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A Preliminary Study on Processing of Cashew-nuts and Production of Cashew-nut Shell Liquid (CNSL) on a Commercial Scale in Sri Lanka

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Abstract : At present processing of cashew-nuts in Sri Lanka is done at a cottage level using traditional methods. The quality of the kernels so produced shows considerable variations in degree of "completeness" and colour. Further, the liquid present in the cashew shells which consists of phenols and known commercially as a versatile industrial raw material, is not recovered. Production of cashew-nuts in Sri Lanka is expected to show a five-fold increase within the next few years. Therefore, a study has been undertaken to investigate processing of cashew-nuts and production of cashew-nut shell liquid on a commercial scale in Sri Lanka. It has been established that using the "hot-oil-bath" method, cashew-nuts can be processed satisfactorily and cashew-nut shell liquid can be recovered efficiently with 185°C to 190°C as the temperature of processing. The time of processing can be either 1½ minutes or 4 minutes.

1. Introduction

The cashew-nut is 2 to 4 cm long and kidney shaped. The shell of the nut is about 0.3 cm thick, having a soft leathery outer skin and a thin hard inner skin. Between these skins is a soft honeycomb structure containing a viscous reddish-brown liquid known as Cashew-Nut Shell Liquid (CNSL). It is a phenolic material having an irritating action on the human skin and gives natural protection against insects for the white cashew kernel. The shell forms about 60% to 70% of the raw cashew-nut and CNSL is present to the extent of about 25% to 30% in the shell. CNSL is a versatile industrial raw material with a wide range of useful commercial applications.

At present, Sri Lanka produces about 100 tons of cashew-nuts. This production is expected to show a five-fold increase within the next few years. Hence it is of extreme importance to initiate studies on the processing of nuts and production of CNSL on a commercial scale. In this paper we report results of a laboratory scale investigation on the commercial processing of cashew-nuts.

2. Processing of Cashew-Nuts

2.1. Present Method of Processing of Cashew-Nuts in Sri Lanka.

In Sri Lanka, the extraction of the kernel from the shell of the cashew-nut is a manual operation. The sun-dried or roasted nuts are cracked with a small hammer to split the shell along the natural line of cleavage. The kernel is then carefully removed and slightly roasted to remove the testa and also to improve the taste. All these operations are carried out traditionally by the women-folk.

This method, although satisfactory at the cottage level, cannot be applied to produce cashew kernels on a commercial basis. The quality of the kernels in respect of the degree of "completeness" and colour shows considerable variations. Also, when the nuts are roasted to make the shell brittle, CNSL is partly destroyed and the remaining liquid undergoes certain chemical changes (polymerization).

2.2. The "Hot-Oil-Bath" Method

The "hot-oil-bath" method is the most common commercial way of processing the nuts and extracting CNSL partially. Here the raw nuts are roasted in a bath of CNSL maintained at 185°C to 190°C, the time of contact of the nuts with the liquid being a few minutes. The shell of the nut gets brittle due to partial release of CNSL into the liquid bath. The temperature of the bath should be maintained at 185°C to 190°C. If it is below this range, the process tends to be inefficient and at higher temperatures considerable damage to the liquid and to the kernel takes place. The nuts so processed are wiped off of any CNSL adhering to the surface using sawdust or ashes and then cracked using a small hammer to extract the kernel. The quality of the kernels depends much on observing the proper temperature of the CNSL bath (185°C to 190°C), optimum time of contact of the nuts with the liquid and on the skill of labour cracking the nuts.

3. An Experimental Study of the "Hot-Oil-Bath" Method

3.1. Experimental Procedure

Experiments on the "hot-oil-bath" method were carried out using facilities available on the cashew plantation of the Cashew Corporation at Kondachchi in the Mannar District. Processing of the raw nuts was affected by dipping the nuts placed in a wire basket in a hot CNSL bath. The CNSL bath consists of a mild steel rectangular tank, which is heated using firewood. The liquid was stirred well during the operation to ensure uniform heating and the temperature was recorded by means of a thermometer immersing deep into the liquid through an opening on a side-wall of the tank. The heating was so manipulated to maintain the temperature of the bath between 185°C to 190°C. The time of retention of the nuts in the liquid was varied between

1½ minutes and 9 minutes. After each operation, the CNSL adhering to the basket and the nuts was allowed to drain off into the main bath and then the nuts were tumbled in ash to absorb the remaining liquid coating the outside of the shell. The nuts were then cracked with a small hammer to extract the kernel.

