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Erasmus+

INNOVATIVE INTEGRATED TRAINING IN HEALING PLANTS BUSINESS

IO3 - The Total Business Plants Training Material

Module No.2

“Methods for harvest treatment”

1. Unit 6 Specific guidelines examples

• Summary

In Unit 6 there are given seven examples of complete harvest and post-harvest treatment regarding different raw materials and final products. Those examples reflect how harvest and post-harvest treatments are differentiated according to the nature of the raw material (roots, seeds, leaves, flowers, fruits, bark, bulb).

• Learning outcome descriptors

• Knowledge, understanding and professional skills

1. Discuss complete harvest and post-harvest strategies for specific plants
2. Explain the different needs for specific plant parts used as raw material

• General and transferable skills:

1. Plan a research task
2. Work independently or with a minimal guidance where appropriate
3. Work in team with minimal guidance where appropriate
4. Show good written and oral communication skills
5. Demonstrate computer literacy
6. Perform online (computer) search to develop information technology skills in order to retrieve information from a variety of sources

6. Specific guidelines examples

Roots (Ginger)

Fresh rhizomes (Figure 7) must be cleaned of foreign materials, stems and roots. When possible, washing under pressure is preferred as it is more effective and tends to reduce bacterial load. Traditionally, the rhizomes are 'killed' by immersion for 10 minutes in boiling water. This procedure can also deactivate the enzymatic processes. After that, they are dried in the sun. Peeling or scratching is recommended to reduce drying time. In addition, it reduces the growth of mold and fermentation. However, while this process minimizes the fiber content, removing the outer layer of the skin, it also tends to remove some oil components, since their concentrations can be higher in the bark. Peeled rhizomes can be bleached in order to gain a better appearance.

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Figure 7. *Fresh untreated ginger rhizomes (© Giuseppe Mazza)*

After peeling and washing, the rhizomes are soaked in water for two to three hours. After that, they are placed in a 1.5-2% solution of calcium oxide for six hours. Then, the rhizomes are drained and dried in the sun. This approach is followed when a light, shiny color is wanted.

Cleaning and drying procedures should be done as soon as possible after harvest. The rush is to make sure that the loss that could occur due to microbial contamination, mold growth and fermentation, will be minimized. Mechanical washers, slicers, and solar or hot air driers can help reduce dust contamination throughout post-harvest processes. Undrying peeled ginger takes 7 to 9 days to reach a moisture content of 7.8% to 8.8%. If the ginger is cut into slices, it takes only five to six hours using a cross-flow drier. On the other hand, if the ginger is whole it takes sixteen to eighteen hours under the same conditions. Mechanical drying provides a product that is cleaner and more homogeneous. When drying with hot air, airflow and temperature must be adjusted. Drying should not exceed 60°C in order not to allow discoloration.

Grading and packaging

A large volume of rhizomes can be stored in jute bags, wooden boxes and covered cartons for transportation. Dried slices or powder are stored in plasticized bags. Storage in a cool and dry environment is of high importance for dry spices.

Storage

Dried spices

Dried rhizomes or slices must be kept in 10-15°C temperatures. When stored at room temperature (23-26°C), losses of up to 20% oleoresin (dry weight) were observed on dry ginger after 3 months, and the content of (6)-gingerol decreased. Is therefore recommended to extract or distill dried ginger rapidly, if cold storage is not available, when oil or oleoresin is the final product. The significance of a dry storage for dried ginger destined for distillation can only be emphasized due to mycotoxins from mildew may be co-distilled with the essential oil. Mildew and bacteria growing on dried rhizomes may be efficiently controlled with Cogamma-irradiation at doses of 5 to 10 kg, with only a few changes in the quality of ginger oil. Also, ethylene oxide can be used for steam disinfection. For both techniques mentioned, special and extremely safe installations are necessary.

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Fresh ginger

Fresh ginger must be stored in a humid and low temperature environment. However, low temperature storage may not always be easy near the production area. Fresh ginger rhizome shelf life might be extended by storage at 10-12°C and high humidity.

