POST HARVEST TECHNOLOGY OF COMMON CROPS OF KERALA

K. P. VISALAKSHI
ABDUL HAMEED
T. M. KURIAN

PROJECT FOR THE PROMOTION OF
AGRICULTURAL ELECTRONICS
(A Project Sponsored by the Department of Electronics, Govt. of India and ICAR)

KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA-680 654

English

POST HARVEST TECHNOLOGY OF COMMON CROPS OF KERALA

May, 1990

Copies : 300

Published by:

Dr. A. G. G. Menon
Director of Extension
Kerala Agricultural University
Mannuthy 680 651
Trichur, Kerala, India

Printed at:

Kerala Agricultural University Press
Mannuthy 680 651

Foreword

Post harvest handling, storage and product development is an important area which has to be given due importance when we aim at increased food production. In Kerala, the post harvest technology assumes greater significance, especially due to the fact that the plantation crops, the fruits and vegetables produced in the State can attain value addition by proper processing technology. The nutritional security of the masses could be achieved to great extent, if protective foods like fruits and vegetables are made available throughout the season at low cost.

The post harvest handling and storage methods so far developed, although lack perfection in several cases, many innovative technologies have been developed which may perhaps suit the rural needs. The product development necessarily calls for qualitative improvement. In order to achieve the desired standards of the processed produce, it is necessary to have methods developed to find out the quality of the end produce.

Agricultural Electronics offers considerable scope in its application to several aspects of post harvest technology. Electronic instruments and equipment used in the estimation of moisture content, acidity, colour and other parameters of the processed produce will help the farmer as well as those engaged in the post harvest handling, to improve the quality of products.

In the present compilation, the authers have made an attempt to compile the available information of the several aspects of post harvest handling, storage and product development which will provide the necessary basic information to the scientists engaged in agri-electronics to give a thought on the possible areas of application of agri-electronics in the field of post harvest technology.

Dr. M. ARAVINDAKSHAN
Director of Research

Preface

Post harvest technology is assuming greater and greater importance as consumers are becoming more and more quality conscious. Proper post harvest processing and storage preserves the quality of produce thus helps in fetching better price in the market. Unscientific handling of perishable agricultural produce not only incur financial loss to the farmers but is also a cause of health hazard.

Electronics offers good scope in reducing post harvest losses of field and plantation crops both in terms of quantity and quality. An attempt has been made to project the importance and throw light on the various post harvest operations of common crops in Kerala. It is hoped that the book will be of use to scientists, students and all concerned in the field of post harvest technology.

The authers are indebted to Dr. E. G. Silas Vice Chancellor, Kerala Agricultural University for giving encouragement and valuable suggestions during the preparation of this book. Thanks are due to Dr. M. Aravindakshan, Director of Research, Prof. T. P. George, Dean i/c, Kelappaji College of Agricultural Engineering and Technology, Dr. P. A. Wahid, Professor (Radio tracer) Smt. Shanti Mary Mathew, Asst. Professor (Post harvest technology) and our colleagues for their help.

The co-operation and help of Dr. A. G. G. Menon, Director of Extension and Sri. K. Rajappan, Press Manager in arranging the printing of the publication is gratefully acknowledged.

The authers are also grateful to the Dept. of Electronics (Govt. of India), Indian Council of Agricultural Research, New Delhi and Kerala Agricultural University for providing necessary assistance and facilities for bringing out this publication.

CONTENTS

		Page
Rice	—	1
Coconut	—	11
Arecanut	—	13
Cashew	—	15
Groundnut	—	16
Cocoa	—	21
Coffee	—	22
Tea	—	23
Rubber	—	24
Cassava	—	25
Pepper	—	26
Ginger	—	27
Turmeric	—	28
Cardamom	—	29
Nutmeg	—	30
Cinnamon	—	30
Vanilla	—	31
Fruits and vegetables	—	32
Appendix		
Safe moisture content of crops at the time of storage	—	37
References	—	38

Rice

India is the second biggest paddy producing country in the world after China. Paddy, being the major cereal crop of India, covers an area more than 40 million hectares, which is the largest under any crop. Rice is the most important crop in Kerala whether in terms of area of cultivation, production, consumption or value. The rice milling and processing is thus of foremost importance in Kerala.

Threshing

Today in various parts of the world threshing is accomplished by treading the grain under the feet of men or the hooves of the animals, striking the grain with sticks, rubbing the grain between the rasp bar and concave of a combine.

The traditional method followed in India for threshing is by treading the ears under the bullock's feet or by beating the crop with sticks.

In addition to the traditional methods of threshing the threshers are now being extensively used for all types of crops. It is estimated that the total population of threshers in the country is about 0.5 million units.

General Purpose Thresher

A general purpose thresher is capable of threshing a variety of crops such as Rice, Wheat, Barley, Gram, Peas, Sorghum, Jowar, Bajra etc. In the multy-crop rotation system, there is a demand for a multy-crop thresher with special attachment for a particular crop (fig. 1). It is operated with an electric motor of 5 Hp. or an engine of 7.5 Hp. Its capacity for wheat threshing is about 200 kg/hr. The recommended drive-speed for different crops varies between 550 and 850 rpm. Three men are required at a time to operate the machine. The output of these machines varies from 40-50 kg. of the clean grain per Hp-hour.

Japanese Type Rotary Paddy Thresher

This machine consists of a threshing cylinder, driving mechanism and supporting frame. Threshing of paddy crop is done by holding the bundle against the teeth of the revolving cylinder. The grains are thus separated or combed out easily. The capacity of single man machine is about 1.5 to 1.9 quintals per day. The cost of threshing will be about Rs. 1.60 per quintal of grain.

Power Driven Stationary Thresher

This threshing machine is very similar to the threshing unit of the combined harvester thresher. The peg tooth type cylinder and concave are mostly used on these threshers. It is self feeder type and consists of a conveyor on which the crop

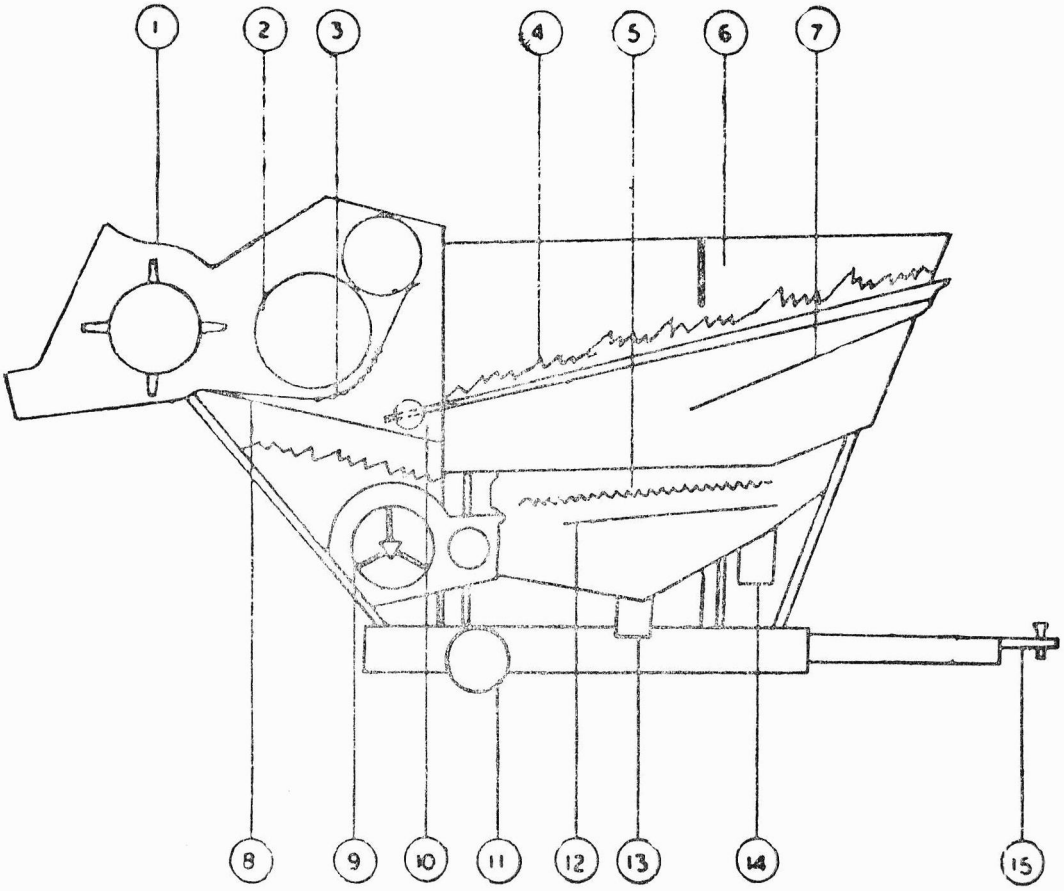

Fig. 1 Multicrop Thresher

1 Auger beater
2 Threshing Drum or Cylinder
3 Concave
4 Straw Walker
5 Sieve Box
6 Kernel Canvas
7 Return Pans
8 Grain Pans
9 Blower
10 Crank Shaft
11 Support Wheel
12 Changeable Sieve (Flat sieve)
13 Spout I for Clean Grains
14 Spout II for Tailings
15 Tow Bar

Source: F. C. Das (1981). Improved threshers developed in India, C. I. A. E. Bhopal.

is put by the workmen and by which it is carried to the cylinder. Before the crop is fed to the cylinder, band cutters cut the bands of the bundled crop fed to the machine. A small hand fed stationary thresher operated by a 5 Hp. oil engine is successfully used for threshing paddy crop. It consists of a peg tooth cylinder and concave straw rack, a sieve and grain pan. In the absence of a fan, the threshed material has to be winnowed for separating the grain and chaff. In a working day of eight hours, about 4.5 to 5.6 quintals of grain can be threshed.

Paddy thresher developed at Tamil Nadu Agrl. University

The paddy thresher consists mainly of a feeding tray, a threshing drum with four rasp bars, a blower and sieves (fig. 2). The harvested crop is fed through the tray. When the crop reaches the concave, the beating action of the rasp bar separates the grain from the straw. The paddy and straw fall below on the sieve and the blower sends a blast of air which separates the straw from the paddy. The straw is then thrown out and the clean paddy is collected at the bottom.

Power paddy thresher developed at Allahabad Agrl. Institute

The thresher consists of a feed chute, threshing drum, concave, blower, baffle plates and sieves (fig. 3). The crop is fed through the feeding chute to the gap between rotating threshing cylinder and concave. The impact of the wire loop on the threshing cylinder separates the grain. Further threshing is obtained by rubbing action as the material passes through the restricted clearance space between the cylinder and the concave. The threshed grains then fall on the side plate through the concave and chaffs are blown away by blower. The straw is removed over the straw walker.

Winnowing

Winnowing fans

Various types of hand operated and pedal operated winnowing fans are being manufactured by many firms in India. The fan blades create a steady blast of air at the front side of the fan. One or more persons standing on the front side can drop the threshed material for effective separation. The threshed material can be poured on the front side of the fan at a distance of 1.2 to 1.8 m from the fan along its central line for most effective cleaning.

Drying

Losses due to shedding and shattering of grains in the field can be considerably reduced when paddy is harvested between 23 and 25 percent moisture content, and hence the need to bring down the moisture to the safe level of 12 to 14 percent. Sunlight is not a dependable source of heat to dry paddy because in many areas harvest time coincides with heavy rains and moist paddy cannot be stored safely more than a day or two without damages from fermentation. On the other hand, mechanical dryers facilitate drying of large columns of paddy in relatively short periods of time irrespective of weather conditions.

