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Applications and Extraction of Cashew Nut Shell Liquid from Cashew Nut Shell

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Abstract: *CNSL has many applications such as friction linings, paints, laminating resins, rubber compounding resins, cashew cements, polyurethane based polymers, surfactants, epoxy resins, foundry chemicals, and intermediates for chemical industry. Liquid from Cashew Nut shell is generally extracted by three methods are mechanical, roasting and solvent extraction which contains oil of about 20 to 25%. Solvent extraction (expeller) process of oil extraction is more feasible. CNSL using solvent extraction with different solvents. For solvent Ethanol shows 1:3, 1:4 and 1:5 CNS to ethanol ratio the % yield 32 %, 35% and 37 % resp. As per observation ethanol is the best suitable for extraction of CNSL from the cashew nut shell. Ethanol can easily separate after extraction and has higher yield than other with low cost. Selected solvent should be easily separated from the CNSL and giving high yield operation with low cost. Size of cashew nut shell has influence on the recovery of oil and recovery of oil large size cashew nut shells is more than small size. By the Experimental analysis 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 8-10 on wet basis was 80 – 85 %. The highest recovery of when the shell moisture content at 10 % wet basis. The ration of feed to solvent also important factor to be consider for extraction process which effect on the yield of CNSL. The optimum value for feed to solvent is 1:4 on which maximum yield for CNSL extraction. Here, we select the ethanol as a solvent that can easily recoverable, low cost and having low loss by vaporization. As petroleum ether flash at room temperature..*

Keywords: Cashew Nut Shells Liquid (Oil), Solvent Extraction, Different Solvents Petroleum Ether and Ethanol, Moisture content, Shell Size and solvent to feed ratio

I. INTRODUCTION

Liquid from Cashew Nut shell is generally extracted by three methods are mechanical, roasting and solvent extraction which contains oil of about 20 to 25%. The expeller process of oil extraction is more feasible for adoption on industrial scale. 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. Cashew-Nut Shell Liquid Oil (CNSL) is an important by-product of cashew. India's Cashew-Nut Shell Liquid Oil Export Market. Along with quality cashew kernel, Indian cashew nut industry is producing quality Cashew-Nut Shell Liquid oil which is also exportable. Indian cashew nut industry has big market for CNSL. CNSL oil is used in industries has good demand from industrially developed countries like USA and China are the top most importers. The thick vesicant oil liquid contained in the shell of cashew nut, called cashew nut shell liquid. The shell is formed of three concentric layers the epicarp, the mesocarp and the endocarp. The mesocarp is spongy and comprised of a mass of tissues and ducts containing about 35% of sticky, resinous liquid called cashew nut shell liquid (CNSL). The CNSL is highly caustic-brown in color and inedible. It affords the fruit some natural protection against insects. CNSL consists of two highly reactive phenolic compounds which are anarcardic acid (90%) and cardol (10%).