Drying

Ginger drying involves two stages: peeling of the rhizomes to remove the outer skin and mechanical drying or drying in the sun at acceptable humidity levels. For the production of dry ginger, the harvesting takes place at full maturity. In most areas, the peeled ginger is dried in the sun.But in areas where the weather conditions do not allow the sun drying, improved drying methods with mechanical or solar dryers are also used. In mechanical dryers, 57.2°C is reported to be the highest temperature at which ginger for the spice market could be dehydrated. At higher temperatures, the color tends to lose its brightness.

Traditional method of drying ginger

The method involves placing peeled, cut ginger in clean bamboo or cement surfaces and drying in the sun until the moisture level reaches 10%. Drying can last from seven to fourteen days, according to the weather conditions. Disadvantage of this method is that it cannot be used in rainy conditions.

Modern method of drying ginger

This method includes the use of a mechanical drier like a hot air tray drier used to make the drying process faster. For drying a whole peeled ginger it takes about sixteen to eighteen hours in a mechanical dryer. It is rather important to monitor the air flow and temperature during drying.

Processing methods

Green (Fresh) Ginger

A significant quantity of green (fresh) ginger is consumed worldwide as vegetable. Ginger for vegetable use should be fleshy with low fiber content and, therefore, harvesting is done from the sixth month onwards.

To prepare the fresh ginger, the clusters are raised carefully with a shovel and then the rhizomes are carefully cut of the plants. The rhizomes are pretty close to each other and their shapes are irregular. This allows the inclusion of dirt in the interspaces, which have to be removed during washing. The adhering roots are also removed. After washing, the ginger is slightly sun-dried before it is placed on the market in this form.

Although there is significant consumption of fresh ginger worldwide, most of the production is altered into dry ginger. Traditionally, the drying of the spice was carried out in highly unsystematic and unhygienic ways, resulting to the often failure of the product to conform to the quality standards of international trade, especially on microbiological grounds. However, modern farmers have acquired considerable awareness on the quality specifications and follow good agricultural practices.

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Solvent Extraction of Ginger Oil and Oleoresin

The recovery of the essential oils of ginger depend on kind and origin of the plant as well as the cultivation, moisture at the time of harvest, the methods of extraction and, to some extent, the age of the plant.. Ginger oil is extracted by hydro distillation; water distillation and steam distillation. Extraction of ginger oil is usually achieved by hydro distillation method. Hydro distillation involves the use of water or steam to recover volatile components from the plant. The essential feature of hydro distillation is that it allows the distillation of a compound or a mixture of substances and then the recovery at a much lower temperature than that of the boiling point of the individual components.

Oleoresin, which is obtained by extraction with volatile solvents, contains the aroma and flavor of the ginger in a highly concentrated form. The procedure essentially contains the following three steps: contacting the powder with the solvent to transfer the ingredients from the spice to the solvent, separating the solution from the powder and distilling the extract to recover the product. The efficiency of oleoresin extraction is affected by factors such as particle size, extraction medium and temperature of extraction.

Mechanical Expression of Juices

Mechanical expression is used widely in the extraction of juices and oils from fruits, vegetables, and oilseeds. They are based on the application of pressure to fluster the plant cells and release the contained juice or oil constituents. The by- products of mechanical expression are solid remnants such as pomace or peels, which are either put in procession to become animal feeds or discarded in the agricultural land..) The benefit of mechanical expression over chemical extraction is that it keeps the liquid free of diluted chemicals and plus that it is a safer procedure.

Seeds (Cardamom)

Harvesting

Harvesting at the right stage of maturity is crucial for a high quality cardamom capsules production. The fruits should only be harvested once they are fully ripe. A mature capsule contains black seeds (Figure 8), while an unripe white. When the capsules are ripe, they can be easily removed from the stem. Harvesting should begin from the base of the stem, moving upwards, removing only the capsules that are easy to cut, while the rest should remain in the plant to mature.

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Figure 8. *Mature cardamom capsules and seeds (© 2017 Profexports.com)*

Cleaning

The crop should be cleaned before processing. The first stage is to take away dust and dirt using a winnowing basket. An experienced worker can clean up to 100kg of cardamom in an eight hour day. Small machines are available for cleaning, but they are not that affective according to their cost.