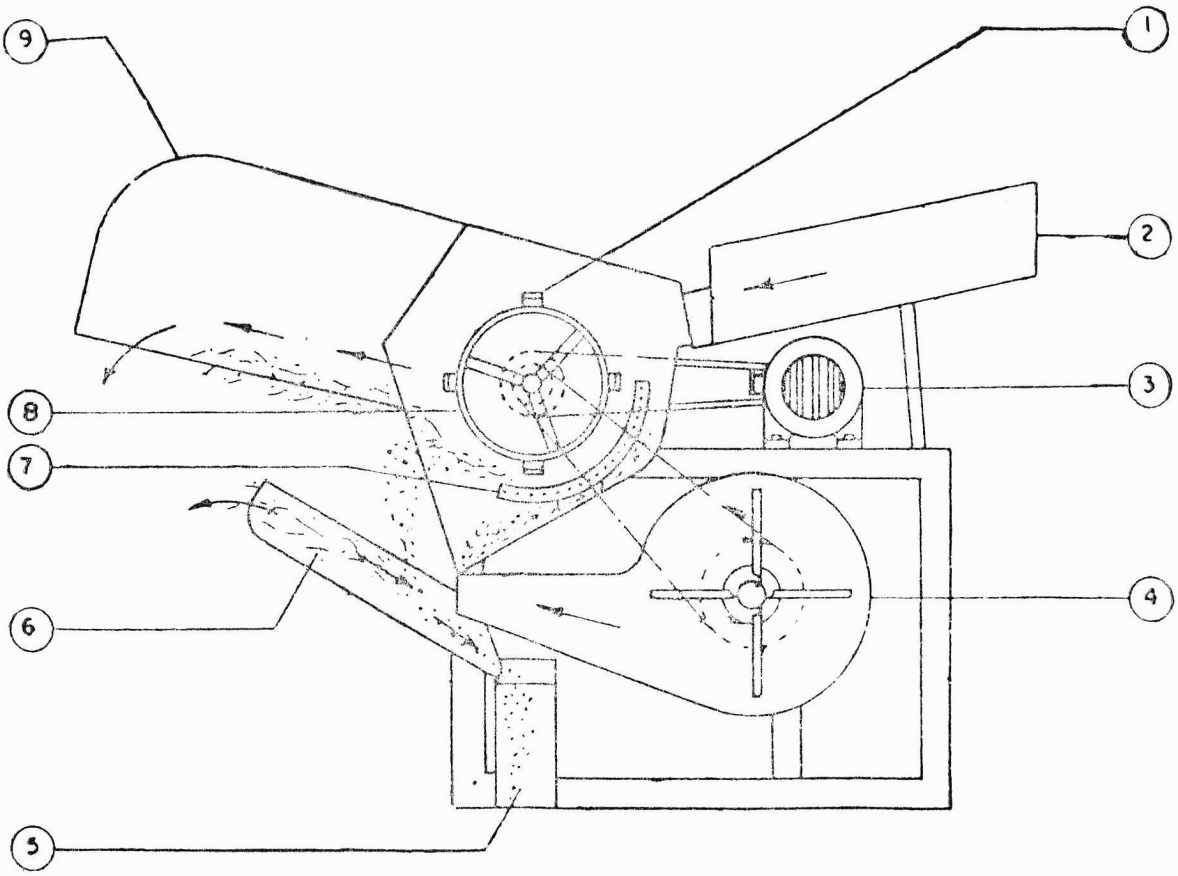

Fig. 2 Paddy Thresher

1 Rasp Bar
2 Feed Hopper
3 Electric Motor
4 Blower
5 Grain Outlet
6 Chaff and Dust outlet
7 Concave
8 Threshing Drum
9 Threshed Paddy Straw Outlet

Source: F. C. Das (1981). Improved Threshers Developed in India, C. I. A.E. Bhopal.

Early harvest and Mechanical drying

The rice farmer can harvest paddy earlier in the maturity stage and reduce the chances of weather damage or loss. Grains reach maturity from 1 to 3 weeks before they are dry enough for storing. Early harvest fetched field yields as losses are reduced in harvesting, transporting and threshing the crop. The recommended moisture content of harvesting paddy crop is between 21 and 23 percent.

Early harvest, followed by mechanical drying, gives the best milling recovery since the percentage of brokens will tend to be minimal. Storage losses,

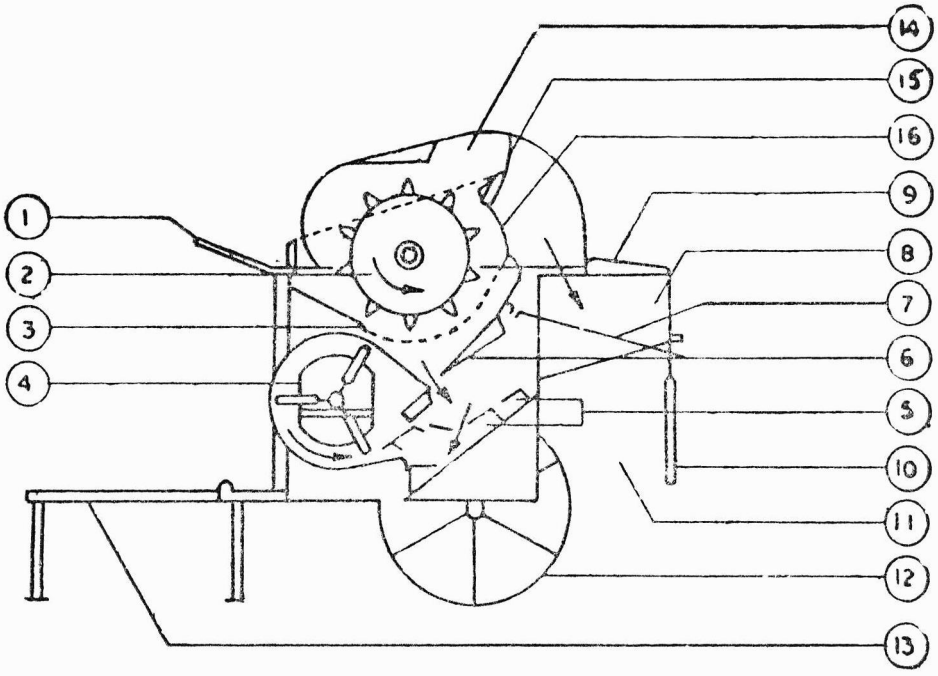

Fig 3 Power Thresher (Naini Junior)

1	Feeding Trough	9	Curtain Cover
2	Threshing Cylinder	10	Grain Recovery Plate
3	Concave Screen	11	Rear Opening
4	Blower	12	Transport Wheel
5	Air Passages	13	Standing Platform
6	Grain Slide Plate	14	Top Cover
7	Straw Shaker	15	Dust Removing Louvre
8	Side Curtain	16	Straw Release Louvre

Source: F. C. Das (1981). Improved threshers developed in India, C. I. A. E. Bhopal.

either for paddy or rice, will be less under conditions of optimum moisture content. This enables farmers to obtain favourable market prices after harvest as the grain can be stored for longer periods.

Mechanical drying

This process utilises mechanical means for paddy drying by ventilating natural or heated air through the grain mass to accomplish the removal of excess moisture from it.

When hot air is forced through the grain mass, the hot air evaporates the moisture from the grain surface, increases the temperature of the grain and carries evaporated moisture from the grain.

There are three methods of drying grain with the use of air. They are (1) Unheated or natural air drying, (2) Unheated air with supplemental heat and (3) Heated air drying.

Unheated air drying refers to the use of atmospheric air forced around the grain for the removal of moisture. It is rather a slow process but is economical when the grain is held in storage for a period longer than is required for drying.

Unheated air drying with supplemental heat involves adding a small amount of heat to the air to decrease the humidity thereby increasing the water holding capacity of the air.

Heated air drying makes use of forced air movement around the grain with the addition of large amount of heat for removing moisture rapidly. This method is used for drying freshly harvested grain at high moisture content which cannot be stored for longer periods.

The mechanical driers are classified as,

a) The sack driers,

b) The rotary driers and

c) The continuous flow driers.

Parboiling of paddy

Many pre-milling techniques have been devised to increase the milling, nutritional, cooking and eating quality of rice. The latest and most widely used of these treatments is parboiling. Parboiling gives about 1—3% more total rice and 3—11% more head rice as compared to raw milling.

Swelling of starch granules may be achieved by soaking paddy in cold or hot water. During hot soaking, energy supplied in the form of heat weakens the granule structure by disturbing hydrogen bonds, giving more surface for water absorption by starch granules. This permits further hydration and irreversible granule swelling initiated by more active dissociated water molecules. This phenomenon is called gelatinization of starch.

This may be achieved by

1) Soaking the paddy in water at or above its gelatinization temperature for a suitable duration depending on the variety.

2) Soaking the paddy in water at or above its gelatinization temperature for some time to facilitate the uniform hydration of rice kernel and then supplying heat to produce irreversible expansion and fusion of starch granules. The heat should be moist, ie, steam, as otherwise drying of soaked paddy will start.

Principles of parboiling

Soaking of paddy can be done at or below its gelatinization temperature. The lower the temperature used, the slower is the process of soaking and vice-versa But it should not be more than 75°C otherwise paddy will get cooked.

Heat for gelatinization of starch is supplied by saturated steam. The higher the temperature of steam and the longer the steaming time, the harder will be the rice and the darker the colour.

Parboiled paddy may be dried in shade, or in sun, or with hot air. Shade drying gives an excellent milling quality but rapid drying in the sun or with hot air gives high breakage during milling. In a continuous drying the breakage starts as the moisture content reaches around 18% and increases rapidly with further drying. Therefore the most convenient practice would be to dry in two passes with a tempering at the moisture content of about 20%.

Methods of parboiling

The traditional process consists of soaking the paddy in water at room temperature for 24-48 hours or more, steaming in kettles and drying in the sun.

In the Double Boiling method, steam is injected into raw paddy in the steaming kettle before soaking. This speeds up the soaking process. Hot paddy raises the temperature of soak water to 45-50°C, which aids in reducing the soaking time to 24 hours only. Thereafter, the soaked paddy is steamed.

Modern methods

The Central Food Technological Research Institute (CFTRI) method:-

The parboiling tanks are filled with clean water and then the water is heated to a temperature of about 85°C by passing steam through the coils already placed inside the tank. Sometimes, hot water is prepared in a separate hot-water tank before being pumped into the tanks. Paddy is dumped into hot water as quickly as possible. The soak water can be recirculated into the hot water tank to maintain a constant temperature of 70°C. After letting the paddy soak for 3-3.5 hours, soak water is drained out and water discharge valve kept open to remove the water that condenses during steaming. Soaked paddy is exposed to steam heat by letting in steam at a pressure of about 4 kg/cm^2 through the open steam coil. Splitting of the husk is the indication of completion of parboiling process. After completing the steaming, steamed paddy can be drawn off for drying by opening the bottom door.

Pressure Parboiling

The principle of the method is the penetration of moisture inside the paddy in water vapour phase under pressure and bringing the gelatinization of the kernel. Paddy is soaked for nearly 40 minutes at a temperature of 85-90°C and then steamed under pressure for 18 minutes. The main advantages were reduction in soaking time, increase in shelling efficiency (nearly 80% of the pappy hull splits during steaming) and milling outturn as grains become resistant to breakage. Increase in the fat content of the bran after milling and increased storage life of grain were observed.