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II. LITERATURE REVIEW

Experimental study shows the effect of processing methods on the yield of cashew kernel oil sample dry roasting produced significantly higher oil yield 44.10 % than other processing methods 39.80 %, 35.14 % and 34.40 % for oil roasting, hand cracking and steam cooking respectively. By study shows that the oil and dry roasting methods are the best processing techniques to be employed to ensure that high percentage of wholesome cashew kernels are produced. Same two methods gave raise to high yield of cashew kernel oil extracted using solvent and screw press extraction methods as compare to hand cracked and steam cooked methods.[1] Solvent extraction method which done in using petroleum ether which is normally used in the extraction of plant kernel oil. The oil extraction was done in small quantities of 20 g of milled cashew kernel and the extraction was allowed for 6 h at 60 OC in a Soxhlet- extractor with 200 ml solvent and the oil was separated by simple distillation/evaporation. [1]. In 2015, Studied by Ashok Praha Chaudhari and Nuancing Scanting Thakor show that Liquid from Cashew Nut shell is extracted by three methods 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 optimizing the moisture content of shells for the extraction process. Extraction of CNSL by screw press method average oil content in cashew nut shells was found to be 26.45%. CNSL content of cashew nut shells imply that there is a good scope for processing the shells for oil. [2] By the Experimental analysis 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 % on wet basis was 80.57 % and that at shell moisture of 12.17 % wet basis and 14.20 % wet basis was 85.54 % and 84.01 % respectively. The highest recovery of 86.68% when the shell moisture content was 10.06 % wet basis. The moisture content of the cashew nut shells at the time of extraction (% recovery) of CNSL has a great influence on the oil recovery. Hence by analysis it's found that 10.06% moisture content Wet basis 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 %. [2] In screw pressing of soaked and sundried flaxseed oil recovery increased from 78 to 88 % as moisture content increased from 5 to 7 %, and 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. By the experimental analysis 10.06 % wet basis is the optimum moisture level at which we obtained maximum yield of CNSL. [2] In 2018, Experimental analysis carried out by Alex Folami Adisa, Elijah Oladimeji Aina and Salami Olasunkanmi Ismaila, the shells were handled separately but were given the same pre-treatment of moisture conditioning to 14 – 17 % (A), 17-20 % (B) and 20-23 % (C) all on the wet basis. The highest percentage oil recovery of 21%, 19.5%, 15.5% at 10 minutes and A, B, C respectively were obtained for 5 kg sample of cashew nut shell while at 2 minutes pressing duration and A, B, C moisture contents, the percentage oil recovery were 12.5%, 10.5% and 9% respectively. The optimum percentage of liquid recovery was 20.5% for sample mass of 5 kg and pressing duration of 10 minutes. The maximum extraction efficiency of 84%, 78% and 62% at A, B C moisture contents and 10 minutes pressing duration respectively were obtained for 5 kg sample of cashew nut shell while at 2 minutes and A, B, C moisture contents, the extraction efficiencies were 50%, 42% and 36% respectively.[3] Cashew nut shell liquid (CNSL) is a by-product from cashew nut processing. CNSL is a dark brown viscous liquid present inside a soft honey comb structure of the cashew nut shell. CNSL contains phenolic compounds, mainly cardanol. Cardanol is a monohydroxyl phenol with a long carbon chain in the met position. It has the potential as a substitute for phenol in resin phenolic- based chemical products. Various methods of extraction of CNSL and isolation of major constituents. different solvents and combination of solvents for extraction of CNSL from Indian cashew nut shell both for Steam roasted shells as well raw cashew nut shells and their yields at different solute to solvent ratios. This enables optimum solute to solvent ratios for extraction of CNSL. Supercritical extraction of Cold extracted CNSL as well as CNSL obtained from Steam extracted shells can also be carried out for recovery of anacardic acid to compare the extent of anacardic acid obtained with that of chemical methods. [4] In 2014, Studied by Idah P. A., Simeon M. I. and Mohammed M. A., Soxhlet apparatus was used for the extraction using hexane as solvent.

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The physical and chemical properties of the extracted oil were analyzed. The percentage oil extracted from the shell of the cashew was found to be 25.5% while that extracted from the kernel was 11.8% oil. The physical analysis showed that the cashew kernel oil (CKO) is light yellow while the Cashew Nut Shell Liquid (CNSL) is dark brown. The boiling points for shell and kernel oil were 92 oC and 95 oC respectively. The cashew kernel oil is non-toxic and the properties of CNSL conformed to, a greater extent, to that exhibited by linseed oil. CNSL has lot of application in the processing and manufacturing industries. The kernel oil conformed both in its physical and chemical properties to those of groundnut and melon oil and thus could be used in the food and pharmaceutical industries.[5] Cashew nut shells can be classified based on the sizes in three classes. The medium size cashew nut shells ranging between 16 to 20 mm are having 80% share in the commercially available sample of shells. The moisture content of the cashew nut shells at the time of extraction (% recovery) of CNSL has a great influence on the oil recovery. Average oil content in cashew nut shells was found to be 26.45 %. CNSL content of cashew nut shells imply that there is a good scope for processing the shells for oil. Size of cashew nut shell has influence on the recovery of oil and recovery of oil large size cashew nut shells is 88.54% [11].

2.1 Applications of CNSL [8]

a. Industrial Applications of CNSL

CNSL is a versatile raw material and has many industrial applications with 200 patents. The most important use of CNSL is for the manufacture of friction modifying material for brake lining, clutch facing and industrial belting.

