and Cooking on Screw Pressing of Crambe Seed. *JAOCS*. 2002:*79,* 165-170.