Rice Process Engineering Centre (RPEC), Kharagpur method

This method consists of soaking paddy in water at 2-3 degree higher than its gelatinization temperature for a suitable period depending upon the paddy variety.

During soaking process paddy absorbs moisture as well as heat. Gelatinization of starch mostly takes place during latter part of soaking. Then the soaked or say parboiled paddy is taken out and either dried in sun or through mechanical driers. The method is economical since it eliminates the steaming process.

Farm level Parboiling Unit

The Cuttack Centre developed a mini parboiling unit (fig.4) for on the farm/domestic parboiling of rice. Traditionally soaking and steaming are done separately. With this parboiling unit both the operations can be done without any further handling in the same unit. A hot soaking for 3.5 hours in 75°C water and steaming and subsequent sundrying results in about 2% more head rice than achieved traditionally.

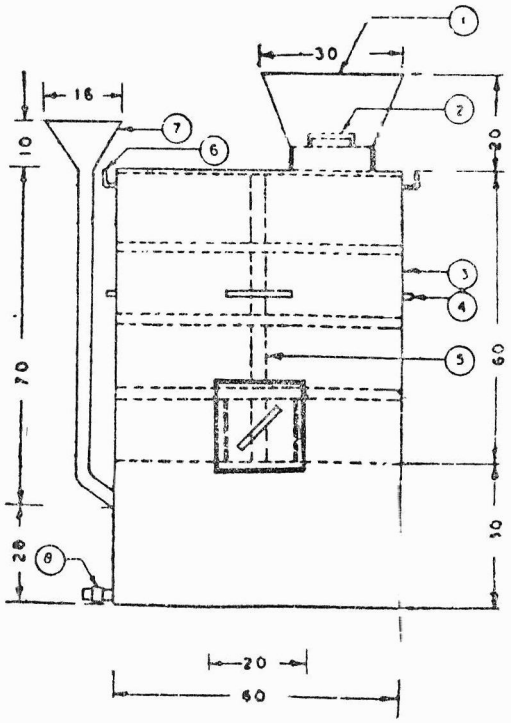

Fig. 4 Schematic diagram of Mini Parboiling Unit

1 Feeding Hopper
2 Cover for Inlet
3 Steaming Chamber
4 Handle
5 Central Pipe
6 Clamp to hold the Cover
7 Inlet to fill Water
8 Drain Pipe

Source: Technical Bulletin No. CIAE/PHTS/81/24

Drying of Parboiled Rice

Paddy after parboiling contains about 35% moisture, wet basis. It has to be dried to about 14% moisture for proper milling and safe storage. If the excess moisture is removed at a very slow rate, the micro-organism will grow and spoil the parboiled paddy. On the other hand, if drying is done rapidly and continuously, cracks may develop and rice will break during milling. The paddy should be uniformly dried by any means (shade, sun or by hot air). The paddy should be dried in the first pass to a moisture content of 16-20% and then collected into heaps and left covered for tempering under sun for a period of 3-4 hours. It is again spread out to be dried to 12-13% moisture content.

Rice Milling

The shell covering the rice grain kernel is known as husk and the process by which it is removed is termed as de-shelling operation and the machines employed to carry out this, are named as huskers or shellers.

Three types of such machines used are,

1) Under-runner disc shellers,
2) Rubber roller shellers and
3) Hullers.

Under - runner disc shellers

This works on the principle that if the paddy grain is pressed between its two ends and rubbed slightly, the husk splits apart and the kernel emerges. It is composed of two horizontal, parellel and co-axial discs, the adjacent surfaces of which are coated with abrasive material, the distance or the gap between them being slightly less than the length of the grains to be de-shelled. The upper disc is stationary and has an opening in the centre through which the grains are fed. The lower disc turns. The grains which fall through the middle on to the lower disc are pulled along by its rotations and move outwards by centrifugal force. While revolving round the axis of the rotating disc and at the same time moving towards its edge, the grains come to assume a vertical position. At this point their tips hit against the rough surface of the upper stationary disc which applies pressure and a slight rubbing action. This pressure does not damage the kernel because the two covering halves of the husk are completely separate from it. They are also longer and have small fibrous growth at their tips.

Rubber roller shellers

This consists of two resilient surfaces moving at different speeds in the same direction, which are tough, rough and adjacent. Experience has shown that the best difference in linear speed between the fast and slow rollers is about 2m/sec. The difference in angular speeds must be such that while passing the grain, the surface of the faster roller must advance (in relation to that of the slower) by a distance of equivalent to or greater than the length of the grain.

Hullers

Hullers consist of solid fluted cylinder rotating at 700 to 800 rpm within a hollow stationary cylinder in the lower half of which is the perforated iron sieve with slots of 1.5 to 7.5 mm. The flute on the cylinder is so arranged as to carry the paddy to the centre from the feeding end, get it milled by scoring action at the centre of the cylinder and then to carry it to the other end where the milled rice is discharged. The hullers are used first for shelling by keeping a wide clearance between the cylinder and the blade. Each huller is driven by a 20-25 Hp. motor using belt drive. The winnower has got a blower which is driven normally by a 5Hp. motor. The husk is blown off and the resultant mixture of rice and brokens is graded by the reciprocating motion of the grader attached with the winnower. The eccentric shaft attached with blower shakes the grader. The grader is fitted with two or more sets of sieves for grading the rice into various fractions.

A paddy grain after being properly de-shelled, remains coated with a thin layer of bran, the germ being loosely adhered to the rice kernel. This bran layer displays a dull appearance to rice grains, a minimum fraction of which is to be removed to bring about the acceptable appearance to the consumers and at the same time to make the grain suitable for human consumption, since bran content of rice, as it is, is a bit too much to be easily digested by human beings. The different types of rice whiteners are: a). Grinding type, b). Friction type and c). Combination of friction and grinding type.

Saving grain after harvest

Food grain losses occur during harvesting, threshing, transportation, loading, unloading, processing and storage. Losses due to improper storage practices, particularly at the farm level, are placed around 10% of production. The stored grains are mostly affected by insects, rats, birds, mites, fungi and moisture.

Vactor (RH787) at 2% as a single dose rodenticide and warfarin 0.025% as multidose rodenticide have been recommended for the control of house rats and mice.

For cutting post harvest losses, five golden rules for proper food grain storage at the farm level have been evolved by the Indian Grain Storage Institute. These are,

1 Store only dry and clean grains.

2 Use dunnage for bag storages.

3 Store grains in improved bins.

4 Fumigate the food grains with ethylene di-bromide and

5 Control rats with anti-coagulant.

Coconut

The main product obtained from coconut is copra or the dried kernel of nut. The 'cup' copra is prepared by splitting the husked nut into two halves and drying them in the sun. After drying for a day or two, the kernel gets detached from the shell or if necessary, it is removed from the shell. The drying is continued for another four or five days to a moisture content of 3-5%. During the rainy season, copra kilns are used for drying the kernel. Good quality copra can be obtained by drying the nuts at an air temperature of 70°C for the first 8 hours and then completely drying at 60°C. 'Ball' copra is prepared by storing fully ripe nuts with husks for about 8-12 months on a raised platform in a shed. They are sometime smoked or heated with a slow fire in order to accelerate the process of drying. During storage, water inside the nuts gets dried up and the kernel gets detached from the shell and rattles on shaking. Nuts are then husked and the shells are carefully broken. The ball copra thus obtained is clean, sweet and highly valued.

Copra is fairly resistant to mold, rancidity and putrefaction and when protected from insects and rodents by good packaging and refrigeration below 10°C, it can be stored for many months.

Recovery of coconut oil

A fine grade of coconut oil is prepared by pounding fresh coconut meat to a pulp and throwing into boiling water, whereupon the oil rises to the surface of the water and is skimmed off. The residual pulp is used for livestock feed.

In the dry hydraulic press method, the oleaginous coconut meat is dried and the oil is pressed from the copra by a series of steps. First the copra is reduced to small pieces by a hammer mill. The material is then heated to coagulate the proteins and to decrease the affinity of the oil for tissue solids, to cause coalescence of small oil droplets and to increase fluidity of the oil.

The oil is removed from the heated ground copra by mechanical pressing by the open hydraulic press. This may be continuous or by batches. By the batch method, the copra is spread on press cloths and metal racks. These are stacked with space between, and pressed with about 14,000 psi applied by the hydraulic lift, causing the oil to flow to the edge of the tier, and down the side into a collecting trough.

Centrifugal separation of the milk yields a cream 'skim milk' and a small amount of protein. The cream is pumped into maturing tanks and subjected to enzymatic action under close temperature and pH control, then chilled in a continuous freezing machine. Chilling is followed immediately by melting. The cream is centrifuged to remove most of the oil, and is then filtered.

Wet processing of coconut

The husked coconuts are steamed in an autoclave at a pressure of 3 kg/cm^2 for 10 minutes to facilitate removal of the kernal from the shell. The nuts are then opened, the kernels pried out and fed into a cutter. The disintegrated material is further comminuted by passing through a roller mill with closely set rollers, then fed into a screw press to squeeze out the 'coconut milk'. The milk is separated into an oil phase and a water phase by centrifuge. The oil phase is heated to 90°C centrifuged and filtered to get good quality oil. The water phase is heated to 99°C in a flow heater to coagulate the proteins which are separated by centrifuge and dried. The whey is concentrated under vacuum to a syrup like product called 'coconut honey'. A pilot plant with a capacity of 5000 coconuts/day is in operation at the Central Food Technological Research Institute, Mysore.

Refining coconut oil

Coconut oil removed from copra must be refined to remove free fatty acids, odours and flavours and yellow or dark colour. The need for refining is increased by the presence of mold or bacteria on the copra, as well as age and high moisture content.

Refining consists of adding a calculated amount of alkali to the oil to remove free fatty acids, subjecting it to steam under vacuum to remove odours and flavours, and filtering with carbon to decolourise it. In the process, a precipitate is formed which is removed for livestock feeding. It is claimed that oil removed from fresh coconut by the cream-centrifuge method does not need refining.

Coir making

The coconut fibre known as coir is extracted by beating the husks, either fresh or after retting, with a mallet to separate the pith. For retting, husks are burried in shallow pits in low lying areas subject to the tidal flow of backwaters for about 6-12 months. The coir obtained from dry husks or husks that have not been properly retted would be of inferior quality. It is easier to extract coir from green husks after sufficient retting and the quality of coir is good. The coir is then dried in the sun and spun into coir yarn by hand or with a machine. Coir yarn is used as such or made into ropes, mats, nets, bags etc.

Coconut Storage

Under good conditions of storage, coconut will keep for months with no signs of yellowing, rancidity or mold. The storage temperature and humidity should be kept as low as 10-15°C and 45-55% respectively. Infestation and moisture damage can be avoided by storing shredded coconut in a cool place.

Arecanut

Dried ripe nuts

The most popular trade type of arecanut is the dried, whole nut, known as 'Chali' or 'Kottapak'. Ripe nuts are dried in the sun for 35-40 days on dry level grounds. The dried nuts are dehusked and marketed as whole nuts. Depending on the size, there are various grades and preference in different regions. The well known grades of chali in decreasing order of sizes are 'moti'. 'srivardhan', 'jamnagar', and 'jini'. The characteristics of a good chali product are absence of immature nuts, surface cracking, husk sticking, fungus and insect attack and good cutting feel, inside structure and taste.