1. Paints and Enamels

Because of its dark color, CNSL is used in the manufacture of dark colored paints and enamels. Paints and varnishes made from CNSL have superior properties than those of conventional oils or synthetic resins. Varnishes resistant to water and gasoline have been made by incorporating Sulphur in CNSL. The dried films are superior to those of ordinary oil paints in respect of resistance to oils, grease moisture and chemicals.

2. Electrical Insulating Varnishes

Electrical insulating varnishes are obtained by treating CNSL with formaldehyde and compounding the resulting material with pure phenolic resin varnish or alkyl resin in suitable proportions. Films of those materials are water chemical resistance as bobbin enamels and laboratory.

3. Polymers

Cashew polymers react with formaldehyde to give a rubbery gel, which can be used as a cement hardening agent that would be immune to acids and alkalis reaction. It can be used for cementing floors exposed to chemical attack. CNSL modified by heating at 160 0C in the presence of certain accelerators give enamels that resistant to alkali and acid solutions. CNSL forms the basic raw material for a vast number of industrially important chemicals and chemical intermediates. The various components of cardanol can be modified to obtain emulsifiers, surface active agents, antioxidants, stabilizers, accelerators, plasticizers, reclaiming agents and ion exchange resins.

4. Adhesive

CNSL-based adhesives for the manufacture of ply- wood and particle boards, among other applications have been made.

5. Lamination

CNSL or cardanol derivatives are extensively used in the laminating industry for reducing brittleness and improving the flexibility of the laminates. Adhesives suitable for plywood are made by oxidizing CNSL with potassium fermagate or manganese dioxide at 100° C reacted with paraformaldehyde and compounded with cuprous chloride.

6. Rubber Products

The use of CNSL in rubber composition improve the performance of rubber products. It helps processing and vulcanizate properties. CNSL enhances insolubility of natural rubber vulcanizates

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in petroleum solvents. It helps incorporation of ingredients in to rubber and increase resistance to moisture. Oxides of Cu, Ba, Zn.

7. Phenoplasts

CNSL and its derivatives can also be converted to phenoplasts with better processability, hydrocarbon solubility and resistance to acid and alkalis than the conventional phenol-based systems. Moulding powders from CNSL, shellac and fillers such as wood flour, saw dust, asbestos are found to give articles with excellent finish, good flexural, tensile strengths and satisfactory water resistance. Stable rigid or flexible covering materials in the form of tiles sheets etc., are made from compositions containing CNSL.

8. Pesticidal action Chlorinated and Copperized

CNSL have been found to have pesticidal effects on insects and fungi.

9. Coatings

Various types of coatings based on CNSL and its isolates have been developed and commercialized. These include, industrial and marine coatings, varnishes, lacquers, and enamels among others. Electrical insulating varnishes obtained by treating CNSL with formaldehyde and compounding the resulting material with pure phenolic resin varnish or alkyd resin in suitable proportions.

10. Pesticidal Action

Chlorinated and Copperized CNSL have been found to have pesticidal effects on insects and fungi.

b. Medicinal Applications [7]

Anacardic acids were reported to have greater antibacterial activity compared to other constituents of CNSL. Anacardic acid found to be useful against medically important bacteria that are involved in the tooth decay, acne, ulcers and infection. Anacardic acid has synergistic effects with methicillin against methicillin resistant staphylococcus aureus (MRSA). Anacardic acid inhibits both gram positive and gram-negative bacterial growth. It displays anti-cancer activity and were most effective against breast cell cancer lines. It also acts as a non-competitive inhibitor of the histone acetyl transferase (HAT) activity of the transcriptional co activators p300 and PCAF.

Separation of shell from the Nut [7]

In order to extract the oil from the shell, the shell needs to be separated from the nut. Earlier method includes roasting of the cashew nut which has resulted in loss of all of the CNSL into the atmosphere from the shell leading to environmental problems.

1. By Application of Cold

In the first method, the nuts were placed in liquid nitrogen bath when they cracked. The shells were broken by light hammering and separated from the kernel and testa41. In an alternative method, the nuts were stored in overnight freezer to make the shell brittle. The nuts were bisected by light hammering along the axis of the junction of the two halves of the shell. The intact kernel in the testa lining was separated.

