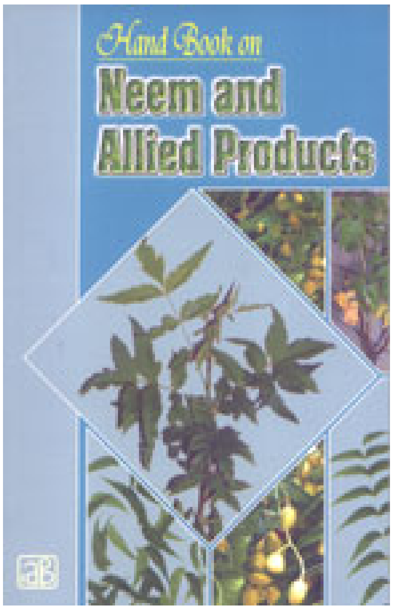
Entrepreneur India

106-E, Kamla Nagar, New Delhi-110007, India.
Tel: 91-11-23843955, 23845654, 23845886, +918800733955,
Mobile: +91-9811043595.
Email: npcs.ei@gmail.com ,info@entrepreneurindia.co

Website: www.entrepreneurIndia.co

Handbook on Neem & Allied Products



Code:	ENI49
Format:	Paperback
Indian Price:	975
US Price:	26
Pages:	478
ISBN:	8178330415
Publisher:	Asia Pacific Business Press Inc.

Nature has blessed man with a number of wonders. Of all, plants are found to be its best boon. Among them, neem is distinguished by their astonishing versatility. Neem is such a fascinating tree that no other tree probably has provided wide range of benefits to mankind. Neem tree and its products have been reputed since long for some physiological activity and have been used quite extensively as a household remedy, since time immemorial, for the treatment of some of the common ailments. The Neem tree, which is also known as Margosa or Indian lilac is grown extensively in Asian and African countries. The neem is very useful tree due to its medicinal and insecticidal properties. Neem oil is the major product of neem seed industry. The chief limitation of the oil is its odour due to the presence of odouriferous substances and other non saponifiable components. Amongst the non edible oilseeds the potential availability of neem is by far the largest because of its very extensive growth throughout the country and fairly good yield of oils from the seeds. Neem seed cake is the major by product of neem seed oil. Various parts of the neem tree have been used as traditional Ayurvedic medicine in India. Almost every product of this invaluable tree has been largely employed for medical purposes. Neem works as blood purifier. Consuming raw neem leaves or neem leaf powder helps in eradicating toxins from the blood. This is one of the greatest benefits of neem tree. Azadirachtinus in the neem products have been found to act as repellents, antifeedants, affect food consumption and utilization and interfere with the growth regulation and ovarian development in insects. Neem manufacturing products are in high demand and several manufacturing companies are readily in business trying to satisfy their natural product consuming and environment sensitive market. Along with a good natural resource management program, Neem can be an income generator and a sustainable medicinal alternative in developing countries.

Some of the fundamentals of the book are technology for production of insecticides of plant origin at rural level, neem seed cake as a source of pests control chemicals, neem oil as possible biorational insecticide, chemistry of neem (azadirachta indica), a sustainable source of natural pesticides, machineries for neem processing, engineering properties of neem nut, neem and transfer of technology, processing of neem fruit and seed, processing of neem oil and its utilization, uses of neem is indigenous system of medicine, cold processing of neem seed, products from neem, development of a neem formulation and its evaluation for control of crop pests, evaluation of nematicidal potential in neem, etc.

The book covers cultivation of neem and processing of its products. It will be of immense value to all concerned with manufacturing of neem products; consultants Institutions or those who want to diversify in to production of neem based products.

Content:

Sample Chapter:

Processing of Neem Fruit and Seed

Although India is proverbially rich in oilseed resources, the *per capita* consumption of fat in diet in this country is far below the required nutritional level. The reason may be ascribed to the non-availability of pure fats at reasonable price for consumption as food. Paradoxically enough, a large proportion of edible fats, particularly of groundnut and coconut, is used for soap making and other non-edible purposes. This is all the more astounding in view of the fact that non-edible oil resources rich in component acids primarily useful for good soap and allied industrial products are in plenty throughout the country. A number of so-called non-edible oils and fats if properly processed and refined are deemed superior to groundnut oil in a soapstock and some of them rich in lauric and myristic acids can advantageously replace coconut fat in soap industry and would substantially add to the lathering and detergent properties of the finished products. The resources of non-edible oilseeds have not hitherto been tapped properly on an economic and scientic background because of certain inherent difficulties peculiar to these raw materials, mainly, (i) disorganised and sometimes wild and scattered growth of these plants and consequent difficulties in the collection of the seeds, and (ii) the fats obtained are malodorous, of bitter acrid taste and dark colour and unless properly purified and refined, they would impart bad odour, colour and rancidity in the soap. Nevertheless, during the last decade due consideration is being given to the problem of utilisation of non-edible fats for soap industry. During the First Five-Year Plan period, the Cottage Industry Panel of the Planning Commission formulated a scheme for production of neem oil and its use in cottage soap industry. Eventually the Khadi and Village Industries Commission organised a Non-edible Oil and Soap Industry section and execution of the programme has since been undertaken in right earnest.

The Indian Central Oilseeds Committee, while considering â€˜the increased production of oilseeds in India during the Second Five-Year Planâ€™, recognised the importance of developing the non-edible minor forest oilseeds and their utilization in industry. It, therefore, recommended that due attention should be paid to the possibility of increasing the utilization of minor oilseeds of forest origin. Estimates should also be made as to the extent they are being utilized at present, together with their potential sustained yield. The possibility of economic collection of these seeds should also be kept in view in the estimates to be made. In the opinion of the Committee the first thing to be done is to organise an economic collection of the seeds through village co-operatives at the appropriate centres. As the seeds now passed through various middlemen, inflating the cost, it was necessary to eliminate them with a view to making the collection economic. The price of oils extracted from such non-edible oilseeds should be appreciable lower than those of edible oils.

The problem is a complicated one involving several aspects which have to be properly co-ordinated before tangible results could be achieved. The various aspects involved are:

1. Analytical and characterisation work in the laboratory to determine the physical and chemical properties of the oil, the composition of the seeds and the oils, etc.
2. Processing and utilization of the seeds and the oils on a laboratory scale.
3. Similar experiments on a pilot plant scale.
4. Similar trials on a commercial scale.
5. Collection of the seeds and their immediate processing as to prevent their deterioration and thereby of the oil.
6. Conservation and propagation of the oilseeds-bearing plants and trees.
7. Dissemination of available information.

It has been indicated that a very intimate and active collaboration and co-operation among the various angencies are essential to achieve a rapid development and utilization of the non-edible oil resources in the country. These agencies are the agricultural and forest department of the various States, technological and research laboratories, small and large-scale industries utilising the oils, soap factories, etc. Although sporadic attempts are being made with regard to the collection of certain oilseeds such as neem, mahua, etc. and utilization of their oils, no sustained efforts have been maintained owing to the lack of an organisation comprehensive and powerful enough to bring all the various agencies together an co-ordinate their activities. The Indian Central Oilseeds Committee is in a position to assume this task.

It is the considered opinion of the Committee that a good deal of research work has been done on a number of non-edible oils, but further work on a large scale should be undertaken. Systematic pilot plant trials should be conducted at one or more research institutes on every aspect of processing the seeds and the oils extracted thereform. Such work should include depulping, decorticating, milling, pressing, solvent extraction, fat splitting, distillation of fatty acids, refining and finally prepration of products such as soaps, fatty acids, lubricants, varnishes and surface active agents.