To facilitate drying, and dehusking sometimes the fruits are cut longitudinally into two halves and sun dried for about 10 days. The kernels are scooped out and given a final drying. This type of product is known as 'parcha'.

A mechanical through-flow drier has been recommended for making chali and parcha. In this type of drier, the hot air is allowed to penetrate through the bed of material kept in trays. The drier has a cabinet which is connected to a heat exchanger through a centrifugal blower. The bottom section of heat exchanger is connected to an oven and the top to chimney. Drying will be completed in 60-70 hours over a period of 7-8 days at progressively increasing temperature between 45 and 70°C. The drying procedure consists of 8 hours consecutive drying followed by equilibrium for 16 hours outside the drier.

Recently a dehusking device to remove husk from dry arecanuts has been developed at CPCRI, Kasargode. The machine is operated by leg while feeding the nuts is done by hand simultaneously. The device loosens the husk of the nuts, which can be easily peeled off by hand. It is reported that an unskilled worker can make about 40 kg of chali in a day of 8 hours.

Kalipak

It is another important form of processed arecanut. The nuts of 6-7 months maturity is soft and finger nail can be pressed into it. Outer skin is dark green in colour at this stage. The processing consists of dehusking, cutting the soft nuts into pieces, boiling cut pieces with water or dilute extract from a previous boiling, kali coating and drying.

During the boiling operation involved in kalipak processing, usually the same batch of water is used for boiling 3-4 batches of cut arecanuts. The extract so obtained is concentrated to make thick kali. After boiling, the arecanut pieces are given coating with the kali. The kali coating can be repeated to get a good glossy appearance.

Both sundrying and oven drying are adopted for kalipak processing. During monsoon, artificial drying over an open fire is done. Though drying is accelerated, smoky off-flavour is not desirable. A well dried product with a dark brown colour, glossy appearance, crisp chewing feel, well toned astringency and absence of over-mature nuts, is most welcome and is rated superior.

There are a few unboiled varieties well known in the trade, Iylon is such a variety made from green arecanuts in which nuts are cut transversely into 5-6 discs and dried without coating kali. The nuts used will be slightly more mature than those used for kalipak.

Scented supari

Dried arecanuts are broken into bits, blended with flavour mixture and packed. Scented suparis are of two types; the one made from chali and the other from kalipak. The former is more popular. At times, saccharine is used for sweetening. Additives like colour and flavour are added. Plastic strips are used for convenient packing. Tin and aluminium pouches are used for bulk packing of scented supari.

Storage

In Kerala. fresh fruits are generally stored by steeping in water. Discolouration of outer husk and foul smell result in this, due to bacterial attack. The inner core is practically well preserved. Such water preserved nuts, known as 'neetadaka' are favourite of many chewers who ignore its mild off-flavour.

Mathew et.al (1963) made use of a mixture of metabisulphite and benzonate at acid pH to preserve fully ripe nuts. An initial heat blanching was given to inactivate any enzyme, acting in the husk. The method consists of washing freshly harvested arecanuts in chlorinated water (100 ppm chlorine) for removing dirt and other extraneous matter. This is followed by blanching in 0.2% calcium chloride solution, which ensures firmness of husk and a lesser amount of surface microbial load. The enzymes of the husk are also inactivated as a result of blanching. The fruits are then kept immersed in a steeping solution containing 0.1% sodium benzonate and 0.2% potassium metabisulphite acidified to a pH of 3.5-4.0 using hydrochloric acid. Chemical and physical analysis indicated that fruits can be stored in good condition for 10-12 months.

Chali nuts are generally stored in single or double gunny bags and kept in fairly well constructed dry rooms. The nuts in storage are protected from infection by sulphur fumigation which also helps for bleaching the colour of the nut.

High grades of thinly sliced processed arecanut in Kerala are mostly packed first in mats made out of palmyrah leaves and then packed in single gunny bags or wooden boxes.

Cashew

The ivory white, dicotyledon kernels are the edible portion of cashewnut. Like all nut kernels, it is rich in protien and fat but poor in carbohydrates. It is superior to other nuts. India is in the fore-front in commercial processing of raw cashew nuts. About 70% of cashewnuts produced in the country comes from Kerala. Quilon is the main processing centre. Cashew occupies an important place in India's trade and is a significant earner of foreign exchange.

Processing of cashew consists of roasting, shelling, extracting the oil, peeling, grading and packing.

Roasting

Kernels are extracted from cashew nuts after roasting or sufficiently drying under sun. In the open pan roasting method, nuts in small quantities are kept in shallow iron pans of earthen pots and heated over an open fire. The nuts are rapidly turned to prevent charring. During roasting, large quantities of shell liquid and smoke would come off. The roasted nuts are then removed from the pan and thrown on the floor. They are quickly covered with earth which would absorb shell oil adhering to the roasted nuts and also cool them.

Sun-drying for 2-3 days can also be done, after which they lose much of the moisture content and become brittle enough for shelling.

In the continuous roasting process, the principle adopted is the same as in the open pan roasting method. This plant consists of single walled or double walled rotating metallic drum. In the case of a single walled drum, gases that escape from the nuts during roasting are allowed to escape through the chimney, while in the double walled drum, the smoke or gases produced escape through the interspace between the two walls of the drum and condensed to shell oil by a cooling system.

In the oil bath process the nuts are held in wire trays and are passed through a bath of cashew shell oil maintained at a temperature of 155-162°C for a period of about three minutes, whereby the shell oil is recovered from the shells to the maximum extent possible. It is claimed that this process ensures uniform roasting of nuts and eliminates charring of kernels.

Shelling

After roasting, shelling is done by human labour. Each nut is placed edge-wise and cracked open with a light wooden mallet and the kernel extracted. Care has to be taken that the inner kernel is intact and is not broken to bits.

Peeling

Extracted kernels have a thin outer skin which is brown and pinkish in colour. Removal of the skin or peeling is done by hand with the help of a safety pin

or small hand knife. Peeling is made easier when the kernels are subjected to a heat treatment for about 4 hours in a drying chamber, with a temperature of 80-90°C.

After peeling, the kernels are spread out indoors on cement flooring so that they may absorb some moisture and become less brittle. This prevents the tendency to break easily during grading. Thereafter, the kernels are kept in well ventilated rooms known as sweating chambers for 2-3 hours. This is not considered necessary in the case of sun dried nuts.

Grading

Grading is done based on number of kernels per pound. The kernels which have not split are separated as wholes. These are again separated into different grades, based on the size of nuts. The broken and split kernels are then classified as scorched pieces, splits, butts, small pieces and each grade is separately packed.

Packing

Packing is done in tins. In this method, the air inside the tin is exhausted and they are recharged with CO_2 before they are sealed air-tight.

Groundnut

Stripping

The most common method of stripping is to pull out the pods from the plants manually. But it is labour and time consuming process and thus becomes expensive.

Comb type stripper

This unit consists of four vertical legged frame with a strip of expanded metal fixed on to each of its sides in the form of a comb (fig.5). The stripping of pods is accomplished by drawing a handful of groundnut vines across the comb with slight force.

Drum type stripper

This stripper consists of a hollow drum formed by two metal discs at the ends, connected on the periphery by five 12 mm mild steel rods inserted inside and covered by thick and soft rubber tubes (fig.6). The drum is mounted on pedestal bearings and is free to rotate. It is fixed on a frame work at a convenient height so that the operator can stand and beat the root portion of the handful of plants over the rubber covered rods of the revolving drum. This was developed at Tamil Nadu Agricultural University and was found economical and efficient to comb type stripper and hand stripping.

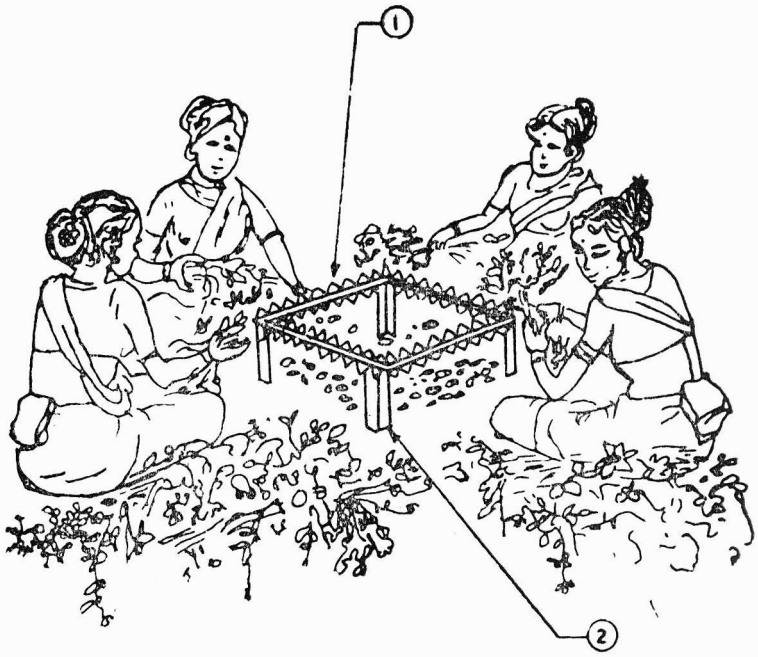

Fig. 5. Comp Type Groundnut Stripper Developed by Coimbatore Centre
1 Comb 2 Frame

Grading

The Tamil Nadu Agricultural University has developed power operated groundnut grader to improve the quality of the groundnut for better price and efficient decortication and other processing operations. It grades groundnut into three category, grade I, grude II and rejects. It consists of a feeding hopper, two oscillating sieves, brushes below the sieves to avoid clogging, frame and a 0.5 hp primemover. At the head end of the sorting sieve, a spreader is provided to create uniform layer for efficiency in grading (fig. 7).

Decorticating

Generally the groundnut kernels are taken out from the pods by cracking the shell applying finger pressure. By this method, the output per man hour is very low. The Tamil Nadu Agricultural University has developed manual as well as power operated groundnut decorticators.

Manual groundnut decorticator

It is a device which breaks the shells and loosens the kernels which can be separated by winnowing or with a cleaning basket. The device consists of an oscillating sector and a fixed perforated concave. The oscillating sector has cast iron blocks with pegs which apply pressure on the pods against concave to achieve decortication. The clearance between the oscillating sector and the concave are adjustable to suit a particular size or variety of groundnuts (fig. 8).