2. Steam Roasting

The raw cashew nuts were steamed in boiler. The cooking time is varied depending upon the conditions of cashew nut and atmospheric conditions. Work was done to study the effect of period of steaming and drying temperature on chemical composition of cashew nut. The authors considered steaming time of 20, 30 and 40 min and temperatures of 50, 60 and 70 OC and reported that cashew nuts processed by steam boiling at 40 minutes and drying temperature of 70 OC recorded best quality as it reduced the residual CNSL and moisture content of the kernel.

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Methods for Extraction of CNSL

a. Thermal Extraction [4]

1. Roasting Method

This is the traditional method of removing CNSL and it involves roasting the nut in drums or baths. The roasting process not only removes the corrosive CNSL but also makes the shell brittle hence aiding the cracking process. This method causes the loss of most of CNSL. In order to extract the retained CNSL the nuts are roasted in baths at a temperature of 180–185 OC. This method recovers 85–90 % of the liquid. Scrapping the shell in a rotary apparatus with sand and steel wool and heated at 100–300 0C for 1 h and then roasted at 400– 700 0C in an inert atmosphere to remove residual oil.

2. Hot Oil Bath Method

This is the most common method of commercial extraction of CNSL in practice nowadays. The technique can be different depending upon the raw material which is either raw cashew nut shell or cashew nut. Cashew nut shells were collected in the cylinder where steam heating was applied at temperatures around 200- 250 0C for 2-3 minutes. CNSL was then released from the shells and the process was repeated. This method yields CNSL of around 7-12 % by weight. The raw nuts are passed through a bath of hot CNSL itself when the outer part of the shell bursts open and releases CNSL. This method produces CNSL which was around 6- 12 % by weight of nut.

b. Screw Press Method

The raw cashew nut shells are put in the hydraulic press on screw pressing and then exert high pressure in order to release CNSL from shells. This method is rather straight forward and quick among others. Work was reported for extraction of CNSL by means of tapered compression screw feeding rollers of transversal zigzag surface type and cylindrical casing with 2 mm diameter holes. By using screw speed of 7-13 rpm and feeding rate of 54 - 95 kg/h and the percentage of CNSL extracted was 20 -21 % and the percentage of CNSL purity was 85-88 wt. % and the rate of extraction was 11.93-14.90 kg/h. The residue from this method contained proportions of CNSL around 10 to15%. This method of extraction had higher levels of impurity, higher viscosity, low thermo-oxidative stabilities. CNSL obtained contained 42% cardol, 47% anacardic acid and 3% Cardanol.

c. Solvent Extraction

This method gives off most of CNSL compared to other methods. The oil remains in the residue was less than 1% by weight. Extraction solvents fall into two groups those which are less dense than water and those which are denser. Commonly used extraction solvents which fall into the first group include diethyl ether, ethyl acetate and hydrocarbons such as light petroleum, hexane or toluene. The second group comprises chlorinated solvents, such as dichloromethane and chloroform, with dichloromethane being the preferred solvent because of its lower toxicity. Chlorinated solvents have a greater tendency to form emulsions than non-chlorinated solvents.

d. Vacuum Pyrolysis [8]

Pyrolysis plays an important role in any thermochemical conversion of biomass. It is referred to as carbonization, liquefaction or gasification depending upon whether the desired product is solid char, liquid fuel/chemical or gaseous fuel. The extraction of CNSL from CNS using vacuum pyrolysis is discussed in literature. CNS having a moisture content of about 10% was taken, on simple heating, at 100– 175°C the CNS produced dark brown oil. After collection of this oil the CNS was further pyrolyzed at 500°C under vacuum (720 mmHg). The CNSL is comprised of oil by heating CNS up to 175°C and the oil obtained thereafter as condensates from the pyrolysis of CNS. Both the oils together amount to about 40 % by weight of the shell which is otherwise obtained by solvent extraction process.

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Extraction of CNSL Using Soxhlet Extractor [8]

The extraction of CNSL was carried out using a Soxhlet extractor and n-hexane as solvent. 350 ml of hexane was charged into the round bottom flask of Soxhlet apparatus and 20 g of crushed cashew nut shell was charged into the thimble. The solvent in the set-up was heated to 68 OC and the vapor produced was 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. The set-up was then re-assembled and heated to recover the solvent from the oil. The extract (CNSL) was separated into various constituents namely anacardic acid, cardanol, cardol using alanine with the aid of shakeout separation equipment. The composition of the CNSL is approximately 10% cardol, 50% cardanol and 30% anacardic acid with the remainder being made up of other substances. The solvent extraction is generally employed to get higher concentration of phenol. The limitations with solvent extraction of CNSL are that they give rise to colored impurities. The solvent extraction has a serious problem of elimination of polluting organic solvent from the extract.

