






SPICE INDIA

April 2020, Vol. 33, No. 04



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Post Harvest Processing of Major Spices

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Spices are high value export oriented crops extensively used for flavouring food and beverages, medicines, cosmetics, perfumery etc. Spices constitute a significant and indispensable segment of culinary art and essentially add flavour, colour and taste to the food preparations. India is the largest producer, consumer and exporter of spices in the world. India produces more than 65 spices out of the total 109 spices listed by International Standards Organisation (ISO). India produces around 4.12 million tonnes of spices annually (2016-17), of which about 10 percent of the total produce is exported to over 150 countries. The USA, Europe, Australia, Japan, the Middle East and Oceanic countries are the major importers of Indian spices. The post

harvest processing of major spices are described in detail as follows:

(I) BLACK PEPPER

Black pepper takes about seven to eight months after flowering to reach full maturity and is harvested during December-January in plains and from January-April in the high ranges of Western Ghats. It is important to harvest pepper at the proper stage of maturity in order to achieve a dried product of good colour and appearance. Harvesting of pepper begins when one or two berries in the spike turn yellow. The spikes are nipped off by hand and collected in bags. Normally, single pole bamboo/aluminium ladder is used as support for climbing while harvesting. If the

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berries are allowed to over ripe, there is heavy loss due to berry drop and damage by birds. Spikes which are fallen on to the ground is collected separately, cleaned and then pooled to the general lot.

Recent advances in product diversification have necessitated harvesting of the berries at different stages of maturity. The level of maturity required at harvest for processing into different pepper products is given in Table-1.

Optimum maturity at harvest for different pepper products

Product	Stage maturity at harvest
Canned pepper	4-5 months
Dehydrated green pepper	10-15 days before maturity
Oleoresin and essential oil	15-20 days before maturity
Black pepper	Fully mature and 1-2 berries start turning from yellow to red in each spike
Pepper powder	Fully mature with maximum starch
White pepper	Fully ripe

Post Harvest Processing

Post harvest processing operations followed for black pepper involves threshing, blanching, drying, cleaning, grading and packaging. During processing care should be taken to maintain the quality during each step of operation.

Threshing

The berries are separated from the spike traditionally by trampling with human legs. This operation is crude, tedious and unhygienic. Chances of extraneous matter, soil particles and filth contaminating the produce are also high. Mechanical threshers with capacities varying from 50 kg/h to 2500 kg/h are available which can thresh quickly and provide cleaner products. Considering the shortage of human labour mechanical threshing can be popularized at cluster level.

Blanching

The quality of the black pepper obtained can be improved by a simple treatment of dipping the harvested green berries, taken in a perforated vessel, in boiling water for a minute before drying. This processing technique has several advantages:

- ❖ Uniform coloured black pepper is obtained after drying.
- ❖ Pepper can be dried in 3-4 days as against 5-6 days required when following the traditional practice
- ❖ Removes the extraneous impurities like dust and reduces the microbial load of the berries.

Drying

Freshly harvested green pepper has a moisture content of about 65 to 70% at harvest, which should be brought down to safe level of 10% by adequate drying. The green colour of matured pepper is due to the presence of chlorophyll pigment. During drying, enzymatic browning sets in and the phenolic compounds are oxidized by atmospheric oxygen under the catalytic influence of the enzyme phenolase and eventually turn black.

Sun drying is the conventional method followed for drying of black pepper. The despiked berries are spread on clean dry concrete floor / bamboo mats/ PVC sheets and dried under sun for 3-5 days to bring the moisture content below 10%. The average dry recovery varies between 33-37% depending on the varieties and cultivars.

Cleaning and grading

The dried black pepper has extraneous matter like dust, spent spikes, pinheads, stones, soil particles etc. mixed with it. Cleaning and grading are basic operations that enhance the value of the produce and help to get higher returns. Cleaning on a small scale is done by winnowing and hand picking which



removes most of the impurities. Such units consist of a fan/ blower and a feeding assembly. The fan is placed at the rear end of the hopper. Cleaning is achieved by feeding the material through the hopper into a stream of air blowing in perpendicular direction. The heavier fractions (dust, immature berries, pin heads and spent spikes) are blown away. Grading of black pepper is done by using sieves (3, 3.5, 3.8 and 4.8 mm etc.) and sifting black pepper into different grades based on size.