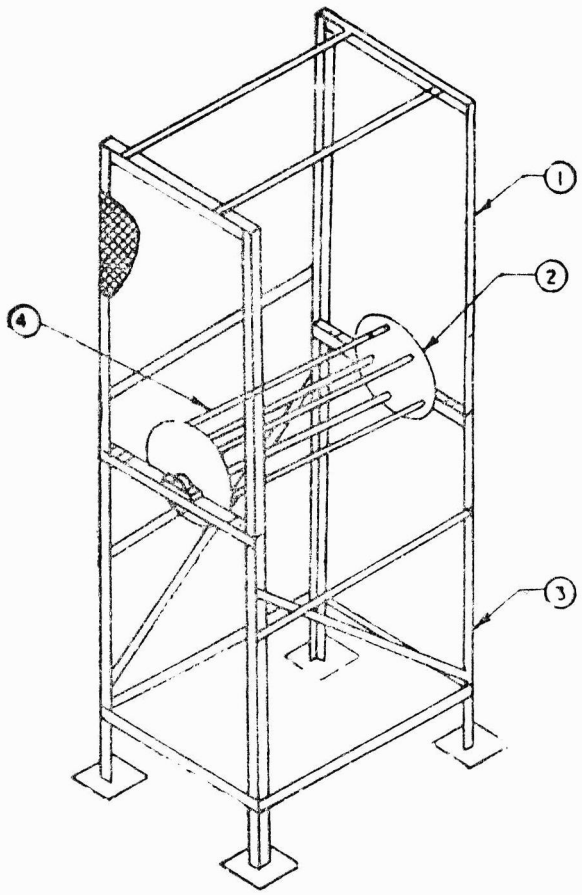

Fig. 6 Drum Type Groundnut Stripper Developed by Coimbatore Centre

1 Hood Frame
2 Revolving Drum
3 Frame
4 Rubber Tube (M. S. Rod Inside)

Source: Technical Bulletin No. CIAE/PHTS/81/24.

Power groundnut decorticator

The machine consists of a hopper, a double crank lever mechanism, an oscillating sector and a blower on a frame (fig. 9). In the oscillating sector unit a number of cast iron plates with projecting pegs are fitted. It associates close to a concave sieve fitted just below the oscillating sector. The pods are fed through the hopper mounted on the top of the unit. The pods are shelled between the oscillating sector and the fixed perforated concave sieve fitted just below the

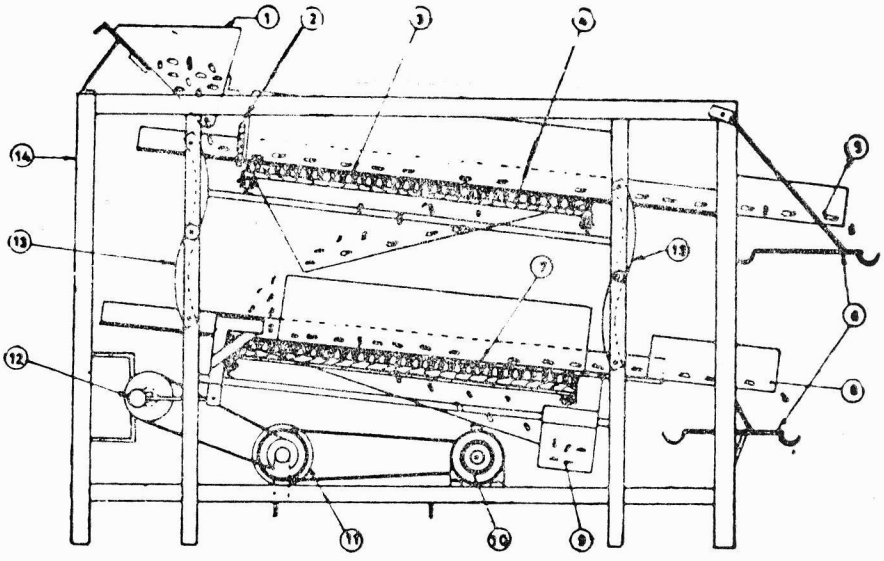

Fig. 7 Schematic Diagram of TNAU Groundnut Grader with Brush

1	Hopper	8	Grade II
2	Damper	9	Rejects
3	Top Sieve	10	Electric Motor
4	Sliding Brush	11	Stepped Cone Pulley
5	Grade I	12	Eccentric
6	Gunny Bag Holder	13	Bell Crank Lever
7	Bottom Sieve	14	Frame

Source: Technical Bulletin No. CIAE/PHTS/81/24

oscillating sector. The pods are fed through the hopper mounted on the top of the unit. The pods are shelled between the oscillating sector and the fixed perforated concave sieve. The mixtures of kernels and shells are subjected to a blast of air from the blower which separates kernels and the shells. The kernels are collected through a spout at the bottom of the machine, while the shell is blown off by the blower. The clearance between the concave and the oscillating sector is adjustable to decorticate the pods of varying sizes and varieties. The sieves are also replaceable, to avoid damage to the kernels.

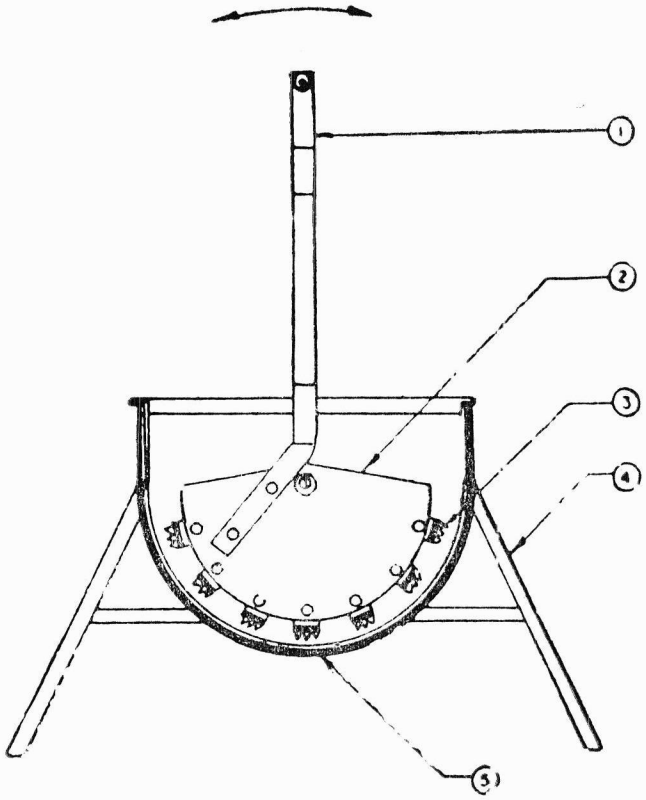

Fig. 8

Schematic Diagram of TNAU Manual Groundnut Decorticator

1 Handle
2 Oscillating Sector
3 Pegs
4 Stand
5 Sieve

Source: Technical Bulletin No. CIAE/PHTS/81/24

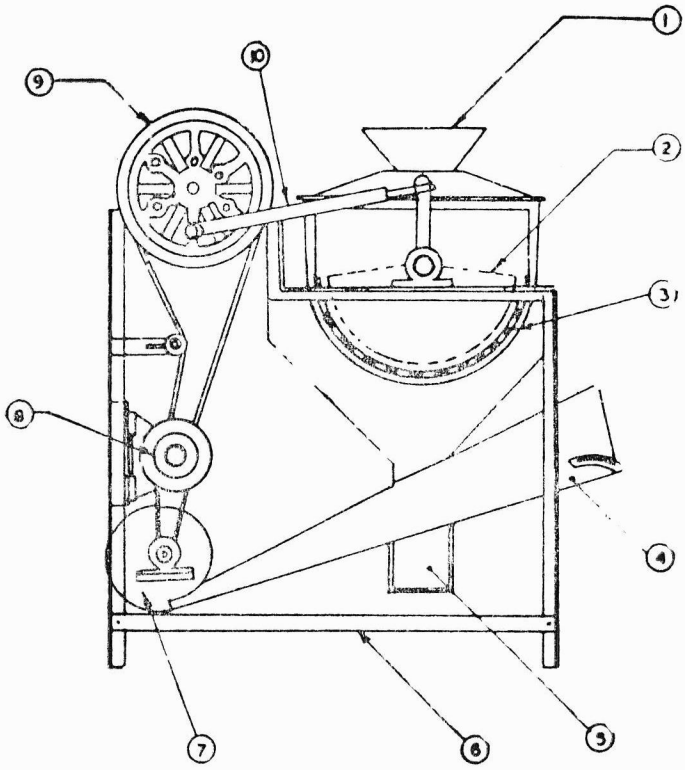

Fig. 9

Schematic Diagram of TNAU Power Groundnut Decorticator

1 Feed Hopper
2 Oscillating Sector
3 Concave Sieve
4 Chute
5 Kernel
6 Frame
7 Blower
8 Elec. Motor 1 HP
9 Fly Wheel
10 Connecting Rod

Source: Technical Bulletin No. CIAE/PHTS/81/24

Cocoa

When the pods are ripe, usually judged by the external colour, they are removed from the tree and stacked for subsequent conveyance to the siteof fermentation and drying. Care should be taken that the pod is not damaged during removal from the tree and that the tree itself is not damaged.

The pods are kept overnight and opened next day. A more efficient and safe way of opening the pods is by the use of a wooden billet. The method is to crack the pod with two sharp blows using one edge of the wooden billet, just distal to the greater diameter of the pod. The distal portion of the pod will fall away, and the beans remain attached to the plasanta in the proximal position whence they may be conveniently extracted with two fingers.

The beans after separation from the pods are to be fermented for removing the pulp or mucilage covering of the beans and to increase the flavour of the beans. The fermentation or sweating process differs in different localities. In the box method the boxes are usually made of wood having a capacity of at least 1 ton of wet cocoa and they should not have any iron nails, as they will stain the beans. The bottom plate of the box is perforated to allow air for fermentation and drainage of the sweat juice produced from the pulp. The beans collected from the pods are kept in the box and they are covered with dry leaves to maintain the temperature required for fermentation. After 24 hours, the beans are mixed and again they are kept in the box for another 24 hours fermentation. After this, the seeds are cleaned by washing. The beans are then dried by spreading them on a table or a mat in the sun. The range of temperature required for drying is 45—60°C. To get uniform drying the beans are stirred and spread again in the sun.

The beans have to be dried to contain 6—8% moisture content to ensure good keeping quality. Electric driers can also be used for this. After drying, the beans are fried and the outer coating is removed. The thick fat (cocoa butter) is removed by applying pressure on the macerated beans. The separation of the cocoa butter from the ground cocoa mass is achieved in the conventional methods by using screw presses, horizontal presses, vertical presses or by solvent extraction. These methods are suitable only for processing large quantities of beans.

The Kerala Agricultural University has developed an equipment for extraction of butter on a small scale. This utilised the pressure developed by a hydraulic jack for extraction of butter. A maximum of 44.8% of butter could be extracted by applying a pressure of 248.72 kg/cm^2 at a temperature of 70°C with this equipment. The other product ie., the cake is powdered to prepare cocoa powder. Theobromine is extracted from the cake.

Coffee

Preparation of parchment coffee

Well ripened berries are selected for preparing parchment coffee. The stages involved in the preparation are described below :

Pulping

It is the removal of the sweet mucilagenous flesh and the skin and freezing the berries inside by pulpers. The berries are pulped in the same evening they are picked and not allowed to lie over.

Fermentation

Firmly adhering mucilage over the berries is loosened by fermentation. This consists in merely keeping the pulped berries heaped up to take fermentation for 12-36 hours.

Washing and trampling

After loosening the mucilagenous coat, they are trampled under the feet and washed in water repeatedly until the berries are quite free and clean. During trampling and washing all the light beans are removed. Under-washing produces spots on the dried parchment which is a blemish, called 'foxiness' in coffee. Over-washing weakens the parchment and causes to split at the drying stage.

Drying

Drying is conducted over mats in the open sun. Seven days of good drying is deemed to be the correct stage.

Peeling

After drying, the outer coats or parchment are removed by peelers and during the process the thin paperly layer called the silver skin surrounding the bean is also peeled.

Instead of preparing parchment coffee, fruits are dried in the sun without any pulping at all. This is called cherry coffee.