Availability of neem

Amongst the non-edible oilseeds the potential availability of neem is by far the largest because of its very extensive growth throughout the country and fairly good yield of oils from the seeds. The results of a recent economic survey of non-edible oilseeds published by the Indian Central Oilseeds Committee show a consolidated all-India estimate of 417, 764 tons (1,12,79,650 mds.) of neem seeds. This estimate, however, does not appear to include the produce from some of the areas having extensive growth of neem trees, such as Delhi, parts of Central India, Orissa, etc. It is interesting to note that mahua *(Madhuca indica)* is second in availability but its potential availability is only about 50 per cent of that of neem.

It is reported that at the time when these surveys had been conducted, their economic importance had not been so much known and understood as at present. Hence, the need for a thorough survey to correctly assess the total potentialities as well as those that can be tapped should no longer be delayed.

Again, it has been found that population of neem trees is fairly concentrated in the northern and central India and to some extent in the South. In a very recent survey, the population of neem trees in Uttar Pradesh alone was estimated at 7.5 millions. It has thus been worked out that U.P. can produce 65,000 tons of neem oil. On an all-India basis, the potential production of neem oil would be of the order of 85,000 to 90,000 tons equivalent to about 10 crores of rupees, and which, when properly utilized, could satisfactorily replace groundnut and other edible oils now being used for soap manufacture.

The following Table 15 shows the population of neem trees in the different States as assessed under a scheme of economic survey of the oilseed bearing trees and plants, sponsored by the Indian Central Oilseeds Committee.

This estimate of 14 million trees does not, however, include the figures for Assam, Andhra, Bihar, Delhi, Orissa, Rajasthan, Punjab and Kerala.

Table 1.

State	Period of survey	Number of neem trees
Bombay	1953-54	11,70,000
Bhopal	1952-54	32,000
Hyderabad	1954-56	2,30,500
Madhya Bharat	1953-56	4,431,000
Mysore	1954	1,74,000
Saurashtra	1956-57	2,03,300
Vindhya Pradesh	1953-54	2,51,200
West Bengal	1956-57	2,65,000

Madras	1949-50	34,00,000
Uttar Pradesh	1957-58	75,00,000
Total	1,36,	57,000

A total all-India figure of 25 million neem trees in the country may not be a very liberal guess.

Collection and processing of fruit and seed

The neem seeds are collected during April-July in the rains and are sundried and stored till October-December or even later, when they are decorticated and kernel pressed in the *ghani** (Plate 10). The main difficulties at present in harnessing such plentiful resources of oil are: *(i)* the harvest of the neem fruits is obtained within a very short time in the beginning of the rainy season or even after the monsoon sets in; *(ii)* the seed obtained contains a lot of moisture and deteriorates quickly during storage; and *(iii)* the oil possesses an offensive odour and bitter taste. The seed, while in storage, often gets so much charred on account of the heat produced by auto-oxidation than no oil can be produced out of it. To obviate these difficulties encountered in the successful utilization of this important raw material, both extensive and intensive investigations have been carried out with the different aspects of the problem, *(i)* to find out proper method of teatment of the fruit to produce good dry seed which can be stored throughout the year; *(ii)* to work out best method of pressing the seeds for oil; and *(iii)* to process the oil to remove the undesirable properties inherent in this oil.

Generally, the field officers of the Commissionâ€TMs Non-edible Oil and Soap Industry section look after the collection of the seeds, etc. and put in efforts to solve the associated problems as enumerated above. A good deal of research work has been carried out at the J.B. Central Research Institute for Village Industries, Wardha, on the problem of processing of seeds, depulping, decortication, pressing of oil in *ghanis,* etc. Similar work on the processing of the seeds after the age-old conventional methods is being carried out at the various places where collection of neem seeds is sporadically organised by individuals or groups, sometimes with guidance from the State Departments of Agriculture or of Cottage and Village Industries. No mean achievement is reported from these disorganised centres in regard to the improvements in the methods of processing the seeds and their pressing *vis-a-vis* development of hand-operated contrivances and appliances.

The following description and discussion of the problem of neem seed collection and its processing are primarily based on the experiences recorded by the Khadi Commission field officers working on the project, during the last couple of years. Prior to that no systematic approach appears to have been made in tackling the problem of organized collection and processing with the ultimate objective of producing good quality oil in economically workable yields.

Deterioration of neem seeds when stocked without proper drying is a well-known fact to the workers dealing with the collection and processing of this seeds. It is, therefore, absolutely necessary to keep vigilance over the whole process, right from the initial stage of collection of the fruits in the villages.

According to Hervatte, there are places where it is possible to impress upon the local seed collectors the importance and the economic advantage in depulping the seed and then bringing depulped and dried seed to the collection centre. But at a majority of places, it is quite impossible to convince them and the centre has necessarily to purchase fresh neem fruit from the villagers, thus undertaking the entire work of processing the seed before storage. The neem fruits received at various collection centres, can be, according to him, roughly divided into following four categories.

A. Dried fruit.

B. Semi-dried fruit.

C. Fresh fruit (undried).

D. Wet and/or damaged fruit.

Each lot of fruits arriving at a rural collection centre is kept separately and mixed with another similar lot classified on the basis of above categories. Four broad types of fruit lots are thus obtained for the purpose of tackling the problem of initial dumping, temporary storage of preprocessed fruits, depulping, drying and final storage of seeds.

Initial dumping is usually made in heaps. These heaps should be mechanically agitated and raked at intervals so as to avoid stagnation and to help in dissipation of heat produced by fermentation of the carbohydrates present in the pulp and flesh above the seed coat, as well as respiration of the seed. The heaps should be comparatively smaller in height and frequency of the agitation should be more when the fruits contain larger amount of moisture. The thickness of the layer of the heap decides the degree of accumulation of heat and retention of moisture; both the factors go hand in hand to set in deterioration of the fruit. The C and D types of lots should never be stocked in big pyramidal heaps for more than one day. The A type fruits can be dumped in big heaps as also in tall bins temporarily made out of bamboo matting about 4â€TM in diameter. Such bins provide good ventilation and can, in fact, be used for storage of any dried fruit or seed in the absence of storage bags.

The agitation of the initial dumps is normally done by big fork-shaped agitators (used in agricultural operations) but a better and time-saving method would be to have three heaps in 3 quadrants of a storage area leaving the fourth quadrant vacant, as shown in the following figure:

Every day or as and when necessary, one of the heaps is shifted to the vacant space, the circulation always being done either clockwise or anticlockwise from one quadrant to the other. The shifting shuffles the heap completely upside down and incidentally provides the necessary aeration to it. Much less time is required in this operation which can be more effectively carried out if the heaps are on mattings instead of on the floor. Transfer from one mat to the other can be done simply by tilting the mat. As already mentioned, agitations or shiftings are more frequently required in the case of wet fruits than that of the semi-dried ones.

The fresh wet fruits would take the longest time for drying and it would be unwise to dry the fruit in wet and/or in damaged condition where the deterioration had already started and would proceed with accelerated rate even during drying. The prudent course would be, therefore, to depulp the fruit and then dry it.

In the case of semi-dried undamaged fruits, steps should be taken to dry them completely as quickly as possible either in bright sunshine or in a suitably devised drier. The completely dried whole fruits can be decorticated later and Kernels obtained for pressing.