After winnowing, clean water is used to wash up the capsules. Two or three large plastic buckets (15 litre capacity) are adequate for small amounts but for large quantities, it is usually better to use a sink with a drainage hole. Only water that is safe to drink should be used. It should be changed regularly to block infection.

Drying

Drying is the most important part of the process, since final product's quality is directly affected by it. It is important to dry the cardamom capsules soon enough after harvest to prevent the loss of flavor. As well it is important that the drying process is as short as possible so that mildew does not develop on the capsules and the bright green color is preserved. The drying temperature should not be higher than 50°C as this affects the color and delicate flavor of the final product. In most places, cardamom capsules with a good green color can be sold for a premium price.

A fresh cardamom capsule has about 85% humidity, which must be reduced to 10% in the dried product, in order to store it. If the drying period is too long mildew can start to develop on the cardamom. There are quite a few methods available to the small-scale processor, depending upon the size of the business and the local weather conditions at the time of processing. Each method has its own benefits and drawbacks.

Grinding

Cardamom capsules are sold whole in general, but grinding can be a method to raise the value of the product. However, it is not recommended to grind spices, since they can become more susceptible to spoilage. Compounds that give aroma and flavor are not stable and will soon be lost from the product. The storage life of ground spices has less duration than of the whole spices. It is very difficult for the consumer to estimate the quality of a ground spice. It is also very easy for unprincipled processors to

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contaminate the ground spice by adding other material. So as a result most consumers, from wholesalers to individual customers, prefer to buy whole spices.

Packaging

Cardamom capsules can be packaged in polythene bags of differ sizes in association with the market demand. The bags must be sealed in order not to let moisture enter. Sealing machines are used for this purpose.The product must have labels that are easily read. The label must have all the information that is relevant to the product: the name of the product, trademark (if appropriate), producer's information (name and address), date of production and expiry, weight of the contents, added ingredients (if relevant) plus any other information that the country of origin and of import may require.

Storage

Dried cardamom capsules must be stored in dry containers, without being exposed to direct sunlight. For long term bulk storage, polythene-lined gunny bags (strong sacks made from jute fibers) inside wooden boxes are used. The polythene bags contribute to the preservation of the green color of the pods. Any moisture within the bags will lead to the rotting of the capsules, so it is of highest importance that the capsules are completely dried before they go in the gunny bags. The stored cardamoms must be checked in a regular basis for signs of spoilage or moisture, and when high levels of humidity are detected they must be re-dried until moisture drops to 10%.

The storage house must be clean, dry and cool and pests and insects must not have access to it. Mosquito netting should be fitted on the windows in order not to allow pests and insects from entering the room. Strong smelling foods, detergents and paints should not be stored in the same room as they will spoil the fine aroma and flavor of the cardamom.

Leaves (Stevia)

Harvesting

The harvesting time of stevia is usually affected by growth behavior and accumulation of the steviol glycosides, so the exact harvest time depends on the particular Stevia cultivar used and the growing season. In tropical and subtropical climates, the first harvest generally happens after 4 months of planting and the next harvests are after every three months, but in less warm areas, the number of harvests per year is usually lower. There are some places, particularly in Mainland China, where only one harvest is done in a year.

Harvest usually happens just before flowering, since after flowering, the steviol glycoside content of the leaves is reduced.

For harvesting, stevia plants are cut at approximately 4 inches (10 cm) height from ground. Some specialists recommend cutting at 6 inches (15 cm) height. There is a plethora of manuals and

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mechanized harvesting systems that can be used for stevia harvesting. After harvesting, usually a prophylactic fungicide is used to control fungal infection at the cut end of the stem.