Chemicals and Raw Materials

1. Cashew Nut Shell
2. Ethanol

Apparatus Requires

1. Soxhlet Apparatus
2. Simple Distillation
3. Digital Thermometers
4. Heating Element/Mental
5. Measuring Cylinders
6. Glass Rod
7. Beaker
8. Oven
9. Water Bath (If Available)

Experimental Process for Ethanol Solvent

1. Take 100 gm cashew nut shell are dried in oven or sunlight to remove the moisture.
2. Calculate the % moisture content in the cashew nut shell.
3. Crush the cashew nut shell in small size.
4. Take 1:3, 1: 4 and 1:5 various ratios of cashew nut shell to solvent.
5. Take cotton cloth or filter paper and keep cashew nut shell in cloth or filter paper.
6. Put this cloth or filter paper in thimble of Soxhlet Extraction apparatus contains CNS.
7. Take 300 ml of the Ethanol (For 1:3 ratio) as solvent in round bottom flask of Soxhlet.
8. The mixture then heated at 75 OC-80 OC (B.P. solvent) for 2 - 4 hrs.
9. After extraction removal of round bottom flask from Soxhlet apparatus.
10. CNSL (B.P. 92-95 OC) to be separated from the solvent using simple distillation.
11. Separation by simple distillation carried out at temperature 75-80 OC.
12. In distillation ethanol recover as top product and CNSL as a bottom product.
13. Calculate % recovery or yield of CSNL.
14. Repeat the experiment for various feed to solvent ratio and calculate the yield for the various feed to solvent ratios.

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Experimental (Actual) Material Balance Balance For Feed to Solvent - 1:3 Ration
CNS Powder + Ethanol/Petroleum Ether
= (Solvent + CNSL) + Powder Residue

100 gm + 300 ml = 175 ml + 130 gm + 95 ml of ethanol Flash during extraction
CNSL + Ethanol = Distillate (Ethanol) + Residue (CNSL)
175 ml = 143 ml Ethanol + 32 ml CNSL

Balance For Feed to Solvent - 1:4 Ration
CNS Powder + Ethanol/Petroleum Ether
= (Solvent + CNSL) + Powder Residue

100 gm + 400 ml = 275 ml + 125 gm + 100 ml of ethanol Flash during extraction

CNSL + Ethanol = Distillate (Ethanol) + Residue (CNSL)
275 ml = 240 ml Ethanol + 35 ml CNSL

Balance For Feed to Solvent - 1:5 Ration
CNS Powder + Ethanol/Petroleum Ether
= (Solvent + CNSL) + Powder Residue

100 gm + 500 ml = 360 ml + 120 gm + 120 ml of ethanol Flash during extraction

CNSL + Ethanol = Distillate (Ethanol) + Residue (CNSL)
360 ml = 323 ml Ethanol + 37 ml CNSL

% Yield of CNSL
The maximum amount of CNSL in CNS up to 40
%. Hence according this composition yield can be calculated. The maximum yield will be 40 %.
% Yield of CNSL = [Mass of CNSL Extracted / Mass of Cashew Nut Shell] *100
Yield Using Ethanol Feed to Solvent Ratio 1:3

% Yield of CNSL = [Mass of CNSL Extracted / Mass of Cashew Nut Shell] *100
[32/100] * 100 = 32 %

Yield Using Ethanol Feed to Solvent Ratio 1:4
% Yield of CNSL = [Mass of CNSL Extracted / Mass of Cashew Nut Shell] *100
[35/100] * 100 = 35 %

Yield Using Ethanol Feed to Solvent Ratio 1:5
% Yield of CNSL = [Mass of CNSL Extracted / Mass of Cashew Nut Shell] *100
[37/100] * 100 = 37 %

5.% Recovery of CNSL or Oil

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% Recovery of CNSL = [CNSL Extracted / Maximum Amount of CNSL in CNS] *100
5.3.1. Recovery Using Ethanol Feed to Solvent Ratio 1:3
% Recovery of CNSL = [CNSL Extracted / Maximum Amount of CNSL in CNS] *100