Packaging

Organically grown black pepper should be packaged separately and labelled. Mixing different types of pepper is not good from a commercial point of view. Eco friendly packaging materials such as clean gunny bags or paper bags may be adopted and the use of polythene bags may be minimized. Recyclable/ reusable packaging materials shall be used wherever possible.

Storage

Black pepper is hygroscopic in nature and absorption of moisture from air, during rainy season when there is high humidity, may result in mould and insect infestation. Before storage, black pepper has to be dried to less than 10 percent moisture content. The graded produce is bulk packaged separately in woven polypropylene bags or jute bags provided with food grade poly ethylene liners or in multi layer paper bags. The bags are arranged one over the other on plastic/wooden pallets after laying polypropylene sheets on the floor to reduce the ingress of moisture into the produce.

(II) CARDAMOM

Cardamom plants start bearing two or three years after planting suckers or seedlings, respectively. The capsules ripen within a period of 120-135 days after its formation. Harvesting period commences from June-July and continues till January-February in Kerala and Tamil Nadu. While in Karnataka, harvesting begins in August and prolongs till December-January. Usually harvesting is done at an interval of 15-30 days.

The capsules are harvested when they attain physiological maturity, which is indicated by dark green colour of rind and black coloured seeds. Harvesting of ripened capsules is avoided as it leads to the loss of green colour and also causes splitting of capsules during curing process. Immature capsules on processing yields uneven sized, shriveled and undesirably coloured produce. When a cardamom capsule is fully matured it can be easily removed from the stem of the plant without too much force. The harvester should start harvesting at the base of each stem and move up the stem, taking off any capsules that easily fall off without pulling. The capsules that do not fall off easily should be left on the plant to ripen.

Post Harvest Processing

Freshly harvested capsules are subjected to post harvest operations like cleaning, alkali treatment, drying, destalking, grading, packaging and storage.

Cleaning

Harvested capsules are washed in water to remove the soil particles and other dirt adhering to it and this process helps to get good quality finished product.

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Pre-treatment

The fresh cardamom capsules are soaked in a solution of sodium bicarbonate (2-5%) for ten minutes to help retain the green colour. A two per cent solution of sodium bicarbonate is prepared by dissolving 20 g of sodium bicarbonate in 1 litre of water. The capsules are removed from water and are spread on wire net trays of the drier.