Drying

After the leaves are harvested, they must be dried as quickly as possible to prevent browning and loss of steviol glycoside content. If the leaves are not dried in a proper way and within a specific time window after harvesting, this will may lead to a drastic loss of steviol glycoside and a loss up to half of the primary glycoside content within three days. The initial moisture content of fresh leaves is more or less 80% and they are to be dried to a final moisture level of 10% for long term storage. Therefore, the total loss of weight in drying process is 78%. Higher residual moisture percentage in the leaves during storage results not only in decay of the glycoside content but also mildew growth and decomposition, that would lead to the uselessness of the leaves for glycoside extraction.

Separation of leaves and stems

The stems of Stevia plants include very little steviol glycosides, so their presence in the harvested part decreases the overall glycoside content. Moreover, stems elute a lot of tannin and waxy material during extraction, which messes with the purification of glycosides. So, for making the leaves extraction worthy, the stems are to be separated from the leaves. For very small farms, it can be done by hand, but mechanical procedures are necessary for larger farms. The stems can be separated both before and after drying.

Baling and Packaging

Dried and cleaned stevia leaves (Figure 9) have very low bulk density and are therefore very bulky in nature. For easier and more efficient storing and transport they are compressed into bales and then packaged either in non-woven HDPE bags or in clear LDPE bags. For baling stevia leaves hydraulic horizontal or vertical bailing press is used.

Figure 9. *Dried stevia leaves*

Flower (Lavender)

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Pruning

Flower buds should be pruned off in the first two years so that the plant can grow in the best possible way and create a strong frame. In the years to come, pruning should be carried out as a separate post-harvest process, usually in autumn. The reason for that is because harvesting the plant blossoms for their oil leaves most stalks on the plants. Less frequent pruning will result in crops growing more slowly. Pruning can be done by using machines such as specialized trimmers.

Harvesting

The harvesting of lavender for essential oil should occur when the flowers have grown and the lower half is starting to open. The harvest is usually done at the end of December and early January, depending on the season. The harvest time can be from four to ten days and then the quality will be reduced. Planning the harvest, especially for large plantations, in good weather, is crucial, because the water that comes into contact with the oil during the preheating stage of distillation decreases oil quality and extraction efficiency. Harvesting must also not be performed in too high temperatures and very windy conditions as considerable volumes of oil can be lost through evaporation. Very low temperatures block the development of esters, and harvesting has to be delayed until the weather is warmer. The flower spikes are cut 15 to 20cm below the flowers. It can be hand harvested by means of sickles or shears or by using machines designed for the task. Cutting the flowers to be sold fresh or dried, usually happens a week later than it would be for the production of their essential oil. Flowers are also cut having longer stems.

Steam distillation

Once picked, the lavender is distilled. The value of the oil depends on distillation. If the levels of pressure or temperature are too high, it may result a change to the molecular structure of the molecules responsible for the fragrance, changing the chemical components. The yield of the oil may differ considerably from one season to the next, as the age of the bushes and the weather will influence both the quantity and quality of the product.

Solvent extraction

A smaller quantity of lavender and lavandin concretes is produced by solvent extraction. Concretes are secreted from fresh plant material using solvents like toluene, hexane and petroleum ether. The solvents are evaporated to produce residue called concretes. Concretes are used by the perfume industries (mainly soaps) and for further improvement they are blended with ethanol. The mixture is then cooled and filtered. After that the ethanol is evaporated and leaves a wax-free residue called an absolute, which is more widespread in fine perfumery. Usually there is a 50% loss from concrete to absolute.

Dried flowers

After harvesting the flowers, these are put together in bundles and hung up to be dried in the shade (Figure 10). Some flowers are stripped from the spikes after drying and are then stored into boxes or cases lined with paper. Generally, 8 to 10kg of fresh flowers are required to produce 1kg of dry flowers.

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Figure 10. *Dried bundles of lavender*

Packaging and storage

Essential oils are volatile and so they must be treated with care. Keep the oils in dark, air-tight glass bottles and do not let them be exposed to heat or heavy metals. Decay begins if the liquid is much darker or thicker than normal. With proper care essential oils remain potent for 6 months to 2 years; if freshness is suspected the oil should be disposed. Dark glass or ceramic containers, as well as the use of fluorinated plastic and processed aluminum, are some other ways of storing. In the context of the value-added market, packaging should be clearly labeled, decent and professional.