Industrial processing

Roasting

Before the full flavour of the coffee can be brought out, the beans are roasted for 20-30 minutes. The roasting machine consists of a rotating, closed cylinder which is heated. The cylinder must be closed because during roasting, volatile material is driven off and re-absorption of this by the beans later, gives the characteristic flavour. Small-scale hand-operated roasting drums can also be used for this purpose.

Grinding

The grinding of roasted coffee is done by machines which vary in size and employ the principle of corrugated rollers with one rotating and the other stationary. Ground coffee especially when finely ground, loses its flavour rapidly: it is therefore often sealed hermetically in tins before despatch.

Soluble coffee like Nescafe, are made from an infusion of coffee from roasted and ground beans, which is then dried very rapidly by spraying into very hot air. Extremely rapid evaporation takes place and the dried product easily dissolves again in water to give back the original infusion.

Tea

The manufacture of tea starts in the field from the time of plucking. The flesh is transported from the field to the factory where it undergoes mechanical processes associated with the manufacture of the finished product. The processes involved in the manulacture of tea are withering, rolling, fermentation and drying.

Withering

Withering is done to prepare the leaf for the subsequent processes of manufacture. The leaves if used without withering would be a mass of torn pieces. Tea leaves undergo a period of dehydration in specially constructed sheds or lofts. The plucked leaves are spread in tiers of gunny pieces arranged one over the other. The temperature of the air is adjusted by fans. The leaves attain a flaccid condition and then ready to pass on to the rolling chamber. The following tests will be useful to judge whether good withering of tea is obtained.

1. Well withered leaves should not produce crackling sound when squeezed.
2. When pressed with the hand should form a compact ball.
3. The stalk of the withered leaf should not be brittle.
4. Withered leaf will be like a silk hand kerchief to touch and feel.

Rolling

Rolling is carried out by machines and due to this action cells in the leaves are broken and liberate the sap containing enzymes necessary for fermentation.

When the leaf is rolled during the breaking of the leaf the polyphenol substances contact with the enzyme polyphenol oxidase and in the presence of oxygen the polyphenols are oxidised and changed to two highly coloured groups of substances viz; theaflavins and thearubigins. The former are a bright and reddish golden colour responsible for the bright and red colour of a good tea liquor: the latter have a muddy red brown colour producing deep colour and excess producing dull liquors.

Teas are rolled 2-3 times for 30-40 minutes. After the first roll the leaf is spread over a sifter called the green leaf sifter with a view to separate fine teas

from the coarse. The fine teas will be sent to fermentation room whereas the coarse teas will be given a second rolling.

Fermentation

Fermentation is one of the most important factors determining the character of the liquors. The leaves are either spread on the cement concrete bed or aluminium trays. Fermentation time generally varies from 1-3 hours. In fact fermentation commences from the time of rolling to the entry into driers. Oxygen and temperature are important for fermentation, these influence polyphenols in the cells to undergo chemical changes. If the fermentation time is for 2 hours, the maximum briskness, quality and colour can be obtained except strength. The strength and colour may be improved if the fermentation continues for 3 hours, but the briskness and quality will suffer. It is therefore essential to adjust the time of fermentation to have a balance to produce the maximum strength, colour, briskness and quality.

Drying

The fermented leaves undergo a process of drying in special oven called driers. The driers are maintained at a higher temperature initially from 120-138°C and then reduced to 94°C and at the end still further reduced. The leaves are dried for 30-40 minutes. The leaves after drying contains 3-4% moisture. Final drying is done at 66°C before packing.

Blending

Tea as manufactured has to be blended before it reaches the consumers. Blending is done to produce a product with uniform character so that the consumer may get a similar product in each packet.

Green tea

The leaves for green tea are heated as quickly as possible after harvest to a temperature which inactivates the oxidising enzymes. It is then cooled and rolled and by further heating and rolling, is dried eventually to about 4% moisture. To make green tea, it is important that good quality leaf with small shoots should be plucked. Green teas are very strong and pungent. The liquors have an olive or pale yellow colour but never reddish or brownish.

Rubber

Anti-coagulants (solutions of ammonia, formalin or sodium sulphite) are added to the latex to prevent its coagulation before it reaches the factory. The latex is bulked first and then strained to remove the impurities. Then it is diluted to a standard consistency of 12-15% rubber. Special hydrometers like metrolac, latex meter etc. are employed to measure in lb. of latex/gallon or the percentage of rubber. After dilution and short delay for precipitation of heavy particles like sand, the latex is strained through a 60 mesh screen for the second time. Then it is poured into the special coagulating tanks or aluminium pans and acetic acid or formic acid is used for

coagulation. Slow coagulation produces a soft rubber which is easy to work on the rollers. The acid is to be added quickly and mixed thoroughly with the latex. Froth formed is removed to avoid formation of bubbles on the surface of rubber sheets. Precautions have to be taken during these processes to avoid bacterial contamination or development of defects in the rubber.

Smoked sheets

After coagulation, rubber is washed several times with changes of water and passed through hand or power operated rollers. Washing of the rubber in water is carried on to free the impurities as far as possible. The washed rubber is often called as biscuit or sheet and is sent through rollers. In this process, excess water and dissolved impurities are pressed and squeezed out. The surface of the rollers may be either smooth, or grooved. The sheets are hung in shade for two to three hours of dripping in a dust free place. Then they are taken to smoke houses for thorough drying. Smoking of rubber sheets is done with the object of drying the sheets properly and gradually to avoid blisters. During smoking the rubber sheets not only get dried but also absorb some creosotic particles from the smoke which prevent the growth of moulds when exposed to damp conditions. During the first day of smoking, the sheets are smoked at a low temperature (44-48°C) with fairly high humidity. Subsequently during second to fourth day the temperature being 60°C with low relative humidity. Then they are taken out, graded and packed. High grade rubber sheets are clear, free from flaws, transluscent and of golden brown colour and fetch a better price.

Cassava

Raw cassava tubers are extremely perishable and do not keep well for more than 4-5 days. To prolong the shelf life of freshly harvested tubers the roots are washed to remove the dirt and then dipped in a container of melted paraffin. Under this method, cassava stored at 20°C and 60% relative humidity will have a 100% index of conservation.

Under field conditions the tubers are successfully stored in a clamp which is a heap of tubers about 1.25-1.5m diameter and 1-1.25m height, covered and underlain by straw or soil. This condition will maintain tuber quality upto 8 weeks. The method adopted in Kerala is to store the product in dried forms. Immediately after the harvest, the tubers are peeled, sliced and dried in the sun for 4-5 days to produce the white chips.

Another dried product is the parboiled chips for which the freshly harvested tubers are sliced without peeling and cooked in boiling water for about 10 minutes prior to drying. The white chips keep well for about 6 months in dry season but are liable to get mouldy in wet weather. The parboiled chips when kept in dry places can be stored for 12 months or more. The white chips of superior quality are mainly used for the manufacture of cassava flour and the inferior quality chips are used as cattle feed.

Cassava flour is prepared by grinding the white chips and is used in different preparation as rice and wheat flour. It also finds use in confectionary, biscuits and other processed foods.

In an experiment on storage done in Kerala Agricultural University, it was found that tubers packed with fresh cassava leaves remained in good condition for about 6 months. Cassava leaves as a packing medium was found superior to other media tried and the best results were obtained when perfectly good tubers immediately after harvest were used.

Pepper

Black Pepper

Sun drying is the major processing step in the production of black pepper. Another method of processing is by keeping the harvested berries in boiling water for one minute followed by spreading them in sun to give the pepper a shining colour due to the upsurge of wax like compounds.

The curing process in pepper comprises its cleaning and processing. This aims at reducing the moisture level upto or below 11%, elimination of light berries to below 2%, elimination of all foreign matters like leaves, stones and to make the produce free of mould etc.

Ungarbled black pepper will be a better raw material for oleoresin production due to its price advantage. During grading, immature and fully formed berries with wrinkled surface are used as raw material. Now, blending of oleoresin with essential oil is accomplished to reach suitable oleoresin with optimum quality. Oleoresin is solvent extracted. Alcohol and acetone are popular solvent at 30ppm levels.

White pepper

White pepper is produced from fully ripened berries, which are greenish-yellow and at the point of turning red. After being picked, the berries are packed in sacks and soaked in slow-flowing water for about 8 days. These softened berries are then trampled on or otherwise macerated to rub off the outer hull. The grey inner pepper-corns are washed and dried in the sun for several days on mats or on concrete floors until they turn creamy white in colour, to become the white pepper of commerce. This white pepper is known as 'Muntok'.

Mature green pepper is steamed or boiled in water until skin is soft, and the skin is rubbed off and berries dried. This method is quick. This gives a fine smelling product. The skin can be distilled to recover oil as a by-product. From one tonne of green pepper about 200gm of white pepper can be obtained.

Canned and bottled green pepper

Green pepper is exported from Kerala in the form of dehydrated green pepper and green pepper in brine. For making dehydrated green pepper the cultivars like 'kalluvally', 'karimunda' and 'chetan' give a bright green product with very good flavour. The green colour remains stable for fairly long periods. When the pepper is soaked in lukewarm water, it will regain its original fresh green colour and flavour.

Ginger

The unit operations in processing of ginger are washing, peeling, drying, polishing, pulverization, packing and storage.

Washing

Ginger is soaked in still water overnight and next day water is sprayed over it to clean it. For cleaning of rhizomes soaking and water spray types of washers are used. In some cases a rotary drum type washer is also used as commercial washing device because of its simplicity, high capacity through cleaning and causing minimum damage to the product.

Peeling

Indegeneously, peeling of ginger is performed by rubbing the ginger pawns soaked in water overnight, against jute bags or by scrapping with sharpened bamboo or sea shells. Use of abrasive brush peelers gives satisfactory results in large scale. The scrapped or peeled rhizomes are again washed well and dried in sun for a week or more and rubbed again to give a polish. This process produces unbleached dried ginger.

For producing bleached ginger, the green peeled rhizomes ere placed in large shallow cisterns and covered with 2% clean lime water for 6 hours, then removed, fumigated for a few hours with sulphur and dried. This process is repeated 2-3 times to get a fully bleached white product.

Drying

The moisture content of ginger is about 80-93% (wet basis) at the time of harvesting, which is brought upto 11-14% or even less for its storage. Indegeneously, ginger is sundried in a single layer in open yard which takes 7-10 days for complete drying. The dried ginger presents a brown, more or less irregular wrinkled surface and when broken shows a dark brownish colour. In mechanical drying chamber and with the help of the electric heating coil and blower, the rhizomes are dried at 80°C temperature.

Polishing

Polishing of dried ginger is done to remove the wrinkles developed during drying processes. Hand or power operated polishers are employed for this purpose. Turmeric polishers are used for polishing ginger also.

Pulverization

Ginger powder is produced by pulverizing dried ginger rhizomes with the help of conventional power operated hammer mill. Power operatad macro-pulverizer driven by 2 hp. motor could be used for pulverization of dried ginger.

Storage

Rhizomes of ginger must be protected from chilling injury and sprouting during storage. Moreover, ginger is susceptible to shrivelling and mold growth. Ginger is normally stored in under ground structures. Temperature of 12.8°C at 65% relative humidity is recommended for safe storage of ginger for 3 months. Powdered ginger should be stored in cool dark cellar at temperature not exceeding 17°C and 65% relative humidity. Bleached ginger in thick polythene bags can be stored for one year without much quality deterioration. Bleached ginger has a better storage life than unbleached ginger (Valsala *et al.* 1988).