Drying

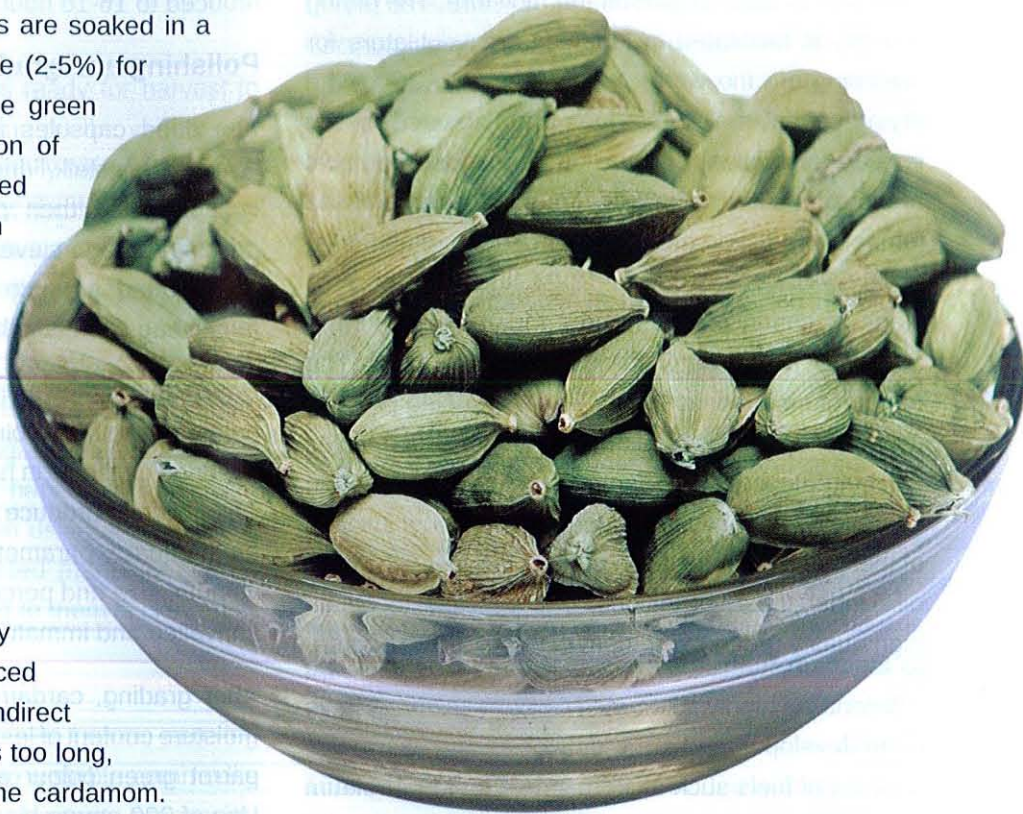
Drying/curing of cardamom is the process by which moisture content of freshly harvested capsules is reduced from 80-85% to 10% through indirect heating. If the drying period is too long, mould can start to grow on the cardamom. There are several methods available to dry cardamom for the small scale processors, depending upon the size of the business and the local weather conditions. Each method has different advantages and disadvantages:

Cardamom is dried by adopting two methods:

1. Natural (Sun drying)
2. Artificial drying

Natural (Sun drying)

Freshly harvested capsules are directly dried under sun for a period of five to six days or more depending on the availability and duration of sunlight. Natural drying does not retain green colour of capsules and also leads to splitting of the capsules. During cloudy and rainy weather conditions, proper drying of capsules cannot be accomplished and hence the quality of the capsules deteriorates. In general, sun dried capsules are not preferred for export. Sun drying is commonly practiced in some parts of Karnataka.



Artificial drying

It is one of the best methods of drying by which high quality green cardamom can be obtained. A traditional firewood based curing house consists of a furnace for burning the wood, flue pipes for conveying the hot air and drying racks for stacking the trays. A drying chamber with dimensions of 4.5 m in length and breadth is sufficient for a plantation, which has a production capacity of 2 tonnes of fresh cardamom. In general, 3-4 kg of firewood is consumed for drying 1 kg of fresh cardamom.

The capsules are evenly spread as a single layer on the trays. After staking the trays on the racks in the drying chamber, the curing room is closed. Hot air generated by burning firewood in the furnace is circulated through the flue pipes, which are placed few centimeters above the floor. This process enhances the room temperature to 45-55°C, which is maintained

for a period of 3-4 hours. During this period, the capsules sweat and give off the moisture. The drying process is facilitated by opening the ventilators for sweeping out the water vapour generated from the drying capsules. Exhaust fans are also used for the speedy removal of moisture. After complete removal of water vapour, the ventilators are closed and the temperature inside the chamber is again maintained at 45-55°C for a period of 18-24 hours. In the final stage of curing process, the temperature is further raised to about 60°C for another 1-2 hours. The temperature is raised to hasten the cleaning process by which debris like stalks attached to the capsules can be removed easily. Temperature inside the curing chamber is maintained around 65°C to avoid splitting of the capsules and also to prevent the loss of volatile oil. Under these conditions, it is possible to obtain high quality green cardamom in about 24-30 hours.

Efficient and highly automated cardamom dryers have been developed and are widely used with alternative sources of fuels such as kerosene, Liquid Petroleum Gas (LPG) and diesel or with combination of fuels. Such kind of improved systems have the advantage of retaining high quality of produce with respect to

colour and duration of curing is also substantially reduced to 16-18 hours.