Fruit (Fresh Chiles)

Harvest and handling

In the course of harvest and handling, it is significant to remember that chile fruits soften easily and appear postharvest diseases if they are damaged, bruised, or exposed to high temperatures All types of chile peppers, especially New Mexico green chiles, are particularly sensitive to water loss, sun exposure and high temperature exposure.. These issues are likely to occur if chiles are allowed to sit for more than an hour in direct sunlight. Fresh chile peppers (Figure 11) that are harvested in the summer may have temperatures in their pulp of 32°C or above. For these reasons, they must be collected early in the morning, placed away from direct sunlight and cooled rapidly. If the chiles are not cooled within 1 to 2 hours, they will begin to loose water and soften. Most fresh chili peppers are hand-picked in buckets or sacks and then placed in containers to be transported to a shaded area for packaging or processing. A harvest of field of long green chiles can be harvested in early August and then again in September. A third harvest will typically yield small fruits and may not be worthy.

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Figure 11. *New Mexico chile pepper*

Once at the shed, the chile is either dry-dumped onto padded ramps or moving conveyor belts, or wet dumped into a chlorinated wash tank. Wash tanks should be cleaned daily, and the chlorination levels should be checked in regular basis. These sanitation practices are essential due to chiles are quite sensitive to bacterial diseases that could be introduced through the wash tanks. Then the peppers are sorted to remove the infected, overripe, untamed and otherwise defective pieces. After that, classification according to USDA or other market standards can be done. Usually fresh chile peppers are packed in 1 1/4 bushel size corrugated cartons that hold 30 lb. The boxes may be waxed, and should have top and bottom gaps and side slots for airing and cooling. Cartons must be considerably strong to withstand stacking and shipping. Packaging in plastic lined bags (polyethylene) offers an extra protection for peppers from the loss of moisture. Plastic films decrease water loss from the chiles, but may meddle in with cooling efficiency. Small perforations in the plastic will counterbalance for the barrier by improving gas exchange and increasing the airflow during cooling and storage. Chili peppers can also be packed in plastic bags or film-wrapped trays when they are to be sold in retail markets for individual consumers. These retail packages can be made at the packing shed or, more commonly, at the delivery center. Both storage temperature and package container affect chile fruit weight loss. Chiles stored in boxes lose weight per day of about 3.5% at 24°C, but only 0.5% at 8°C. In order to reduce fruit weight loss further, plastic wrapped trays or polyethylene bags can be used, especially at lower storage temperatures.

Cooling and storage

Fresh chile is quite spoilable merchandise. Proper cooling expands the shelf life by slowing respiration, water loss, color change, and decomposition. Temperatures higher than 21°C accelerate rippening through breathing and ethylene production.The most preferable cooling methods for chiles are room cooling and forced-air cooling. Cooling and storage are independent operations and for that reason the specific requirements for quick cooling should be considered separately from cold storage needs. In room cooling, where the fresh product is exposed to cold air in a refrigerator, bins or boxes must be stacked properly in order not to prevent airflow between the individual storage units. Room coolers should be divided into sections so that recently harvested chiles with high field heat are kept separate from previously cooled product. Powerful fans and ceiling jets can be used to increase the airflow and, as a result, the cooling efficiency of room coolers. Forced-air cooling is an active cooling procedure and

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is a much faster way to remove field heat than room cooling. In forced-air cooling, fans send cold air directly into the boxes or bins where the products are stored. Room coolers can be altered into forced-air coolers relatively quickly and without high cost by adding extra fans and partitions. There are quite many variations of forced-air cooling designs; the most common is the forced-air tunnel design. In this system, a series of buckets or pallets are placed on each side of a fan, creating a runway between the two rows. The corridor and the open end are covered with canvas to create a tunnel and the fan creates negative pressure in the tunnel and sends cold air through the stacks to cool the product. The containers must have adequate ventilation so that the air flows properly during cooling. Forced-air evaporative cooling is a system that uses evaporative coolers instead of refrigeration units. This cooling system is practical in areas with dry climate. An evaporative cooler needs less energy than mechanical refrigeration. Furthermore, growers can build their own systems. Forced-air evaporative coolers can reduce product temperature to 16°C and come in use for cooling sensitive products (such as chiles) for a local market.