3.2. Extraction of the residual CNSL

During processing of the nuts in the "hot-oil-bath" a portion of CNSL is released into the liquid bath. To extract the residual CNSL in the shells, after the kernel has been removed from the processed nuts, the shells were subjected to a mechanical extraction process. A hand operated screw-type expeller available at the Ceylon Institute of Scientific and Industrial Research was used for this purpose. CNSL thus obtained was filtered through a filter cloth to remove any solid matter and the shell-residue was extracted with n-hexane to recover any residual liquid. The CNSL content of the shells of the nuts processed at different retention times in the hot-oil-bath was calculated and these CNSL samples were analysed, according to the Indian Standards Specification for CNSL ; IS : 840—1964. CNSL content of the raw (unprocessed) nuts was also determined, thus the amount of liquid extracted during processing of the raw nuts could be calculated. The cashew kernels from the nuts processed for different time intervals were examined for physical appearance and taste.

3.3. Changes in the properties of CNSL on prolonged heating at 185°C to 190°C

It is well known that CNSL when heated to high temperatures undergoes certain chemical changes, for example, polymerization. During the processing of cashew-nuts in the hot-oil-bath, CNSL in the bath as well as the liquid that gets continuously extracted into the bath are subjected to prolonged heating at 185°C to 190°C. For the process to be economically feasible, the quality of CNSL in the bath should not deteriorate below the accepted standard specifications, for otherwise it will not be possible to market the liquid. Therefore proper consideration must be given to any changes undergone by CNSL in the oil-bath during processing and a study was undertaken to follow the changes in physical properties of a sample of CNSL on prolonged heating at 185°C to 190°C. The sample was heated for three days, for a period of six hours a day and the viscosity, iodine value and specific gravity were determined after each day of heating.

3.4. Results and observations

The results and observations of the experiments to process raw cashew-nuts in a hot bath of CNSL are tabulated in Table 1.

TABLE 1. Properties of the CNSL and Cashew Kernel Obtained by Different Extraction Procedures

Sample	% CNSL content of the shells			Fraction of CNSL extracted during hot-oil-bath process %	Iodine value of CNSL (Catalytic method)	Specific gravity of CNSL 30°C	Viscosity of CNSL in CP at 30°C	Physical appearance and taste of the kernel
	Extracted on expelling %	Extracted on solvent extraction of the residue after expelling %	Total CNSL %					
Raw nuts	23.5	1.5	25	—	423.0	0.9495	93.49	White/acrid taste
Processed at 185°C to 190°C for 1½ minutes	20.0	3.0	23	8	418.0	0.9500	105.63	White/acrid taste
Processed at 185°C to 190°C for 3 minutes	10	12	22	12	416.4	0.9542	114.51	White/bland taste with a slight acrid taste
Processed at 185°C to 190°C for 4 minutes	5	10	15	40	416.5	0.9520	120.20	White/pleasant bland taste
Processed at 185°C to 190°C for 6 minutes	1	11	12	52	420.65	0.9534	134.32	Pale brown/slight roasted taste
Processed at 185°C to 190°C for 9 minutes	0	10	10	60	420.7	0.9554	158.82	Scorched/over roasted taste
CNSL from the processing bath	—	—	—	—	381.3	0.9664	809.3	—

Table 2 contains the results of an experiment to study the variations in the physical properties of a sample of CNSL on prolonged heating at 185°C to 190°C.

TABLE 2. Changes in the Physical Properties of a Sample of CNSL on Prolonged Heating at 185°C to 190°C

No. of hours at 185°C to 190°C	Iodine value	Specific gravity at 30°C	Viscosity in CP at 30°C
0	392.5	0.9656	180.8
6	378.4	0.9636	229.5
12	375.3	0.9670	397.1
18	380.1	0.9734	681.6

4. Discussion

It is evident from the results that CNSL from the shells of the nuts processed for different intervals of time all satisfy the Indian Standard Specifications in respect of iodine value (375), specific gravity (0.950 to 0.970 at 30°C) and viscosity (550 CP, max.). Optimum colour and taste of the kernel can be achieved by processing for 3 to 4 minutes at 185°C to 190°C. When the nuts are processed for 3 minutes about 12% of the total CNSL gets extracted and when the processing time is 4 minutes about 40% goes into the extraction bath.

After 3 minutes extraction in the hot-oil-bath, a further 45% of CNSL can be extracted by subjecting the shells after decortication to mechanical expelling. The solvent extraction process to recover the residual liquid is too expensive and is commercially not viable. This means that only about 57% of the total CNSL is extractable by combining the hot-oil-bath extraction with subsequent expelling of the decorticated shells. Similarly, about 73% of the total CNSL can be extracted when the raw nuts are processed for 4 minutes in the hot-oil-bath followed by expelling the shells. From the nuts that are processed for only 1½ minutes, about 80% of the liquid can be extracted alone on expelling the shells. But the taste of kernels thus obtained is unsatisfactory. The acrid taste can however be easily eliminated by a post-roasting operation.

The results of the experiments outlined so far show that for optimum recovery of CNSL and for good quality kernels, the following processing times and temperatures are feasible :

(*a*) at 185°C to 190°C for 1½ minutes followed by roasting the extracted kernels for a short period of time to improve the taste,

(*b*) at 185°C to 190°C for 4 minutes.