As has already been stated, depulping, drying and decortication of the fruit or seed is of basic importance for large-scale production on neem oil of good quality. Recently, due attention was being given to these aspects of processing of neem seeds, and work has been carried out on the technological development of mechanical devices.

The work was undertaken primarily with a view to *(a)* designing and fabricating the necessary contraptions for processing the neem seed and practical trials thereon as well as *(b)* to arrive at a tentative layout of an economically workable neem seed processing unit.

Processing of neem fruit has hitherto been carried out in a rather crude and unscientific manner. In certain places where there is plenty of rain and infrequent sunshine during the neem fruit season, the fruit is collected and subjected to the following processing:

(i) depulping and washing of the fruits:

(ii) drying of the wet depulped seeds; and

(iii) decortication of the dried seed.

Depulpers, driers and decorticators

The depulping process involves the operations of soaking, depulping and washing.

For carrying out the soaking operation, cement concrete tanks of different sizes and capacities (14â€™ X 8â€™ X6â€™, 3â€˜ X 3â€™ X 3â€™, 5â€™ X 4â€™ X 6â€™) were constructed. The fruits were soaked with water in the tanks till the outer pulp got decomposed and became easily detachable. It took about 4 to 5 days depending upon the condition of the fruits and their moisture content.

The fruits were then transferred to the depulper. Two sizes of depulpers have been fabricated: a small hand-operated machine for treating about 40 kg. of fruits at a time. Both the machines are similar in design and essentially consist of a cylindrical steel drum with a central revolving shaft carrying blades, baffles being fitted on the wall of the drum.

The cost of the small-size machine worker out to about Rs. 4000//-.

In the washing machine which consists of a shaking sieve fitted in an inclined plane with a number of jets spraying water over it, the material from the depulper is charged at the higher end of the sieve and slides down as the sieve shakes and sprays of water play upon it. They pulpy matter is washed away with the water falling through the sieve while the depulped seed collect below the lower end of the sieve. The cost of the machine is estimated at about Rs. 700/-.

For the purpose of bringing down the moisture content of washed seeds below the critical level in the shortest possible time, merely sun drying is often inadequate and suitable types of driers are essential.

Driers

Three types of driers were designed and fabricated.

Tray driers. Two types of tray driers were designed. One type consists of a rectangular brickwork chamber (about 4â€™3" Ã- 3â€™6" Ã- 6â€™6") with a furnace by its side. The flue gases from the furnace pass through the chamber from top towards the bottom and finally pass through the chimney. Eight trays, each 3â€™6" X 3â€™6" X 2Â½â€, with perforated bottoms are placed inside the chamber, one above the other with 8â€ spacing, being supported on angle irons fitted inside the chamber. Each tray leaves about 9â€ of space on one side of the wall, each alternate tray leaving such space in alternate side so that the hot flue gases have to pass through the chamber in a zig-zag manner until it leaves the chamber at the bottom. Each tray has a capacity of about 20-30 kg. of the fruit or seed. The fruit or seed to be dried is placed in trays which are then placed inside the chamber. After charging all the trays, the door of the chamber is closed and the hot flue gases from the furnace are allowed to pass through the chamber. Several trials on the drier showed that full charge weighing about 150-250 kg. of fruit of seed takes about 12 hours to dry consuming about 150-200 kg. Steam coal depending upon the moisture content. The estimated cost of the drier including the furnace worked out to be about Rs. 900/-.

The second type of tray drier designed is similar to the above, but it provides for hot air instead of hot flue gas being used for drying. Hot air is obtained by blowing air through a closed coil placed inside the flue of the furnace and is passed through the chamber containing the fruit or seed in trays. The hot air enters the chamber at the bottom and leaves it at the top. A few trials conducted on this drier showed that the drying period is much longer, *viz.* about 18-20 hours more than in the previous drier. In view of the higher initial cost and also higher processing cost due to power required for running the blower for longer period of drying, this type of drying was not considered feasible.

The estimated cost of the drier including the furnace and blower, etc. is about Rs. 1,500/-.

A thrid type of drier, a small hand-driven rotary drier, was also fabricated. It consists of a revolving drum surrounded by a jacket of hot flue gases coming from a furnace situated on one side of the drier. The drier is hand-operated and takes a charge of about 40 kg. at a time. A few trials conducted on this drier showed that one change takes time of about 16 hours to dry, consuming about 150 kg. Of steam coal. the cost of the drier worked out to about Rs. 425/-. It was not found economical.

Decorticators

Only the kernel of the neem seed is the seat of the fixed fat. It is, therefore, unnecessary to crush the whole

fruit or seed to press out the oil. Apart from the extra load being put on the crushing machine (or *ghani*), the pressing of the whole fruit or seed is liable to yield a poorer quality of oil due to extrinsic impurities being carried from the seed and/or the fruit coat and also the yield of oil is less due to some of it being absorbed by the shell and/or pulp. Decortication, therefore, is a necessary operation in the processing of neem fruit.
The following two types of decorticators had been designed and fabricated at the Technological Institute:
Hand chakki. It is just an ordinary *chakki,* consisting of two circular discs one over the other. For this work, the lower disc was made of stone and the upper one was made of wood. The surfaces of the two discs facing each other were corrugated. To find out the optimum weight per square inch of the upper disc most suitable for decortication, the weight of the upper wooden disc was varied by fixing on its top iron plates of known weight. The *chakki* was tried for decortication of neem fruit as well as neem seed. In the case of neem fruit, it was not found satisfactory as the fruit, when passed through it, gets flattened but does not get broken. It was found to be quite satisfactory for neem seed. Its output is rather low, but it can be utilised with advantage for spare time working in villages.
A typical chakki of 15â€ diameter was worked on with a sample of seed (moisture, 6.5 per cent; kernel, 43.7 per cent) and it was found that with the increasing weight of the upper disc (0.11 to 0.16 lb. p. s. i.), decortication (percentage) increases from 83.0 to 100; but with this increment, however, the percentage of broken kernel increases from 3 to 24 and loss of kernel form 8.5 to 10.7 per cent. The optimum weight of disc is about 0.12 to 0.13 lb. p.s.i. The capacity of the chakki is about 15 to 20 lb. of seed per hour.
A *chakki* from 23â€ to 30â€ diameter can be easily run by one man and its capacity may be about double that of the above chakki, i.e*.,* about 30-40 lb. of seed per hour.
Decorticators consisting of one pair of rollers.These essentially consist of two cast iron rollers mounted side by side on a cast iron stand and moving in opposite directions by means of suitable gear arrangement and with arrangement either for mechanical drive or hand working. There is a feed hopper on top of the rollers with a slide plate for regulating the feed. The fruit or seed coming between the rollers gets broken due to the pressure of the rollers. The gap between the two rollers can be adjusted according to the size of the fruit or seed to be decorticated.
(a) Decorticator having plain rollers.As a result of trials carried out on a decorticator having plain rollers, it was not found satisfactory, evidently due to the lack of sufficient grip and want of cutting action in the rollers.
(b) Decorticators having grooved rollers. Following three types of decorticators have been designed and fabricated:
(1) Decorticator having rollers with longitudinal groovers.
(2) Decorticator having rollers with slanting groovers.
(3) Decorticator having rollers with circular grooves.
The grooves in cased had rounded bottoms. The dimensions of the grooves were as follows:

	Longitudinal	Slanting groovers at 10o	Circular
Depth (inches)....	1/16	1/16	1/16
Width (inches)...	1/8	1/8	1/8
Distance between two adjacent grooves (inches)...	1/8	1/4	1/16