Storage

The ideal storage conditions for fresh chiles are to 7-10°C and 90 to 95% relative humidity. Chilling injury happens at lower temperatures. The symptoms of chilling injury are softening, pitting, and a raised sensitivity to decomposition. Damage from freezing occurs at 0°C. If the right cool temperature is kept, most fresh chiles can be stored for 2 to 3 weeks. Chiles should be shipped on refrigerated trucks, however these vehicles should not be used for pre-cooling because refrigerated trailers do not have sufficient cooling capacity or ventilation to remove field heat fast enough. Transit cooling is intended only to maintain previously cooled product cold during shipping. Inadequate temperature management and ethylene accumulation during storage or transit make the appearance of ripening and decomposition easier. Some fruits and vegetables produce much larger amounts of ethylene than chiles, so chiles should never be stored or shipped with crops like tomatoes, apples, or melons. Storage rooms should be aerated properly to minimize the accumulation of ethylene in the environment. The placement of ethylene scrubbers containing potassium permanganate in the storehouse or transport vehicle may also drop ethylene levels. Preserving a chain of quality from grower through consumer is crucial when handling fresh chiles. The basis of the chain of quality is proper cooling, but reducing mechanical injuries, diseases, and ethylene exposure are also essential for maximum chile quality.

Bark (Cinnamon)

Harvesting

Cinnamon bark is harvested twice a year right after each of the rainy seasons when the moisture makes the bark peel more easily. The first harvest occurs when the trees (Figure 12) are three years old. That is one year after the first pruning. The side stems that are about three years old are taken away and the bark is stripped off. Cinnamon bark can only be acquired from stems that are between 1.2 and 5cm in diameter.

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Figure 12. *Peeled cinnamon tree*

Processing

About 60% of the cost of production of cinnamon goes to processing, since the peeling of bark from the stems is labor strenuous and is usually done by hand, by skilled peelers. Cinnamon's quality depends on how well the bark is separated from the stems, with the larger pieces or quills having higher price in the market than the smaller broken pieces. Drying is also a significant stage of the procedure of cinnamon, since it is one of the factors that influence the quality of the final product.

Processing stages

• Take away the tender stems (with diameters less than 1.2cm) and use them as a fertilizer.

• Stems with diameter greater than 5cm are not used to prepare cinnamon bark, but they can be used for oil distillation.

• Take away the soft outer bark with the use of a good rounded knife with thick rasp.

• Rub the stripped stem with a brass rod to loosen the inner bark. It is essential to use a brass rod so that the bark color does not fade away.

• Drill holes around the stem at intervals of 30cm using a small sharp knife. The knife blade should be stainless steel or brass to avoid staining the bark.

• Make long cuts along the length of the stem, so that the bark can be carefully eased off the stem. Use the pointed knife and the rubbing rod to help ease off the bark.

• The pieces of removed bark are called quills. Put those quills inside one another to create long compound quills (up to 1m long), by using the best whole quills on the outside and fill in the center with broken pieces of bark.

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Drying

The compound quills are placed on coir rope racks and dried in the shade to avoid misshaping. After four or five days of drying, the quills are rolled on a board to clinch the filling and then placed in soften sunlight for further drying. In wet climates or during the rainy season, it is necessary to use mechanical driers in order to complete the drying process. There are many types of dryers available to serve different situations (electrical, gas fired, biomass fueled).

Grading

The quality of cinnamon depends on the thickness of the bark, the appearance (broken or entire quills) and the aroma and flavor.

Grinding

Grinding can be a method of raising the value of a product. However, it is not recommended to grind spices. After grinding, spices are more easily spoiled. The flavor and aroma compounds are unstable and will quickly vanish from ground products, so ground spices have much less storage life than the whole spices. For consumers is difficult to judge the quality of a ground spice. However it is not difficult at all for unethical processors to contaminate the ground spice by adding other material. Consequently most consumers, from wholesalers to individual customers, prefer to buy whole spices.