In the case of (*b*) of the 73% commercially extractable CNSL (not taking into consideration the amount of solvent extracted CNSL) about 64% gets extracted in the hot-oil-bath.

It can be seen from Table 2 that when a sample of CNSL is heated for 18 hours at 185°C to 190°C the values for viscosity and the specific gravity fail to satisfy the Indian Standard Specification for CNSL. In this study, heating was not done continuously for 18 hours but for periods of 6 hours a day for three days, a more realistic condition in the commercial operation of the process.

This study indicates that the quality of CNSL in the processing bath after three days (assuming a daily extraction period of six hours) will be below the accepted specifications. Therefore if the liquid in the processing bath is used for three days or more, then it will not be possible to market the CNSL as good quality oil. Since the economy of the process depends both on the quality of the cashew kernels and on the quality of CNSL produced it will be important to replace the liquid in the bath with fresh liquid after two days of operation. After twelve hours at 185°C to 190°C, which is equivalent to two days of commercial processing with an extraction period of six hours a day, the quality of the liquid satisfies the Indian Standard Specifications. Analysis of a sample of CNSL from the processing oil-bath at Kondachchi gave a very high value for viscosity (Table 1) indicating that the liquid has been used for a long period of time.

4.1. A comparison between extraction of the raw nuts for 1½ minutes and for 4 minutes

From Table 1 it is seen that when the nuts are processed for 1½ minutes at 185°C to 190°C, the amount of CNSL expelled into the oil-bath is about 8% and when they are processed for 4 minutes 40% of the total available CNSL is extracted. Also, while 80% of the liquid can be extracted by expelling the shells after the hot-oil-bath extraction for 1½ minutes, only about 20% can be extracted the same way from the shells after a 4 minutes extraction in the oil-bath. Thus renewal of CNSL in the oil-bath after two continuous days processing will be an essential requirement in the 4 minute process. This means for successful operation of the plant on every third day of operation there should be a fresh supply of CNSL from the expeller process which is at least enough to fill the processing bath upto the minimum operational level.

If the raw nuts are to be processed only for 1½ minutes, then since a major portion (80%) of CNSL can be recovered by the expeller process, renewal of the liquid after 2 days of operation will not pose any problems. Even if the bath liquid is not replaced and is used for a longer period of time (much more than two days) it will not be economically very critical because of the 80% good quality CNSL recoverable from the expeller process.

5. Conclusion

A laboratory scale study has been done on the processing of cashew-nuts and production of cashew-nut shell liquid on a commercial basis. It has been established that the raw nuts can be processed in a hot bath of CNSL either (*a*) at 185°C to 190°C for 1½ minutes followed by roasting of the kernels extracted to improve the flavour, or (*b*) at 185°C to 190°C for 4 minutes, no further treatment of the kernels being necessary.

In the case of (*a*) about 80% of the total CNSL can be extracted by expelling the shells of the processed nuts and in the case of (*b*) about 40% of CNSL being extracted into the hot-oil-bath during the processing of the nuts. Renewal of the liquid in the processing bath every three days is to be affected, this being essential if the nuts are to be processed for 4 minutes.

Which of the conditions of operation outlined above is suitable will depend on the cost of further processing of the kernels after the hot-oil-bath treatment in the case of 1½ minutes extraction and heating the CNSL bath for an extra 2½ minutes in the case of the 4 minutes extraction. This cost comparison study has to be done at least on a pilot plant scale.

For the domestic market the traditional processing methods adopted by small holders to extract the cashew kernels appear to be satisfactory. The cashew-nut shells from sun-dried and decorticated nuts can be expelled using a screw type expeller to yield good quality CNSL (Table 3). The present availabllity of CNSL assuming that all the shells from the processed nuts could be collected and expelled is about 125,000 kg of the liquid. Central processing factories will be an essential feature of the Cashew Industry in Sri Lanka in the very near future when the cashew cultivation of about 25,000 acres on a plantation basis goes into full production. A situation where the cashew-nuts produced by the small holders will be for local consumption and that produced on state or private plantations for export market can well be anticipated. Cashew-nut shells from the smallholders as well as from the plantations could be subjected to central processing (expelling) to obtain CNSL which can partly be used locally and partly exported. At present, export prospects for cashew kernels and CNSL are promising.

TABLE 3. Analysis of a Sample of CNSL obtained by Expelling shells from Sun-Dried and Decorticated Cashew-Nuts

Property	Sample	Specification
(1) Specific gravity at 25°C	0.9650	0.950 — 0.965
(2) Viscosity at 25°C	1.60	1.5 — 3.5
(3) Volatile loss at 105°C	0.21	1% max.
(4) Iodine value at 25°C	307.4	250 min.
(5) Ash%	1.50	1% max.
(6) Distillation test (3.00 mm/Hg)		
Initial pt. (0°C)	135.0	190°C min.
Distillate below 205°C	2.7	3.0% max.
Total distillate	75.0	60.0% max.

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