Turmeric

Cleaning

Harvested turmeric rhizomes are cleaned off mud and other extraneous matters adhering to them. Only good fingers separated from the bulbs are used for curing.

Boiling

The boiling of fingers is done in M. S. pans. A rectangular M. S. pan of 1.0m x 0.62m x 0.48m will be sufficient for this purpose. The cleaned fingers (approximately 50 kg) are taken in a perforated trough of size 0.9m x 0.55 x 0.4m made of G. I. or M. S. sheet with extended parellel handle and kept in the pan. If the water is acidic; sodium bicarbonate or sodium carbonate at the rate of 100gm n 100 liters of water may be used to make it alkaline and poured into the trough so as to immerse the turmeric fingers. The whole mass is boiled till the fingers become soft which can be tested by piercing a wooden needle. The needle will pass through the finger without much resistance. Generally it takes about 30–40 minutes. The cooked fingers are taken out of the pan by lifting the trough and draining the solution into the pan. They are unloaded on the ground in the form of a heap and left undisturbed for 4-5 hours. Alkalinity of the boiling water helps to develop orange yellow tinge upto the core of the rhizome.

The drained solution in the pan can be used again for cooking another lot of turmeric. The cooking of turmeric is to be done within two or three days after harvest. Delayed and over cooking will spoil the quality of turmeric.

Drying

The cooked fingers are dried in the sun spreading in thin layer on bamboo mat or drying floor. Usually it takes 10-12 days for drying in the sun.

Polishing

In order to smoothen the rough and hard outer surface of the boiled dried turmeric and also to improve the colour it is subjected to polishing.

1. *Hand polishing*

It is simple which consists of rubbing the turmeric fingers on a hard surface or trampling it under the feet, wrapped in gunny bags. The improved method is by using hand operated barrel or drum made of expanded metal mesh mounted on a central axis. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against the mesh as well as rubbing against one another as they roll inside the drum.

2. *Machine polishing*

It consists of an octagonal or hexagonal wooden drum mounted on a central axis and rotated by power.

Storing

The polished turmeric is stored in gunny bags. Fumigation with a suitable insecticide helps in storing the turmeric for longer periods.

Cardamom

After harvesting, cardamom is processed within 24-36 hours to avoid deterioration. Processing includes pre-treatment, drying, cleaning, packing and grading.

The freshly harvested cardamom fruits are washed in water to remove dirt. Washing capsules with sodium carbonate solution for about 10 minutes cleans the capsules as well as in retaining the green colour during artificial drying. In case of alkali wash, the capsules may be again washed in fresh water and the water is completely drained off before drying. The process of bleaching in the production of bleached cardamom consists of pre-treating the freshly harvested capsules by soaking them in 1% solution of bleaching powder for 30-60 minutes followed by dipping the lot in dilute solution of HCl for 23 minutes. The treated capsules are washed and sun dried to 8-10% moisture content. Bleaching shows slight reduction in oil content as well as may have an adverse effect on the characteristic aroma and flavour.

For producing green cardamom, freshly harvested capsules are dried to reduce the moisture content from 80% to 10% without effecting the colour which is very easily bleached if exposed to sun. Artificial drying in such cases becomes a necessity. The drying operation in green curing is done under controlled conditions of temperature and air flow in specially built drying houses by using radiated heat. For this purpose, the devices in use vary from sheltered mud platforms heated by a slow fire from beneath to large drying houses or kilns heated by flue pipes as is mostly done in large plantations. In kiln driers, temperature is maintained at 45-55°C and air circulation is achieved by natural convection or with exhaust fans. In electrical driers, temperature is kept at 50-65°C and air circulation is done by an electrically operated fan. The time required for drying vary from 24-36 hours in kilns and 12-24 hours in electric driers.

After drying, the cardamoms are rubbed by hand or with a rough coir matting or a piece of wire mesh for cleaning. This process is known as garbling. This operation can be done in gunny bags also. The dried cardamoms are filled in gunny bags with few stones (50-100kg) and tied. Give jerky shakes for 5 minutes and then winnow the product to remove the foreign materials. As green cardamom need protection from light and air during storage and packing, they are usually stored in gunny bags with black polyethylene sheet.

Nutmeg

The nutmeg of commerce is the ovoid kernel which is hard and brown enclosing which is a thin brittle shell. Surrounding this shell is the arid, scarlet in colour which furnishes the mace of commerce.

The mace is separated from the nut carefully without breaking. The nuts and mace are dried separately. After drying, nuts are preserved in air-tight containers in a dry place. Nuts are dried in the sun. The nuts are either shelled or preserved with the shell. The kernels are treated with lime before export to give them a good colour and to prevent insect damage.

Mace is used as a culinary spice and largely as a flavouring agent. It contains the volatile oil 'macine'. The husk is used for pickling when the fruit is at tender stage. Fresh husks of the ripe fruit can be used for making jelly.

An essential oil is extracted for use in medicine, toilet soaps, dental pastes etc. The aromatic oil has butter like consistency and is orange in colour. Nutmeg butter is used in the manufacture of scented oils, perfumes and soaps and as flavouring agent in cooking and confectionary. A great point in its flavour is that it does not turn rancid, even after long storage on account of the small quantity of essential oil combined with it.

Cinnamon

Peeling and extraction of bark

The cutting of shoots for peeling of bark is commenced as soon as the rain ceases. The new growth of bushes of leaves should stop and the trees should have mature leaves. This indicates the free flow of sap between the bark and wood. This is the proper stage at which the best quality bark can be obtained in the cutting. Shoots selected for cutting are usually one metre long and 1-2cm thick. The shoots suitable for peeling are removed from the stumps and the terminal ends of shoots are removed. The cut stems are collected, tied, bundled and carried to the shed.

Peeling is done with the help of a small knife having a round edge at the end. The cut stems or sticks are given longitudinal slits from end to end. By working the knife the two halves of the entire bark is removed. The bark does not peel easily, the sticks are rubbed in between hard pieces or wood so as to enable easy detachment of the bark.

Rolling

The barks are packed together and placed one above the other and pressed well. The length of the bark is reduced to 20 cm and piled up in small enclosures made by sticks. Then they are covered with dry leaves or mats so as to preserve the moisture for the next day operation and also to aid a slight fermentation. The preservation of moisture is very important for subsequent operations known as piping.

Piping

After peeling and rolling, the outer skin of the barks are scrapped off with a small curved knife. The scrapped slips are sorted into different grades according to thickness.

The graded slips are rolled to form pipes by fitting in over the outer cover of the pipes. The slips are trimmed, ends are cut and pressed over pipes. Soon after piping, they are allowed to dry. During drying smaller quills are inserted into the bigger ones, forming smooth, pale brown cane like bundles or compound quills about one metre long which are known as pipes, or ‚quills'. The quills are arranged in parellel lines in sheds for drying. After drying, they are packed in mats and then send to the market.

Good quality cinnamon should be light brown with wavy lines and produce a sound of fracture when broken. Shoots which are exposed to sun are said to be more spicy than those grown under shade.

Cinnamon chips

Chips are prepared by scrapping and clipping the bark, after removing the outer bark. The chips are made into powder and saturated with common salt and distilled to get 0.2—1% cinnamon oil. The colour of the oil is from yellow to cherry red. The oil is higher in density than water and possesses a strong odour. It is used for blending of camphor and cinnamon.

Vanilla

The pods ripen in about 9—11 months time. When the fruit turns yellow from the tip it is harvested for curing.

Curing

After harvest, the beans are allowed to shrivel for 3-4 days. Then immerse in hot water (80°C) for one minute and spread out for drainage. After drainage the pods are spread on a blanket and exposed to sun for drying. When the beans become hot, fold the blanket over them and keep for the rest of the day. At night put the beans in a sweating box lined with blanket. This process is repeated for 8-10 days till the beans turn dark brown in colour. When properly cured, dried vanilla beans will be almost black in colour and ripple enough to be twisted round the finger without rupturing. It is then stored according to the length, tied into bundles and kept in airtight containers till marketed or used for extracting vanilla essence.

Fruits and Vegetables

Banana

Dehydration

Sun drying

The keeping quality of food materials is greatly influenced by their water contents. Fruits and leafy vegetables containing high percentage of water deteriorates more rapidly. In India more food is preserved by sundrying than by any other means.

'Plantain figs' are prepared from mature but hard bananas. The fruits are peeled after dipping them in boiling water for 2—3 minutes and cut lengthwise first into halves and then into 3 or 4 pieces. The slices are dried in the sun for about a week in fly and damp-proof trays. Dehydration may also be effected in home driers or specially constructed drying rooms.

Mechanical dehydration

The modern process of dehydration consists of the removal of moisture from foods by the application of heat usually in the presence of a controlled flow of air. A satisfactory dehydrator will permit close control of temperature, air velocity and relative humidity. Mechanical drying affords a means of producing dried fruits of new forms, and in some instances of better quality than is possible by sun drying. Preparation of fruit for dehydration is similar to that for sun drying.

Green bananas are blanched before peeling to loosen the skin. They are cut into slices, sulphured for 15—30 minutes and dried at about 60°C. Drying takes 18—20 hours. Ripe bananas are peeled and dried whole. They are of dark colour, unattractive in appearance but of fairly pleasing flavour. If the ripe fruit is sliced lengthwise and sulphured for 20 minutes before drying much more attractive product is obtained. Green banana dried product is brittle and is ground to make banana flour.

Canning

Fully ripe fruit is peeled with hand and cut laterally into slices of $\frac{1}{2}$"—$\frac{3}{4}$" thickness. Sugar syrup of 25—30% Brix containing 0.2% citric acid is used. The pH value of banana is found to vary from 4.5—5.3. The cans are processed for 15 minutes in (1) boiling water, if the pH of the fresh fruit is 4.8 or lower and (2) in a pressure cooker after 5 lb. steam pressure if the pH is higher than 4.8. Cooling after processing should be quick and thorough.

Mango

Dehydration

Sun drying

Partial dehydration of juice and pulp is carried out in households and on a cottage industry basis in many localities by spreading the material on shallow pans and exposing to the sun. The pulp may be mixed with sugar and warmed before drying. The dried product is brown in colour and used in ice creams, cakes etc.

Mechanical dehydration

Fresh juice of ripe mangoes is dried by spreading out the juice in trays to a depth of $\frac{1}{8}$", first at a temperature not exceeding 50°C for 4—6 hours, in a shelf drier and then at 60°C for one hour in a vacuum drier. Addition of cane sugar (10%) improves the taste and treatment of juice with sulphur dioxide improves the colour but affects the flavour.

Canning

Among the numerous varieties, Neelam, Mulgoa, Alphonso etc. are more important for canning purposes. Juicy and fibrous varieties are not suitable for canning.

Firm ripe mangoes are picked and ripened in straw. These are then peeled with hand and pulp cut into chunks and slices which are placed in 2% common salt solution or a solution containing 0.05—1.0% citric acid to prevent browning. Since most of the varieties are comparatively sweet, it is necessary to add 0.2—0.3% citric acid to the syrup for safe processing of the cans.

Pineapple

Mechanical dehydration

Well ripened pineapple are peeled and cored. They are sliced about 3/8" in thickness. The slices are brought to boiling in a syrup of 40° Brix, made of sucrose and corn syrup in equal proportions, plus water to give 40° Brix and allowed to stand for 3 hours before drying. Drying is carried out at 65°C in air blast dehydrator at 12m/sec. air velocity.