Cinnamon is sometimes ground to a powder prior to sale. The powder should be packed in moisture-protected packages (polypropylene bags) to keep the flavor.

Packaging

Cinnamon quills (Figure 13) are cut to create pieces up to 10cm in length and packed into n polypropylene bags to be protected from moisture. The bags ought to be sealed to avoid moisture entering. In order to seal the bags, sealing machines can be used. Attractive labels should be applied to the products. The label needs to include all relevant product and legal information – the name of the product, brand name (if appropriate), details of the manufacturer (name and address), date of manufacture, expire date, weight of the contents, added ingredients (if relevant) plus any other information that the country of origin and of import may ask.

Figure 13. Cinnamon quills

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Storage

Dried cinnamon quills should be stored in places protected from moisture and sunlight. The stored cinnamon quills should be frequently checked for signs of decay or moisture. If they have absorbed moisture, they should be re-dried to a moisture content of 10%. The storage room should be clean, dry, cool and pest-free. Mosquito netting should be fitted on the windows in order not to allow pests and insects from entering the room. Strong smelling foods, detergents and paints should not be stored in the same room as they will ruin the delicate aroma and flavor of the cinnamon.

Bulb (Garlic)

Harvesting

Garlic can be harvested at different stages of its development for special markets. However, most of the garlic is harvested after its bulbs mature. Harvest occurs after the tops have fallen and are very dry. Garlic is grown in rich soil, so it is necessary to break over the tops to prevent too much top growth. For the garlic planted early in the fall, a cover crop of oats can be sown at planting time to provide winter protection for the young plants (Figure 14). In cold season, a layer of organic mulch is applied which stabilizes the young plants preventing them from frost heaving, cold injury or premature growth.

Figure 14. Covered garlic field

Post-harvest technologies

Garlic powders

The simplest method of preserving garlic is to dehydrate fresh garlic cloves and grind them. Ground garlic can be used as a flavoring agent for condiments and processed foods. While preparing the powder, garlic cloves are cut in slices, crushed, dried and ground into powder. The average content of allicin present in garlic is 0.8%, however, raw garlic contains around 3.7 mg/gm of allicin. In India small scale industries use tray drier for drying the garlic cloves. The moisture content of garlic cloves is minimized from initial moisture content of about 60- 65% (wb) to a safe level of 6% (wb). The dehydration of the garlic cloves using tray dryer is both energy strenuous and time consuming

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procedure. It takes about 9-10 hours to dry garlic cloves in a single stage in a tray dryer at the temperature of 70°C.

Garlic oil

Garlic oil is another significant preparation. It occurs from the distillation process of raw garlic. Steam distillation is the method used to obtain the essential oil of garlic. Garlic cloves' content of essential oil is 0.2-0.5%. It consists a variety of sulfides, like diallyl disulphide and diallyl trisulphide.

Garlic storage

Garlic and its dried products should be stored under low humidity conditions. Sprouting happens if the storage is done at intermediate temperatures. Furthermore, the variety of garlic affects the potential storage life. The conditions to be employed for commercial storage depend on the storage period. Garlic can be stored in good condition for 1-2 months at ambient temperatures (20-30°C) under low relative humidity (< 75%). But under these conditions, bulbs will eventually soften and become spongy and shriveled due to water loss. For long term storage, garlic is best preserved at temperatures of -1°C to 0°C with low relative humidity (60-70%). Also good air flow is essential to avoid moisture accumulation. Under these controlled conditions, garlic's storage life can be increased up to 9 months. Garlic loses dormancy, which is indicated by the sprouting of bulbs. It happens at the storage temperatures of 5-18°C. Also high levels of humidity will favor the mildew development. Moreover, it must be taken under consideration that garlic should be stored separately to avoid the transmission of odor to other products. For bulk storage of garlic, ventilation systems should be designed to supply air into the store room from the bottom at the rate of 2 cubic feet per minutes per cubic feet of production. The rows of containers must be placed parallel to the direction of the air flow and be spaced six to seven inches.

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