A large number of trials were undertaken on each of the above types of decorticators. Experiments were carried out with varying gaps between the rollers. In the case of power-operation, experiments were performed only with neem fruit and with varying gaps and at different speeds of rollers. The neem fruit and seed used in the experiments were first separated into different sizes and experiments were then performed with a more or less uniform size of fruit or seed. The fruit was separated into two sizes, one which was retained on a sieve having three mesh per linear inch (+3) the other which passed through the above sieve but was retained and by a sieve having 4 mesh per linear inch (â€"3, +4). The seed was separated into three different sizes, one which was retained on a sieve having three mesh per linear inch (+3), another which passed through the above sieve but was retained on a sieve having four mesh per linear inch (â€"3, +4) and a third one which passed through the sieve having four mesh per linear inch (â€"4). Although in actual practice it may not be feasible to carry out such a size separation before decortication, yet it was considered necessary for the investigations in hand so as to get comparable results. In the case of experiments carried out with hand-operated decorticators, one kg. of fruit or seed was used for each experiment. In the case of power-driven decorticators, 10 kg. of fruit was used for each experiment. Each experiment was carried out with gap between the rollers varying from 1/16 to 3/16â€; with each variation of seed size 5 experiments were carried out with progressive increase in the gap between the rollers. The results with the decorticators conditioned by the factors discussed above are summarised in Table 16.

The loss of kernel shown in the last column of the foregoing Table is theoretical percentage of kernel in the fruit seed takenâ€"(percentage of kernel obtained + theoretical percentage of kernel left in the undecorticated fruit or seed). The separation of kernel from the husk and undecorticated seed after decortication has been effected by hand winnowing and the loss of kernel shown, therefore, represents small pieces of broken kernel which have escaped with the husk.

Cottonseed decorticator used for neem seeds. It essentially consists of a rotating barrel or cylinder carrying knives on its periphery and a concave or 'breast' which holds the stationary knives. The position of the cylinder in relation to the concave is adjustable. There is a feed hopper fitted with a feed roll and adjustable feed gate to ensure a regular feeds. The seed falling on the rotating barrel is caught between the rotating and the stationary knives and both the husk and the kernel are carried round to the lower and of the â€˜breastâ€TM end dropped out of the machine.

Experiments were also conducted to study the efficiency of the cottonseed decorticator (power-driven; speed, 340 r.p.m.) for decortication of neem fruit. Ten mds. of fruits were used in each experiment. While decortication achieved was from 80 to 100 per cent, broken kernel and loss in kernel were 25 to 65.6 and 5.3 to 7.7 per cent respectively, with the variation of the gap between revolving and stationary knives being 3/16â€ to 5/16â€.

Discussion of Results

Decorticators with one pair of rollers having grooved surfaces. There can be three criteria for judging the performance of a decorticator, *viz., (i)* percentage decortication effected, *(ii)* decortication without undue breakage of kernel, and *(iii)* loss of kernel during decortication. As regards percentage decortication effected, it is considered that for proper decortication at least 75 per cent decortication should be achieved. As regards breaking on kernel and loss of kernels, these go hand in hand because greater the breakage of kernel, greater is the loss. Therefore, the higher the percentage of whole kernel, the better the decortication. Of course, greater the loss of kernel the more unsatisfactory is the decortication.

It may be observed from Table 16 that as regards hand-operated decorticators, results with neem fruit have been more satisfactory than with neem seed, there being greater losses in the case of the latter. From an over-all consideration, it appears that both circular and longitudinal grooves give more or less similar performance, whereas slanting grooves tend to produce more of broken kernel and hence leat to higher losses in the kernel.

Table 16

Decorticator	Seed Size	Decortications per cent	Broken kernel percent	Loss of kernel percent

		max.	min.	max.	min.	max.	min
(hand-operated) Roller grooves: Longitudinal.	3;-3	98.0	37.0	46.6	7.6	3.7	0.2
		94.8	18.0	61.9	3.2	7.8	T
	3;-3, 4;	98.5	39.0	66.8	3.5	14.7	T
	-4	96.6	6.5	65.9	3.5	11.5	T
		90.0	5.0	49.2	16.0	7.6	T
Salanting.	3;3	100.0	42.2	78.0	3.0	16.3	T
		100.0	20.6	74.0	2.0	15.8	T
	3;-3, 4;	100.0	36.0	74.2	1.9	22.7	T
	-4	100.0	6.4	73.5	0.3	23.5	T
		97.0	2.8	68.0	â€"	15.5	T
Circular. .. .	3;-3	96.3	32.8	6.7.7	â€"	2.5	T
		97.6	6.8	69.4	â€"	5.3	T
	3;-3, 4;	97.3	35.4	50.7	4.6	16.1	0.5
	-4	97.7	8.6	47.5	â€"	10.6	T
		93.7	2.2	56.6	â€"	11.9	T
(Power-operated) Roller grooves;	speed of roller: 150 r.p.m. (with 1/16â€ gap between, rollers, seed is disintegrated)						
Lonitudinal. .. .	3;-3	99.1	52.2	85.5	10.0	5.6	4.4
		98.5	86.2	84.4	16.4	2.3	1.3
Slanting. .. .	,, ,,	98.4	42.8	58.5	4.8	10.1	2.7
		97.0	20.4	58.3	7.0	1.6	1.1
Circular. .. .	,, ,,	99.3	59.9	93.2	26.9	2.7	T
		99.7	25.4	68.1	5.1	1.8	T
speed of roller: 255 r.p.m.							
Longitudinal. .. .	,, ,,	98.1	60.5	45.6	7.8	0.2	T
		81.4	31.4	26.0	1.6	T	T
Slanting. .. .	,, ,,	94.5	16.9	57.0	2.3	0.9	T
		96.2	â€"	60.0	â€"	1.3	T
Circular. .. .	,, ,,	98.3	56.6	54.3	7.8	T	T
		93.9	20.4	37.9	5.7	T	T
Tâ€"Traces.							

As regards power-operated decorticator, from an over-all consideration the circular grooves give the best performance, next in performance being longitudinal grooves, the slanting grooves being least satisfactory. In the case of cicular grooves, the losses in kernel are very low.

Decorticators consisting of a pair of grooved rollers can satisfactorily decorticate dried neem fruit or neem seed.

With circular or logitudinal grooves and hand-operated machine, over 80 per cent of decortication with not more than 2 per cent loss of kernel can be achieved in the case of neem fruit, but in the case of neem seed, although the same degree of decortication can be achieved, the losses in kernel are rather high, sometimes going above 5 per cent.

With circular grooves and power-operated machine, over 85 per cent decortication can be achieved. The losses in kernel are also quite low.

The work carried out indicates the need of further work on the longitudinal and circular grooved rollers by using varying width and depth of grooves and varying distances between adjacent grooves and on mechanical separation of kernel from the husk which in the present series of experiments has been done by hand-winnowing.

The cottonseed decorticator is also suitable for the decortication of neem fruit. Over 80 per cent of decortication is achieved but the losses in kernel tend to be rather high, going above 5 per cent. The machine is costly and complicated and may be suitable only in larger industrial units where high output is needed. Here also the necessity for devising a suitable attachment for carrying out efficiently the mechanical separation of the kernel from the husk simultaneously with decortication, is indicated.