Polishing and grading

The dried capsules are rubbed on wire mesh to remove the stalk, dried portion of flower from the capsules and then graded according to size by passing through sieves of sizes of 7, 6.5, 6 mm etc. The graded produce is stored in polythene lined gunny bags to retain the green colour during storage.

Dried capsules are polished either manually or with the help of machines. Polishing is carried out by rubbing the dried capsules in hot state against a hard surface. The polished produce is subsequently graded based on the quality parameters such as colour, weight per volume, size and percentage of empties, malformed, shrivelled and immature capsules.

After grading, cardamom capsules are stored at a moisture content of less than 10% to retain the original parrot green colour and to prevent mould growth. Use of 300 gauge black polythene lined gunny bags improves efficiency of storage. It is advisable to store the dried cardamom in wooden boxes at room

Well managed turmeric crop is ready for harvest in seven to nine months depending on the variety and time of sowing. The crop is generally harvested during January to March. On maturity, the leaves turn dry and are light brown to yellowish in colour. In Kerala, turmeric is grown in raised beds and harvesting is done either manually or by using a tractor.



temperature, preferably in the curing houses.

(III) TURMERIC

Well managed turmeric crop is ready for harvest in seven to nine months depending on the variety and time of sowing. The crop is generally harvested during January to March. On maturity, the leaves turn dry and are light brown to yellowish in colour. In Kerala, turmeric is grown in raised beds and harvesting is done either manually or by using a tractor. In case of manual harvesting, the land is ploughed, the clumps are carefully lifted with spade and the rhizomes are gathered by hand picking. Harvesting with a tractor attached to a turmeric harvester is followed when the raised beds are taken using a tractor. The harvested rhizomes are collected manually and all the extraneous matter adhering to them is cleared.

Post Harvest Processing

The harvested turmeric rhizomes before entering into the market is converted into a stable commodity through a number of post harvest processing operations like boiling, drying and polishing. Boiling of turmeric is taken up within 3 or 4 days after harvest. The fingers and bulbs (or mother rhizomes) are separated and are cured separately, since the latter takes a little longer to cook. The dry recovery of the different turmeric varieties vary widely ranging from 19 to 23%.

Boiling

Boiling is the first post harvest operation to be performed at the farm level which involves cooking of fresh rhizomes in water until soft before drying. Boiling destroys the vitality of fresh rhizomes, avoids the raw odour, reduces the drying time and yields uniformly coloured product.

In the traditional method, a vessel made of galvanized iron sheet is used for turmeric boiling. Boiling of turmeric rhizomes is carried out till froth forms and white fumes come out of the pan with a characteristic odour. Boiling is considered complete when a pointed stick can penetrate easily into the rhizomes with slight

pressure. The other indications of the completion of boiling process are softness and easy breaking of rhizomes when pressed between the fore finger and thumb and a yellow interior instead of red one. An effective cooking time of 45 to 60 minutes for fingers and 90 minutes for mother rhizomes is considered essential. Overcooking and undercooking are found to affect the quality of the rhizome.

Improved turmeric boiler using steam boiling technique is followed when large quantities of turmeric are to be cured. The Tamil Nadu Agricultural University (TNAU) model of improved steam boiler for turmeric consists of a trough, inner perforated drums and a lid. The outer drum is made of 18 SWG thick mild steel to a size of 122 x 122 x 55 cm. A lid is provided with hooks for easy lifting and also provided with an inspection door. For easy draining and cleaning, an outlet is placed at the bottom of the drum. Four numbers of inner drums of 48 x 48 x 45 cm size are provided in the outer drum. The capacity of four inner drum is 100 kg. The inner drums are provided with a leg for a height of 10 cm, so that the rhizomes will not come in contact with water filled for about 6-8 cm depth in the outer drum. The outer drum is placed with more than half of its depth below the ground level by digging a pit, which serves as a furnace. This furnace is provided with two openings, one for feeding the fuel and the other one for removing the ash and unburnt.