Canning

Pineapples are peeled and cored mechanically. Eyes are also removed. The slicing machine slices them transversely into rings 3/8"-1/2" thick. Slices are put into cans. Cans are filled with syrup and sealed under about 15" vacuum. Processing is done at 92-95°C for 7-10 minutes. The cans are then cooled. Shells, trimmings and other byproducts are shredded and pressed to recover the juice. The cake is used as cattle feed.

Fruit Juice

The extraction of juice from fruit usually involves crushing and pressing. For this special types of juice extractors are available. The extracted fruit juice is then filtered or clarified. Fruit juices after extraction always contain varying amounts of suspended matter which consists of broken fruit tissue, seed, skin, various gums, peptic substances and protein in colloidal suspension. Preliminary heating or pasteurisation reduces the viscosity of the juice 24-48 hours settling usually results in the coagulation of much of the proteins and gums of the juice and its elimination by settling, together with a large proportion of the suspended finely divided pulp. The clarified juice can be filtered easily giving brilliantly clear filtrates. However in the clarification of juices commercially the usual procedure is to treat the juice with peptic enzyme for several hours or overnight followed by filtration.

To retain natural taste and aroma of the juice, it is necessary to preserve it immediately after extraction. The various methods adopted are pasteurization, addition of chemicals, addition of sugar, freezing, drying and filteration.

Fruit Jelly

Fruit jelly may be made from under-ripe, undersize and off-grade fruit, or even from peels, cores and wind-fall fruit. Three essentials are pectin, sugar and acids in the proper proportions. To achieve the pectin/sugar/acid ratio the juices of under-ripe or over-ripe fruit may be blended, the juice of different fruits may be mixed, or artificial colours or flavours may be added.

The viscosity of fruit juice is an index of its jelling power. An instrument devised by Baker (Myers and Baker 1933) is helpful in this respect, because it indicates the amount of sugar necessary to produce a jelly of desirable physical characteristics.

The fruit juices necessary for jelly making are obtained by boiling the fruit with water and later straining or filtering the solid pulp from the juice. The amount of water required depends on the type of fruit. The duration of heating must be no longer than is absolutely necessary because flavours may be dissipated or the pectin may be hydrolyzed and converted to pectic acid.

The heating is usually carried out in steam-jacketed metal kettles which are sometimes glass or enamel-lined. When the juice goes to the kettles, sugar is added in accordance with the acidity and pectin content of the juice. If the sugar content is too low, the resulting jelly is likely to be tough; excessive sugar results in a soft, easily-broken final product. The hydrogen ion concentration of the mixture is of great importance and for satisfactory results pH should be approximately 3.2-3.5.

The contents of the kettle are boiled for the purpose of concentrating the mixture juice, pectin, and sugar until the point is reached at which the concentrate will, on cooling, form a jelly of desired characteristics. During boiling it is necessary to skim off the film or foam which forms on the top, as otherwise the appearance of the finished jelly would be impaired.

The point at which the boiling should be stopped is of the utmost importance. The use of a refractometer enables the determination of the index of refraction which is an accurate means of judgement concerning the end point. Thermometers or thermocouples may be used to indicate the temperature, which should be approximately the boiling point of a 65% sugar solution, 103-105°C, when the process is complete. The maximum jelly strength is usually attained when the sugar concentration of the jelly is approximately 65-69%.

When boiling has been completed, the jellies are run into the final containers while still hot. Glass jars are used for most jellies distined for the retail trader while cans and pails may be the containers for institutions and bakery trade. The temperature of the boiling jelly is usually sufficient to eliminate any spoilage microorganisms present. The high sugar content inhibits growth of most microorganisms encountered subsequently with the exception of molds. After the containers are filled, they should be handled as little as possible until the jelly has set because shaking injures the formation of the physical structure.

Jams

After the preliminary crushing of the fruit or other preparation, the required amount of sugar is added and the mixture is heated in steam-jacketed kettles or preferably in vacuum pans if the fruits have delicate flavours. The heating is continued until the proper boiling temperature is reached, which will depend on the sugar concentration desired in the finished product.

Jams for domestic use are commonly packed in glass containers and usually have sufficient sugar content to preserve them against spoilage due to microorganisms. The effect of heating in containers may cause undesirable changes in colour and flavour just as readily as these many occur in the kettles, so the containers should be cooled as soon as possible.

Vegetables

Dehydration

Certain vegetables eg. sweet potato, peas, string beans, tomato, pumpkin cabbage and beet root are suitable for both canning and dehydration; a few others eg, potato, carrot, onion and sprouts are seldom canned and are well adopted for dehydration.

Vegetables are washed with water spraying or in rotary washers. The washing is repeated after peeling. Cabbage is not washed. Root vegetables are peeled before drying. Potatoes, carrots, turnips and beetroot are peeled by abrasion or by treatment with hot lye, hot brine, or steam at high pressure. The equipment used for abrasion peeling consists of pairs of horizontal drums rotating in the same direction and lined with graded carborundum. Water sprayers are used for loosening the dirt and assisting peeling.

In lye peeling the vegetables are dipped for a short period (3 minutes) in boiling caustic soda (10%) whereby the skin is loosened. The skin is washed off by tumbling in a washing machine.

The peeled vegetables are cut into cubes, strips, flakes or slices. Cabbage is cored, cut into shreds and washed to remove dirt and grit. Potato is cut into strips and washed to remove free starch grains which if allowed to remain gelatinize together during blanching and cause the strips to stick together during drying. Blanching is done by partial cooking in boiling water or live steam. Advantages of blanching are, good keeping qualities of the dried product, expulsion of air from tissues and marked reduction in drying time and retention of carotene and ascorbic acid during starage,

These materials are then loaded uniformly in trays and dried in a suitable drier. Sulphited vegetables will stand upto 72-75°C safely while the unsulphited vegetables (except carrot) usually will not withstand temperatures at the finish of drying above 65°C.

Packaging

Dried vegetables are compressed into blocks and packaged. They are heated to 60-70°C in a current of warm air and pressed while warm in steel moulds at 130-200 kg/cm² for 10-45 seconds. This treatment is suitable for vegetables containing high percentage of soluble eg. carrots, beet roots etc. In the case of leafy vegetables like cabbage which are rendered brittle by dehydration, conditioning in hot and humid air to make them flaccid is necessary before applying pressure. The compressed material is packed in tin plate containers previously treated in a phosphate or chrome bath to prevent corrosion. Cans square in cross section with a capacity of 4 gallon are economical. Cans are sometimes filled with nitrogen or carbon dioxide. Container should be freed from oxygen. Finally, the packaged dehydrated food should be stored at a cool temperature not exceeding 28°C.

Appendix

Maximum safe moisture content for scientific storage and approximate moisture content at the time of harvest/processing for some agricultural crops.

Commodity	Approximate moisture content at harvest/ processing time per cent (wet basis)	Maximum safe moisture content per cent (wet basis)
Paddy	20-25	11.0
Milled rice	13.5	9.0
Coconut (cup copra)	45-50	3-5
Cocoa beans	60	6-8
Cardamom	80	8-10
Pepper	—	11.0
Ginger	80-93	11-14
Tea	—	3-4
Green tea	—	4.0
Coffee	65-70	12.0
Garlic	—	7.0
Shelled maize (yellow)	20-25	9.5
Shelled maize (white)	20-25	10.0
Wheat grains	8-28	10.0
Wheat flour	—	8.5
Jowar	20-25	10.0
Ground nut (shelled)	—	7.0
Ground nut (unshelled)	40-60	9.0
Mustard	20-30	9.0
Soya beans	20-30	7.5
Peas	70-80	10.5
Lintils	80.0	10.5
Chillies	70-80	10.0
Barley	16-20	13.0
Corn	24-30	11-13

References

All India Co-ordinated ICAR scheme for studies on Harvest and Post harvest technology, 1981. *Development and evaluation of processing equipment.* CIAE, Nabi Bagh, Berasia Road, Bhopal.

Spices Board, 1988. *Spices News Letter* 23(9) Spices Board, Cochin-18. pp 29.

Spices Board, 1988. *Spices News Letter* 22(1). Spices Board, Cochin-18. pp 8.

Bavappa, K. V. A., Nair, M. K. and Premkumar, T. 1982. *The Arecanut Palm.* Monograph Series No. 2. CPCRI. Kasaragode. pp. 245-285.

Carl, W., and Hall, P. E., 1980. Drying and storage of Agricultural Crops AVI Publishing Company INC West Port, Connecticut. pp 10.

Das, F. C. 1981. *Improved threshers developed in India.* Central Institute of Agri. Engg., Nabi Bagh, Berasia Road, Bhopal. pp 3-13 & 44-55.

Ganesan, V. 1982. Development of small scale equipment for extraction of cocoa butter and production of cocoa powder, Masters thesis, Dept. of Ag. Engg. KAU. pp 63-73.

Goel, P. K. Technology of Food Products. Food Industries Manual. Small Business Publications. New Delhi. pp. 118-227.

Hall, D. W. 1970. Handling and Storage of Grains in Tropical and Sub-tropical areas. FAO. Us. pp. 51.

Johnykutfy, P. C. 1988. Ginger Cultivation and Processing. *Cardamom.* 21 (6). Spices Board, Cochin. pp 5-6.

Kachru, R. P. and Srivastava P. K. 1988. Post Harvest Technology of Ginger. *Cardamom.* 21 (5). Spices Board, Cochin. pp 49-61.

Kachru, R. P.; Srivastava, P. K. and Patil, R. T. 1988. Post Harvest Aspects of Cardamom. *Cardamom.* 21(6). Spices Board. Cochin. pp 7-15.

Mathew, A. G.; Venkitesan, S. D.; Jaleel, S. A.; Govindarajan, V. S. and Subramonian. V. 1973. Storage of Areca Fruit-1. Preservative Steeping Storage. *Arecanut J.* 14. pp 51-62.

Ojha, T. P. and Michael, A. M. 1978. Principles af Agricultural Engineering. Vol. I. Jain Brothers. New Delhi. pp 511-553.

Rajinder Singh, Sadhana Arora and Vinod Sehgal 1979. Guidelines for effective drying systems in the Country. *Agricultural Engineering Today* 3(4) Indian Society of Agrl. Engineers pp 19-24.

Rohan, T. A. 1963. Processing of Raw Cocoa for the market. Food and Agri. Organisation of the United Nations. Rome. pp 31.

Shanmughavelu, K. G. and Madhava Rao, V. N. 19. Spices and Plantation Crops. Popular Book Depot. 14-B. Sterling Road. Nungambakkam. Madras-34.

Suresh Chand. 1974. Food Processing Industries. 17th Publication on Small Scale Industries. Small Industry. Res. Institute, Delhi pp 77-95.

Thampan, P. K. 1979. Cassava. Directorate of Coconut development. Dept. of Agriculture, Govt. of India, KAU. pp. 34-76.

Valsala, P. A.; Sudhadevi, P. K. and Srikantan Nair, G. 1988. Bleached Ginger Stores Well. *Cardamom*. 21(5). Spices Board. Cochin. pp 15-16.

Woodroof J. G., and Bor Shium Luh. 1975. Commercial fruit processing, West Port, Connecticut, The AVI publishing Company INC pp 447-497.

Woodroof, J. G. 1978. Coconuts, Production, Processing, Products. The AVI Publishing Company, INC West Port, Connecticut. pp 43-99.

□□