Maturity, storage and pressing of seed

Srivastava report the results of their investigation with neem fruit and state that the neem seeds (or, more correctly, neem berries or fruits) are collected from April to July and then dried and stored. The fruits may be stored as such with the dry pulp or the nuts may be stored after depulping of the fruits. In South India, the fruits are usually depulped and the nuts stored. In North India, the general practice is to store the dry fruits. At the Wardha Research Institute both forms of storage have been tried pending investigations of find out the best form of storage. After removal of dry pulp and shell in the case of dried fruits (or shell only in the case of the depulped seed) the kernels are pressed for oil from October to December and even later. The kernels are reported to be crushed exclusively in oil*ghanis.* The neem berry ripens just before the onset of monsoon. A good quality of kernels can only be obtained from the berries which have been in contact with moisture for a very brief period. The best method is to collect the berries before the onset of monsoon, dry them and store them under a roof spread over on a hard floor. It is a good practice to dissipate the heat produced by the respiration of the moist fruit by turning over occasionally. In case the fruits are wetted by rains during collection and cannot be dried quickly, hydrolysis sets in the kernels and on pressing in the oil *ghanis* lower yields of oil are obtained. Hence drying in the sun should be resorted to whenever possible. The neem fruits used in the present investigations were collected from different seasons.

Maturation of Oil in Stored Fruits

An important information which is lacking in minor oilseeds is the time required for maturation of the oil after collection and during storage. It is obviously uneconomic to press the kernels from the seeds before the oil content has reached the highest value. It is also uneconomic to store the seeds for long periods when hydrolysis by spoilage or otherwise of the oil would have set in. Tables 17 and 18 present data collected on the percentage of oil in the kernels during maturation when the freshly collected and dried fruits are spread out on floors under a roof in the dark. Periodical random samples were withdrawn, seeds decorticated and the oil in the kernels was estimated in the laboratory by soxhletting a fine meal of the kernels. The values given are averages of replicates and pertain to the 1957 (June) crop. The oil content increases during storage from an initial value of 39.4 per cent (anhydrous basis) to a final value of 45.7 per cent in a period of about ten weeks. The acid value also increases. Meanwhile, there is a steady but slight loss of moisture from the kernels from 12 to 11 per cent. Therefore, the minimum time of storage required before decortication and pressing is three months.

Depulping of The Neem Fruit

The dry neem berry varies in length from 1.5 cm. to 2.0 cm. and is about 1 cm. in diameter and weighs about 0.5 g. The kernel is light brown in colour, cylindrical in shape and weighs about one-fifth of a gram. The weight of kernel is about 20 per cent of the whole dry fruit. Thus about 80 per cent consists of shell and dry pericarp.

A depulper has been developed at the Institute. The photographs of the depulper-cum-groundnut decorticator are shown in Plates 11 and 12. The machine consists of (1) a hopper, (2) an agitation cylinder consisting of a stationary horizontal wire mesh cylinder in which an agitator with spirally mounted wooden blades rotates (the size of the mesh is 9 but can be varied to depulp different types and sizes of fruits), and (3) water reservoir or tray in which the agitation cylinder is immersed. The capacity of the depulper is about 120 lb. of fruit in 8 hours. The nuts obtained after depulping are light for handling during transport and storage. The depulper is best used as an auxiliary implement in the collection centres since costs of transport are thereby reduced but are offset by the labour costs of depulping. The economic advantages of the depulper can only be determined in actual practice in collection centres.

Incidentally it may be mentioned that the pulp slurry obtained has proved to be an excellent substrate for methane gas fermentation in preliminary experiments at this Institute. It may also serve as a carbohydrate-rich substrate for other industrial fermentation. It has been successfully used to provide filling and binding substance in board manufacture in the hand-made paper industry at the Institute.

The dry fruit can be decorticated without depulping. The Research Institute has developed an inexpensive portable neem seed decorticator. Plates 13 and 14 are the photographs of the front and the right side elevations of the decorticated respectively and the details of the crushing drum with rotating blades and of the bottom wooden block with stationary blades. The decorticator consists essentially of a wooden frames in which a geared wooden crushing drum is rotated by means of a handle with gear. The drum made of solid wood is 18â€ long and 8 Â¼â€ in diameter and is mounted over a mild steel shaft which is fitted with gear at one end and runs on ball bearing supports on the wooden frame. Mild steel blades (47 to 50 Nos.) 18â€ long, 1/2â€ wide and 1/16â€ thick are longitudinally fitted to the drum in grooves so that in section they have a saw tooth appearance. Situated below the drum is a wooden block mounted on springs which can be raised or lowered by thumbscrews. Blades of the same size as above but with a reversed orientation are mounted on the stationary block on a semi-circular on concavely arched surface. The dry fruit is dropped down a hopper and is crushed by a shearing action between the knives of the rotating drum and that of the stationary (but adjustable) block. The shearing action decorticates the fruit and removes the dry pericarp along with adhering shell from the kernel by sharp longitudinal fractures. The sides of the decorticator and the hopper are made of galvanised sheets. The frame is made of wood. The entire assembly is compact and portable and has given excellent service for crushing neem fruits. It has also been successfully used to decorticate several other types of non-edible oilseeds. The total cost is about Rs. 150/- per machine and a carpenter can fabricate the unit with metal parts which are standard and easily available.

When the oil in the seed has matured, the fruits are washed in water from dust and debris and immediately dried in the sun until they are crisp and can be easily crushed by fingers. The decorticator is is fed and worked by one man. The crushing capacity of the decorticator 480 lb. of neem fruits in 8 hours. The kernels are then cleaned by winnowing and sieving. A winnowing machine, as is used to separate paddy husk from rice in the hand pounding industry, is useful for separating the kernels from the rest of the material. Hand-winnowers made from bamboo may also be used. Two sets of wire net sieves mounted in wooden frames are also required, one with 4 Ã- 4 holes per square inch (No. 4) and the other with 5 Ã- 5 holes per square inch (No. 5.) Since the dry neem fruits vary in size, recycling is necessary as shown in the chart.

The decorticating and separating operations give the following average analysis:

Kernels	19.5 per cent
Shell and dry pericarp	71.6
Whole fruits	8.9

The undecorticated fruits are recycled with the next lot.

Cost of Operation

One man at Rs. 1.50 per day can decorticate in the portable neem seed decorticator, 480 lb. in 8 hours. Three labourers at Re. 1.0 per day can clean 720 lb. of decorticated material in 2 days. Therefore, 80 lb. can be cleaned for Rs. 0.67.

Total cost of decorticating and cleaning operation for 80 lb. (1 maund) = 25 nP. + 67 nP. = 92 nP. or say rupee one only. The costs may vary from place to place depending on the prevailing wages.

Crushing of Neem Seed Kernels in Wardha Ghani

The kernels free from stones and grit, as obtained above are crushed in the Wardha *ghani.* As far as practicable, the kernels are utilised fresh from the decorticating and cleaning operations. The method of crushing the neem seed kernels is likely to differ depending on the experience of an operator. However, a standard procedure found highly successful at this Institute is as follows:

Sixteen lb. of kernels per charge are taken in a Wardha *ghani.* A total of about 1.5 lb. of hot water is optimal for liberating oil. Half the water is added at the start and half after 15 minutes. The total time required for crushing is two hours if the seeds are fresh. The percentage output of oil varies between 34 to 39 per cent by weight when the seeds are not aged by long storage.

The following figures indicate the efficiency of oil extraction by crushing neem kernels in ghanis.