After placing the turmeric boiler in the furnace, about 75 litres of water is added (6-8 cm depth). About 55-70 kg of well washed rhizome is taken in each inner drum and placed in the boiler and the lid is placed in position. Using the available agricultural waste materials, mostly, the turmeric leaves, fire is put in the furnace. During the boiling process, it takes about 25 minutes to produce steam and boil the initial batch of rhizomes and 10-15 minutes for the subsequent batches. Through the inspection door, the stage of boiling of the rhizome is assessed by pressing the rhizomes with a hard pin / needle.

Using a long pole, the lid is removed and the inner drums are lifted one by one. For the next batch, about 20 litres of water is added to the outer drum,



depending on the water lost by evaporation. The next batch of rhizomes is loaded in all the drums and heating is continued. At the end of the boiling process, all the drums need to be cleaned free of mud and soil to avoid damage and enhance the life of the gadget. The capacity of the boiler is about 100 kg per batch and the fuel requirement is 70-75 kg of agricultural waste materials.

Drying

The cooked fingers are dried in the sun by spreading in 5-7 cm thick layers on the drying floor. A thin layer is not desirable, as the colour of the dried product may be adversely affected. During night time, the material should be heaped or covered. It may take 10-12 days for the rhizome to dry completely. The bulbs and fingers are dried separately, the former takes more time to dry. Turmeric should be dried on clean surface to ensure that the product does not get contaminated by extraneous matter. Care should be taken to avoid mould growth on the rhizomes. Rhizomes are turned intermittently to ensure uniformity in drying. The yield of the dry product varies from 20-25% depending upon the variety and the location where the crop is grown. The starch gelatinized during boiling shrink

and during the drying process intercellular spaces increase, enhancing water diffusion and reducing the drying time.

Polishing and colouring

Dried turmeric has poor appearance and rough dull outer surface with scales and root bits. The appearance is improved by smoothing and polishing the outer surface by manual or mechanical rubbing. Polishing is done till the recommended polish of 7 to 8 percent is achieved. Usually 5 to 8% of the weight of turmeric is the polishing wastage during full polishing and 2 to 3% during half polishing. Polishing of dried

turmeric also helps in removing the wrinkles.

Manual polishing consists of rubbing the dried turmeric fingers on a hard surface. Manual polishing gives rough appearance and dull colour to the dried rhizome. Polishing is done by using hand operated barrel or drum mounted on a central axis, the sides of which are made of expanded metal screen. When the drum filled with turmeric is rotated, polishing is effected by abrasion of the surface against each other as they roll inside the drum. The turmeric is also polished in power operated drums. Large scale polishing units with capacity to polish 500 to 1000 kg per batch is used for polishing turmeric rhizomes at commercial units. It takes about 45-60 minutes per batch and about 4 percent is wasted as dust. The colour of the processed turmeric influences the price of the produce. Hence to obtain attractive product, turmeric powder is sprinkled during the last phase of polishing.

Cleaning, grading, packing, and storage

Although Indian turmeric is considered to be the best in the world, about 90 percent of the total produce is consumed internally and only a small portion of

the production is exported. Turmeric of commerce is described in three ways:

Fingers: These are the lateral branches or secondary 'daughter' rhizomes which are detached from the central rhizome before curing. Fingers usually range in size from 2.5 to 7.5 cm in length and may be over 1 cm in diameter.

Bulbs: These are central 'mother' rhizomes, which are ovate in shape and are of shorter length and having larger diameter than the fingers.

Splits: Splits are the bulbs that have been split into halves or quarters to facilitate curing and subsequent drying.

Turmeric being a natural produce, is bound to gather contaminants during various stages of processing. The spice is also cleaned to remove such foreign materials. A sifter, destoner, and an air screen separator will help remove materials such as stones, dead insects, excreta, and other extraneous matter. Cleaned and graded material is packed generally in new double burlap gunny bags and stored over wooden pallets in a cool, dry place protected from light. The stores should be clean and free from

infestation of pests and harborage of rodents. It is not recommended to apply pesticides on the dried/polished turmeric to prevent storage pests.