Recovery Using Feed to Solvent Ratio 1:4
% Recovery of CNSL = [CNSL Extracted / Maximum Amount of CNSL in CNS] *100
[35/40] * 100 = 87.5 %

Recovery Using Feed to Solvent Ratio 1:5
% Recovery of CNSL = [CNSL Extracted / Maximum Amount of CNSL in CNS] *100
[37/40] * 100 = 92.5
%Observations

Feed to Solvent Ratio	% Yield With Ethanol	% Recovery With Ethanol
1:3	32	80
1:4	35	87.5
1:5	37	92.5

Table No. % Yield of CNSL for Different Solvents

Observation table shows % yield of CNSL using solvent extraction with different feed to solvent ratio. For solvent Ethanol shows 1:3, 1:4 and 1:5 CNS to ethanol ratio the % yield 32 %, 35% and 37
% resp. As per observation ethanol is best suitable for extraction of CNSL from the cashew nut shell. Ethanol can easily separate after extraction and has higher yield than other with low cost.
Factors Affected on Yield of CNSL

1. Size of Cashew CNS
[32/40] * 100 =80 %
Size of cashew nut shell has influence on the recovery of oil and recovery of oil large size cashew nut shells is more than small size.

2. Moisture Content of CNS
By the Experimental analysis the moisture content of the shell at the time of oil extraction has a great influence on the extraction recovery of the oil.

3. Feed to Solvent Ratio
The ration of feed to solvent also important factor to be consider for extraction process which effect on the yield of CNSL. The optimum value for feed to solvent is 1:4 on which maximum yield for CNSL extraction.

4. Solvent for Extraction
Selected solvent should be easily separated from the CNSL and giving high yield operation with low cost. Solvent have low boiling point. Solvent like Ethanol are best suitable for extraction of CNSL.

III. CONCLUSION

Liquid from Cashew Nut shell is generally extracted by three methods are mechanical, roasting and solvent extraction which contains oil of about 20 to 25%. The Solvent extraction (expeller) process of oil extraction is more feasible for adoption on industrial scale. CNSL using solvent extraction with different solvents. % yield of CNSL using solvent extraction with different feed to solvent ratio. For solvent Ethanol shows 1:3, 1:4 and 1:5 CNS to ethanol ratio the %

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Size of cashew nut shell has influence on the recovery of oil and recovery of oil large size cashew nut shells is more than small size. By the Experimental analysis 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 8-10 on wet basis 85-95 %. The highest recovery of when the shell moisture content at 10 % wet basis. The moisture content of the cashew nut shells increases more than 1 the recovery decrease slightly. The ration of feed to solvent also important factor to be consider for extraction process which effect on the yield of CNSL. The optimum value for feed to solvent is 1:4 on which maximum yield for CNSL extraction. Hence, by the study the factor like Feed to solvent ratio, Moisture content in CNS, size of CNS and the solvent for extraction all are important factor that impact on the yield of CNSL.

FUTURE SCOPE AND BENEFITS

India's Cashew-Nut Shell Liquid (Oil) Export Market. Along with quality cashew kernel, Indian cashew nut industry is producing quality Cashew- Nut Shell Liquid oil which is also exportable. Indian cashew nut industry has big market for CNSL. CNSL oil is used in industries has good demand from industrially developed countries like USA and China are the top most importers. India is the largest producer and processor of cashews. CNSL is a versatile raw material and has many industrial applications. There are currently more than 200 patents for its industrial application. CNSL has many applications such as friction linings, paints, laminating resins, rubber compounding resins, cashew cements, polyurethane based polymers, surfactants, epoxy resins, foundry chemicals, and intermediates for chemical industry. India has the largest area under cashew and stands as the second largest producer of cashew (7lakh MT) in the world. India has a comparative advantage in the production and processing of cashew nuts on account of its skilled labor force. India is the largest processor and exporter of cashew in the world. Maharashtra ranks first in the production 28.78 % of the country. Cashew nut shell liquid (CNSL) is a by-product from cashew nut processing. CNSL is a dark brown viscous liquid present inside a soft honey comb structure of the cashew nut shell. It contains phenolic compounds, mainly cardanol. Cardanol is a monohydroxyl phenol with a long carbon chain in the met position. It has the potential as a substitute for phenol in resin phenolic-based chemical products.

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