The kernels contained 46.9 per cent oil on 4.6 per cent moisture basis as determined in the laboratory. 16 lb. of kernel were taken per charge. The yield of sediment-free oil was 5 lb. 5 oz. or 33.2 per cent on the weight of the kernels. Percentage recovery was 70.8.

The residual cake contained 18.9 per cent oil (anhydrous basis) and 7.4 per cent moisture. The percentage output of oil varies from as high as 39 per cent to as low as 22 per cent. The time of storage of the seed is important for obtaining optimal yield of oil as explained below.

Fall of Oil yield with Storage

It has been found that for neem seed stored beyond six months, the time required for extraction increased and the yield of oil falls. The average figures of percentage oil output illustrating this interesting fact for the 1956 crop of neem seeds collected at Wardha are given in Table 17. The data are derived from 239 crushings extending over months from the same stock of stored seed. The mean output 35 per cent in the November-December-January period. It falls steadily to 23 per cent in the August-September period of next year. The standard deviations of the means vary between 1 and 5 per cent.

It may be concluded, therefore, that the seeds collected during June-July must be crushed preferably after October but before January of the next year, *i.e.*within six months after collection and within three months after the oil has matured in the stored seed to obtain the maximum yield of oil.

Table 17. DATA showing progressive fall in yield of neem oil in the wardha oil ghanis during extended storage of the dry fruit

Date of Crushing	Average of mean percentage yield of oil on the weight of kernels	No. of crushings
November 1999/ December 2000 January 2001	35	34

February 2001/March 2001/April 2001/May 2001	33	134
June 2000/Jully 2000	26	35
August 2000/September 2000	23	46

The statistical data on crushing neem kernel in the *ghani* are given in the Table 18.

Processing of Neem Seed Kernel and production of Neem Oil

As has already been pointed out, it is desirable to crush the kernel rather than the whole neem fruit or the seed. Experiments carried out had shown that neem kernel, when crushed in *ghani,* 40 per cent of oil could be obtained from properly processed kernel (oil content, 50 per cent) and about 35 per cent of oil from the commercial grades of kernel (oil content, *c* 42 per cent). In northern India, neem fat pressing is not efficient in winter without application of external heat to the press. A hand-screw press is satisfactory for the purpose which has provision for supply of external heat. A hydraulic press is also quite suitable, in which about 7 percent of oil is left in the cake as against 8.12 per cent in the case of *ghani.* Oil expellers are not found to be satisfactory as cake formation is inadequate without addition of some harder material such as seed husk with the kernel.

Table 18. Statistical data on crushing neem kernels in ghani

	Obs.	A.M.	Range	S.D
February 1999. . . .	4	35.64 per cent	32.20 per cent37.33 per cent	2.32 per cent
March 1999. .	72	33.29 per cent		2.31 per cent
April. . . .	40	30.33 ,,		1.95 ,,
May.	33	29.60 ,,		1.69 ,,
June. . . .	16	25.36 ,,		1.66 ,,
July. . . .	19	25.41 ,,		2.62 ,,
August. .	24	23.78 ,,		0.91 ,,
September. . . .	7	22.88 ,,		1.06 ,,
October. .	3	26.42 ,,		1.35 ,,
November. .	10	35.50 ,,		1.47 ,,
December. .	14	35.21 ,,		1.80 ,,
January 2000. . .	9	35.25 ,,		0.43 ,,
February 2000. .	3	30.73 ,,		3.5 ,,

Total No. of Observations: 254.

A.M. of output: 30.92 per cent.

When the fruit is properly processed, the oil obtained from it is of much better quality than that available in trade. Typical analytical data of a number of oil samples are shown below for comparison.

	Commercial samples	*Samples obtained by Processed kernel*
Colour	33.0 Y, 11.0 R 40.0 Y,	6.0 R
	To	To
(lovibond, 1/4â€ cell)	60.0 Y, 20.0 R	50.0 Y, 7.0 R
Acid value	26.0 to 55.0	8.0 to 16.0
Odour	Extremely malodorous	Much less unpleasant odour

Similarly, when the cakes were compared, they were found to have more or less the same nitrogen content (*c* 5-6 per cent) commercial samples being sometimes poorer.

The neem fruit or seed is not yet an established commercial commodity. In certain parts of the country, the dried fruit or the seed or the kernel is sold by the villagers in the local bazars. In the absence of organised efforts to standardise the commodity in regard to maturity of the fruit, drying of the seed, storage conditions for the seed or the kernel, a desirable quality is not assured, and evidently the economics of the production of neem oil cannot be rigidly worked out. Often the price of seed or kernel would be fluctuating and that too generally on the higher side primarily due to arbitrary wages assumed for the collection of fruits.

An approximate cost data given by Kanpur workers (*loc. cit.*) are shown below only to indicate an idea :

Cost towards

100 mds. of neem fruit (fresh and moist)	
@Rs. 2.50 per md. .	Rs. 250.00
Depulping	75.00
Drying	50.00
Decortication	50.00
Quantity of kernel obtained 18 mds.	425.00
Cost of kernel per md.	Rs. 32.61

(N.B. The current price of kernel in rural markets varied from Rs. 18 to Rs. 20.)

(When depulping is not necessary)	
100 mds. of dry neem fruit	35.00
Drying and decortication	100.00
	450.00
Quantity of kernel obtained	20 mds.
Cost of kernel per md.	Rs. 22.50
Crushing	
100 mds. of kernel @ Rs. 23.00.	Rs. 2,300.00
Crushing charges @ Rs. 1.50 per md	150.00
	22,450.00

When the price of cake (56 mds. obtained in the working) is about Rs. 450.00 @ Rs. 8.00 a md., the price of oil would work out to be about Rs. 48.00 a md. (42 mds. of oil being the yield).

Shimpi, while reporting the tentative economic data on the collection of neem seed, discussed the various related factors. According to him, effective collection or an economic basis can be made if one keeps himself posted with the information on the following points in the area he is situated in:

(a) availability of the seed,

(b) geographical conditions,

(c) average rainfall,

(d) approach roads,

(e) transport facilities, and

(f) nearest oilseed market.

Generally, the season for neem seed collection starts from the third week of May and ends by the middle of August. A worker in the field may organise his work by earlier contacts and propaganda in the area and wherever necessary local arrangements may be made for washing, depulping and drying the seed before being transported to nearby centres.

The process of drying takes about two months and decortication is generally started in the month of October. By means of a bullock-driven *chakki,* three persons can decorticate and clean (by hand winnowing) about 10 mds. of seed in a day, charges for which are estimated as follows :

Wages for 10 mds.	Rs.1.87
Depreciation for *chakki*	0.13
Bullock charges	2.00
	4.00

Crushing

About 5 charges of 10 seers each can be taken by one *ghani* in a day (8 hrs.), for which the expenses would be,

Wages to oilman	Rs.1.25
Bullock charges	2.00

From 1,200 mds. of seed about 390 mds. of kernel are obtained which can be crushed by two *ghanis* in 6 months. The cost data would be as shown below:

Seed collection :	
wages @1.25 per md. for 1200 mds.	Rs. 1,500.00
Bagsâ€"depreciation:	
@ 0.25 for 500 bags	125.00
Transport charges :	
average 0.50 per md.	600.00
Decortication :	
@ 0.40 per md.	480.00
Crushing :	
Overhead and miscellaneous	620.00
	4,339.00

Three hundred and ninety mds. kernel would yield about 100 mds. oil and 290 mds. cake. When the oil is valued at Rs. 40.00 a md. and the cake at Rs. 4.00 a md., the total proceeds would be Rs. 5,160.00 leaving a profit of Rs. 821.00.