(IV) GINGER

Harvesting of the crop for vegetable purpose starts from the sixth month of planting based on the demand and price of the produce. However, for making dry ginger, the matured rhizomes are harvested after eight months i.e. when the leaves turn yellow and start drying. Irrigation is stopped one month before harvest and the rhizome clumps are lifted carefully with a spade or digging fork. The dry leaves, roots and soil adhering on the rhizomes are manually separated. The mother rhizome has equal market value as that of freshly harvested ginger because of the large size. Late harvest is also practiced, as the crop does not deteriorate by leaving it for some months underground. In India, domestic market prefers fresh green ginger for culinary use while two types of dried ginger i.e. bleached and unbleached are also produced for export purpose.

The most important criteria in assessing the suitability of ginger rhizomes for particular processing purposes are the fibre content, volatile-oil content and the



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pungency level. The relative abundance of these three components in the fresh rhizome is governed by its state of maturity at harvest. Tender rhizomes lifted at the beginning of the harvesting season, about 5 to 7 months after planting, are preferred for the manufacture of preserved ginger since the fibre content is negligible and the pungency is mild. As the season progresses, the relative abundance of the volatile oil, the pungent constituents and the fibre increases. At about eight months after planting, the volatile oil and pungent principle contents reach a maximum and thereafter their relative abundance falls as the fibre content continues to increase. In India, the volatile oil content of ginger has been reported to be at maximum between 215 and 260 days after planting.

Post Harvest Processing

Processing of ginger to produce dry ginger basically involves two stages - peeling of the ginger rhizomes to remove the outer skin and sun drying to a safe moisture level.

Peeling

Peeling serves to remove the scaly epidermis and facilitate drying. Peeling of fully matured rhizomes, is done by scrapping with bamboo splits having pointed ends to remove the outer skin and to accelerate the drying process. Deep scraping with knives should be

avoided to prevent the damage of oil bearing cells which are present just below the outer skin. Excessive peeling will result in the reduction of essential oil content of the dried produce. The peeled rhizomes are washed before drying. The dry ginger so obtained is valued for its aroma, flavour and pungency.

Indian dried gingers are usually rough peeled when compared to Jamaican gingers, which are clean peeled. The rhizomes are peeled only on the flat sides and much of the skin in between the fingers remains intact. The dry ginger so produced is known as the rough peeled or unbleached ginger and bulk of the ginger produced in Kerala are of this quality. Sometimes Indian gingers are exported unpeeled.

Drying

The moisture content of ginger after harvest is about 80-82 percent which is brought down to 10 percent for its safe storage. Traditionally ginger is sun dried in a single layer in open yard which takes 7 to 10 days for complete drying. The sun dried ginger is brown in colour, with irregular wrinkled surface and when broken, shows a dark brownish colour. The yield of dry ginger is 19-23 percent of fresh ginger depending on the variety and climatic zone.

Polishing

Polishing of dried ginger is done to remove the wrinkles developed during drying process. In traditional method, the dried ginger is rubbed against hard surface and this helps to remove the dry scales of the skin attached to the surface.

Bleached ginger

Bleached ginger is produced by dipping scrapped fresh ginger in a slurry of slaked lime, $\text{Ca}(\text{OH})_2$, (1 kg of slaked lime/120 kg of water) followed by sun drying. As



the water adhering to the rhizomes dry, the ginger is again dipped in the slurry. This process is repeated until the rhizomes become uniformly white in colour. Dry ginger can also be bleached by the similar process. Liming gives ginger a better appearance and less susceptibility to the attack of insect pests during storage and shipping.

Cleaning and Grading

Cleanliness of spices has been the major concern of the importing countries. Once the ginger is cleaned and dried, it is graded manually. For ginger, the grading takes into consideration the size of the rhizome, its colour, shape, extraneous matter, the presence of light pieces and the extend of residual lime (in the case of bleached ginger).

Packaging and Storage

Dry ginger, packed in gunny bag, is highly susceptible to insect infestation during ware house storage. It is preferable to use polythene laminated gunny bags for packaging dried ginger. Dried ginger should be stored ensuring protection from dampness. Dunnage made of PVC/wooden crates should be used to stack the

packaged bags to prevent moisture ingress from the floor. Care should be taken to stack the packed bags 50 to 60 cm away from the walls. Insects, rodents, and other animals should be effectively prevented from getting access to the premises where ginger is stored. Prolonged storage of ginger would result in deterioration of its aroma, flavour and pungency.