From the above data furnished by Shimpi, it will be seen that the cost of neem kernel would be about Rs. 8.30 a maund as against a figure of Rs. 23.00 for the same arrived at by the other set of workers (*vide supra*). While the bases of the data of the latter workers are not given and they appear to be much divorced from the reality, the data recorded by Shimpi, a worker in the field, may be, to an extent, dependable. When it is admitted that the cost of the kernel would vary within certain limits depending upon the conditions prevalent in the different localities, one would expect that an organised control can ensure an economically feasible mean rate for the kernel for cheaper production of neem oil and the cake as commercial commodities. In this connection the economics in relation to wages, time and yield, for crushing the neem kernel in bullock-driven *ghanis* may be seriously probed into in comparison with that when the operation is carried in a power-driven *kohlu* or press.

While approaching the problem of collection of neem seed and production of the oil and the cake, taking in view the important commensurable factors, one cannot escape from certain facts which are to be given due consideration. The major oilseeds of the country, *e.g.* groundnut, sesame, mustard, niger, safflower and linseed are agricultural products whereas neem is non-agricultural an neither any arable land is occupied for production of neem nor any labour is employed for its cultivation. It is cultivated in the sense that it is planted either as a shade tree generally by the sides of avenues or sometimes at place to arrest soil erosion. It is, therefore, evident that there is no production cost for neem fruits; and the expenses start with the wages for collection of the fruits and thereafter the economics of production of the oil is more or less the same as that for the production of oil from the major oilseed, groundnut. So it is logically expected that neem oil would be much cheaper than groundnut oil taking into account the agricultural expenses for the latter, when the yields of the oils are more or less the same. When the employment potential of the non-edible oilseed collection campaign commensurate with the present day rural economy cannot be ignored, it may be borne in mind that the seed collection provides mostly a seasonal part-time employment. Another important point is that certain processing is unavoidably needed to bring neem oil at par with, say, groundnut oil for purposes of industrial utilization and this processing cost will have to be included in working out the economics of the production of neem oil. During the initial stages of the efforts to make the organisational set up for neem oil production fruitful, subsidy is one form or other would be necessary as in the case of any new enterprise. It is very encouraging that the Non-edible Oil and Soap Industry Directorate of the Khadi and Village Industries Commission as well as the Indian Central Oilseeds Committee are constantly watching the various factors of this problem and there is no doubt entertained in any quarters that the economy of neem oil production will be competitive enough to establish this fat as an important industrial raw material in the foreseeable futures.

Ozha studied the effects of processing of neem seeds on crushing by *kohlu ghani* and recorded that the properly processed neem seed can be stored and pressed in decorticated or undecorticated condition in a village oil *ghani* of improved Wardha Type *kohlu* throughout the year. The oil obtained from the seed has much lower acid value, is much lighter in colour and has less odour than the oils obtained from improperly processed and badly stored seed. To prove this, certain attempts were made and the experiments were performed as follows :

About 50 maunds of fresh seed was collected depulped after soaking in water for four days in a depulper fitted with a stirrer. About two hours treatment of the soaked fruit in depulper with a speed of approximately a 25 r.p.m of the stirrer, was found sufficient to detach the pulp completely from the shell. The mass was then run out from the bottom and the pulpy matter washed with water. The depulped nuts were dried in the sun for several days.

Storage Experiments on Neem Seed

The following samples were kept in storage for trials:

(1) Whole fruit (Sun-dried),

(2) Undecorticated seeds (Sun-dried),

(3) Decorticated seeds (Sun-dried),

(4) Depulped Weeds specially obtained through a firm,

(5) Decorticated kernels obtained from the same firm.

These samples were examined for their moisture content, oil yield in the Wardha type *kohlu,* at an interval of one month. The results obtained are shown in Tables 19 to 23.

The results indicate that as regards the keeping properties of seeds prepared by different methods, the one prepared by properly drying the whole fruits has best keeping properties. This seed does not undergo deterioration even after one yearâ€™s storage. Next in order of this property are the undecorticated seeds obtained after properly depulping of fruit and drying of seeds. Third in order are the kernels obtained by properly depulping the fruit, drying and decorticating the seeds. These kernels also did not undergo any deterioration during storage for about a year.

Quite contrary were the results with commercial seeds obtained from Rae-bareilly market. The undecorticated seeds from the market began to deteriorate even in the third month and the apparent increase in oil content as obtained by solvent extraction in the soxhlet was evidently due to drying up of the seed and loss of moisture. In the fourth month the seed became darker in appearance apparently due to heating up of the seed by auto-oxidation and the texture of the seed deteriorated so as to bring down the oil yield. Further deterioration was observed in the fifth month in the appearance of the seed and the oil yield. In the sixth month, the seed became almost black and when tried to be crushed in kohlu the cake did not set and crushing could not be done successfully.

Table 19

I. From the kernel of the sun-dried fruits

Period	Moisture content of kernel	Per cent oil content of kernel	Per cent oil yield in *Kohlu*	A.V.
1	2	3	4	5
On Pressing	5.0	51.8	42.0	7.6
After 1 month	4.0	51.8	42.0	7.6
After 2 months	4.9	51.8	42.0	7.6
After 3 months	4.8	51.7	41.7	7.7
After 4 months	4.8	51.5	41.7	7.7
After 5 months	4.8	51.3	41.4	7.7
After 6 months	4.7	51.2	41.5	7.8
After 7 months	4.7	51.2	41.4	7.8
After 8 months	4.7	51.1	41.4	7.8
After 9 months	No experiment was performed			
After 10 months	4.7	51.1	41.4	7.8
After 11 months	4.7	51.0	41.4	7.9

Table 20

II. From Undecorticated seeds

Period	Moisture content of kernel	Per cent oil content of kernel	Per cent oil yield in *Kohlu*	A.V.
1	2	3	4	5
On Pressing	5.1	51.5	42.0	7.7
After 1 month	5.0	51.4	42.0	7.9
After 3 months	4.8	51.5	42.0	8.0
After 4 months	4.9	51.5	41.8	8.0
After 5 months	4.8	51.4	41.6	8.0
After 6 months	4.8	51.4	41.4	8.3
After 7 months	4.7	51.3	41.2	8.3
After 8 and 9 months	No experiment was performed			
After 10 months	4.7	51.2	41.1	8.4
After 11 months	4.7	51.1	41.1	8.4

Table 21

III. From Decorticated seed (sun-dried)

1	2	3	4	5
On Pressing	7.5	52.1	42.1	7.9

After 1 month	7.0	52.4	42.1	7.9
After 2 months	6.5	52.6	41.8	8.0
After 3 months	6.0	52.6	41.6	8.2
After 4 months	6.0	52.6	41.1	8.4
After 5 months	6.0	52.3	41.0	8.6
After 6 months	6.0	52.0	40.6	8.8
After 7 and 8 months	No experiment was performed			
After 9months	5.9	51.1	40.0	9.0
After 10 months	6.1	51.1	39.8	9.6
After 11 months	6.2	51.1	30.6	9.6

Table 22

IV. From Depulped seeds specially obtained

1	2	3	4	5
On pressing	18.2	40.0	35.1	12.0
After 1 month	31.1	43.8	36.0	18.1
After 2 months	10.2	44.0	35.6	25.0
After 3 months	8.1	48.5	27.8	31.0
After 4 months	6.0	46.0	20.2	38.3
After 5 months	4.8	48.1	Cake did not set	
After 6 months	4.3	48.2	" "	

In case of kernel decorticated on a commercial scale, the deterioration was even more rapid as, in the third month itself the yield of oil fell appreciably and in the fourth month not even half of the oil was available by pressing in the *kohlu*. In the fifth month, no oil could be pressed from this seed in the *kohlu* as the cake did not set at all. The seed grew increasingly darker in colour and had almost a charred appearance in the sixth month.

Table 23

V. From kernel obtained from IV.

1	2	3	4	5
On Pressing	15.6	43.0	35.5	15.0
After 1 month	11.2	44.1	33.0	24.3
After 2 months	7.0	45.6	25.1	31.9
After 3 months	6.1	46.8	15.0	40.1
After 4 months	4.3	47.5	Cake did not set	
After 5 months	4.3	47.0	"	
After 6 months	4.3	46.8	"	
After 7 months	4.2	46.6	"	

Conclusions

(1) Neem seed stored at present is processed by crude and unscientific methods, and the seed during storage heats up due to auto-oxidation and yields an oil very dark in colour, of high acid value and of a pronounced unpleasant odour. On account of these defects the texture of the seed deteriorates making it difficult to allow crushing in the *kohlu.* In course of time this deterioration may proceed to such an extent that little oil can be pressed from it even in hand-screw presses.

(2) By proper processing of the fruit consisting of three operations of *(i)* depulping, *(ii)* drying and *(iii)* decortication, it is possible to produce neem seed which can be stored throughout the year and which produces an oil with much less free fatty acids, much lighter colour and less odour. By adopting this process a large potential source of the oil can be opened.

Wide variations in the methods and appliances used in the processing of neem fruits, seeds and kernels for obtaining the seed fat have already been discussed earlier. Evidently, there are found inexplicable and undesirable discrepancies in the physico-chemical characteristics of the oils obtained from various sources. Such discrepancies are not only noticeable with the different commercial samples of neem oil (*vide infra)*, they are also evident with the samples of neem cake available commercially. The following Table gives the relevant findings with three samples of neem cake supplied from the same locality:

Table 24

Analytical data on neem cake (Ballabgarh)

	Samples		
	I	II	III
Oil content [soxhlet : petrol-ether (40-600)]	12.6 per cent	12.2 per cent	6.5 per cent
Acid value of recovered oil	25.7	145.51	95.2
EtOH or MeOH extractive of the oil*	21.4 per cent	1.75 per cent	4.2 per cent
Moisture content of processed meal	9.8	5.3	6.4
Nitrogen content of processed meal	8.3	2.1	1.8

N.B. 1. Sample were mixed with extraneous materials such as, sand, etc.

2. Sample No. I appeared to be a usual sample of neem oilcake, but sample II and III were unusually dry, dark coloured and appeared baked.

* Soxhletted with EtOH or MeOH after defatting; processed meal is free from bitter and odorescent constituents.

Shrikantha Rao, white stressing the importance of the need for systematic study of seed storage, reviewed the various factors influencing the storage conditions and their effects in relation to the non-edible oilseeds. A proper storage involves a careful pre-treatment of seeds, that is to say, â€˜careful preliminary preparation of the seedâ€TM, including such measures as to ensure the preservation of the seed from damage or deterioration so as to prevent the viability of seed from falling off as much as possible.

The problems of storage of seeds are very serious in a country like ours because many of our forest seeds are not capable of retaining their viability for long periods. The fact that it is not possible to provide ideal storage facilities makes the issue more difficult. It is unfortunate that for many of these seeds not much information is available on storage. As such, a lot will have to be gathered from experience in the field.

The necessity to store the seed for long intervals arises also because of our inability to press oil from them within a short interval. These seeds become available during certain fixed time and season every year and offer high employment potentialities during the season. Should it be possible to store them for long periods, that would open new avenues for full-time employment also by way of facilitating oil pressing throughout the year. Obviously, the urgency to strike at methods feasible within the capacity and ability of the indigenous available talent at the seed collection site cannot be overlooked.

The season for seed collection is followed by the rainy season in many parts of the country and thus compels of the seeds in the locality of collection wherever immediate transport and communication facilities

are not available.
The work done so far on methods of seed storage in India has not been inspired by any systematic and well-drawn programme. Whatever little work that is in evidence has been undertaken as the essential pre-requisite of artificial forest regeneration work. It is of paramount importance to form a systematic programme for investigating proper methods of storage for different seeds. Such a programme should basically include the problems of bulk storage and storage mostly under conditions prevalent in the localities of availability, without involving any elaborate arrangements. The objective should be of making these seeds available for oil pressing at least till the next harvest.
Shrikanta Rao indicated that the storage experiments on neem seed at one of the centres of the Khadi and Village Industries Commission had been very useful in checking the process of deterioration of the seeds to a considerable extent. Field trials are now being undertaken so that the storage methods can be standardised.
Characteristics of neem oil and its quality
During the long-range programme of investigation with neem oil for its industrial utilization, Mitra collected a large number of samples of the oil from various places and also of the oil processed under different conditions. The significant data on the constants of these samples of oil are given in Table 25. Even a cursory perusal of the data would show the wide diversity in the quality of the oil produced without any care being taken to standardise the product and so that it can be rendered useful for commercial utilization. Much attention does not appear to have been paid even when an Agmark grade has been proposed by the governmental agency. The standards and physico-chemical constants of neem oil described in the Indian Pharmaceutical Codex would not also appear to indicate a desirable and feasible quality of a medicinal oil of authentic purity.
In order to arrive at a tentative standard specifications for neem oil, it is imperative that the above data are critically studied and the factors for wide variations in most of the characteristics are properly assessed. Such factors, when analysed, would obviously lead to desirable alterations in the methods of processing the seed and also in the mode of pressing.
Colour. When the fresh kernels are pressed at low pressure as in the *ghani,* the colour of the resultant oil is lighter and shows a greenish tinge. Most of the highly coloured samples of neem oil are products from high-pressure expellers or hydraulics. Steaming or addition of hot water or any sort of heat treatment during pressing not only adds to the colour due to polymerisation of the non-fatty constituents and liberation of proteinous materials but the latter renders the oil muddy and unsuitable for further processing and refining. The colour of the fresh or well-stored samples of oil can be as low as 1.5 R+10 Y (Lovibond 1/4â€ cell) and attempts should be made to process the seed in such a way as to produce and oil having not more than 2.0 R + 20 Y (Lovibond 1/4â€cell). Although bleaching of neem oil, when properly purified and refined, would not pose any extraordinary problem and very pale coloured oil can be easily obtained by bleaching the purified and refined oil, the colour index indicates the degree of deterioration of the non-fatty constituents present in the seed *vis-a-vis* the quality of the oil. Practically water-white neem oil can be obtained by a modified process of treating the seed-meal for preferential separation of the non-glyceride constituents and subsequent extraction of the oil from the treated seedmeal.

Characteristics of the purified and refined neem oil, free from the bitter and odorescent constituents

Colour :	0.5 R
(Lovibond ; 1 cm.)	3.6 g
Odour and taste :	faint and non-bitter
sp. gr. (30o) :	0.9087
Ref. index (30o) :	1.4612

Acid value :	0.4
Sap. value :	193
Iod. val. (Wijâ€™s)	66.4
Non-sap. (per cent) :	0.8
Alcohol (95 per cent) soluble matter:	nil