Organic ginger has to be packaged in reusable and biodegradable packaging material whenever possible and the material should not contaminate the organic food. Organically produced ginger should be labeled accordingly. Packaging materials, storage containers or bins that are contaminated with fungicides, preservatives or fumigants are prohibited to be used for packaging ginger as they are likely to compromise the organic integrity of product.

(V) CHILLIES

Chilli is the dried ripe fruit of genus "*capsicum*" which is also called *red pepper* and it is an important commercial crop used as a condiment, culinary supplement or as a vegetable. Among the chilli consumed in India, dried chilli contributes the major share. The Indian *sannam* variety of chilli is well known the world over. It is cultivated in Andhra



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Pradesh and part of Tamil Nadu. The main marketing season for chilli in India is February-March.

Post Harvest Processing

Harvesting of chillies is done when the pods are well ripened and partially withered in the plant itself. Immediately after harvesting of fresh fruits, they are heaped indoors for two or three days, so that the partially ripe fruits, if any, are ripen fully and whole produce develops a uniform red colour. The best temperature for ripening is 22-25°C and direct sun light should be avoided which can cause development of white patches.

Drying

The drying of chilli is done by spreading the fruits on dry ground or concrete floor under sun. In case of cement floor, drying takes five to six days for the reduction of moisture content from 65-70 percent to 10 percent while in mud floor it takes three to four days during sunny days. In case of cloudy weather and intermittent rains, damages as high as 50 percent are reported. Such unfavourable conditions also lead to discolouration with white spots over the surface of final product. Loss of glossiness and pungency

are also noticed. In view of its direct exposure to environment, dirt may also get deposited on the chilli besides; this method involves excessive handling and irrecoverable shatter loss.

Sorting

At the final stage of drying, the discoloured, spoiled and other damaged ones are manually sorted based on eye judgment and experience. These sorted ones are collected and separated. This amount to four to five quintals of dry chilli obtained in a crop area of one hectare. This works out to about 20 to 25 percent of the final produce. The reject is sold separately at a much lower price. During the sorting process itself the dried chilli fruits will be windrowed for easy collection and packaging.

Destalking

Destalking of dried chilli pod is done after drying and before cold storage/marketing. The export lots are preferred without stalk as required by the buyers. Contract women labour are engaged for destalking. Normally a woman can destalk 12-15 kg of chili. The chilli stalks after removal has no commercial value and hence burnt or composted.

Collection and heaping

The dried chilli are collected from the drying yard in polywoven bags and transported to the packing yard and heaped. Being a high volume material, during heaping, compaction is done to accommodate more quantity in less space. To prevent absorption of moisture from the atmosphere, the heap is also fully covered with polythene sheets till packed in bags and transported to the market.

Packaging

The well-dried chilli pods are packed in gunny bags for transporting to the market. Normally the gunny bags will hold about 30 kg of dried chilli and to accommodate more quantity of chilli in each bag, the material being packed is compacted. For compacting the produce, manually it is rammed in the gunny bag by a labourer. By this, about 50 kg of dry chilli is packaged in a gunny bag. This reduces the bulk and helps in easy transportation.

Cold Storage

To maintain the quality and preserve the colour of dried chilli packed in gunny bags, it is stored under cold storage. More than 60 cold storage godowns are available in and around Guntur, Andhra Pradesh state and also a few units available in Tamil Nadu state. Normally the storage will be for the period during February to December. Storage is done at a temperature of four to six°C and the relative humidity ranges 60 to 80 percent. The cold storages are normally with a plinth area of 1000 to 2000 m² with four to six floors. Each floor is to a height of three to four meter and the evaporators are placed in each floor for uniform distribution of temperature. The bottom of each floor is made of wooden planks and only steps are used to reach the various levels of the storage godown. The walls and roof of the cold storage godowns are constructed with brick and concrete. The latest ones are constructed with polyurethane foam lined with metal sheet with improved insulation.



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