Postharvest handling and utilization of cactus fruits, Mexico

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Summary
This practice provides a description of the postharvest handling and utilization of the cactus fruits in food industry. The practice is aimed at building the technical capacity leading to improvement of the products which are prepared from cactus especially for the small scale farmers and agro processors. It covers the technical aspects of processing selected agricultural produce and the appropriate environments in which these products can be processed at small scale level with a small scale farmer in mind.

Description
Cactus is grown for fruit on all continents and is common in such countries including Algeria, Brazil, Colombia, Egypt, Ethiopia, Greece, Jordan, Morocco, Peru, Spain, Tunisia and Turkey (Inglese, Giugliuzza and Liguori, 2004). The crop is also grown in Ethiopia where FAO has been supporting efforts to add value to the crop through preparation of products such as jam.

According to Uzun (1996), the aim species for fruits production worldwide is Opuntia ficus Indica. Other varieties grown in countries such as Mexico, include O. streptaantha, O. lindHEMEIRI, O. amylaea, and O. robusta. The management of the farm including the season of the year tend to influence the quality of the fruits. For example, studies have shown that fruits obtained in summer have more seeds and supplementary irrigation leads to larger seeds.

Whereas traditionally fruit is the main product, stems are also utilized especially in Mexico as a fresh produce. Scientifically the stems are known as cladodes and commonly referred to as ‘paddles’, ‘fleshy leaves’ or ‘racquets’. The cactus stem are also known as Nopalitos in Spanish. Nopalitos have become part of the traditional Mexican diets. On the other hand, in the US, young cactus paddles (also called pads) are popular among the Hispanic population where they are cooked and eaten as vegetables.

1. Harvesting
Normally Opuntia ficus-indica blooms once a year although it has been reported to bloom twice a year in countries such as Italy (Inglese, 1999). Several factors are important in deciding whether the fruit is ready for harvesting. These factors includes:

- Fruits reaching the target size depending on the variety being cultivated; and

- Soluble solids contents exceeding 12° Brix. Brix can be measured using a

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simple hand held refractometer. It is also worth noting that farmers should observe the temperature during harvesting as high temperature is likely to contribute towards dehydration and infestation of the harvested fruits.

The harvesting of the fruits is done either by hand with application of pressure to remove the fruit or with the use of secateurs. However special care needs to be taken when harvesting the fruit because of the spines. Normally the harvested fruits are collected in clean baskets or trays.

After harvesting, fruits are cured in the sun in order to dry out any wounds and to allow glochids to loosen. Fruits are laid out in in the fields on beds of straws covered with a raschel plastic mesh. Once the fruit is dry, depending on the available sunshine, the glochids are removed on the same day by brushing them with brooms made of long tender twigs. A point of note is the confusion in technical literature between spines and glochids. It is correct to refer to large modified leaves as spines, while the glochids are much smaller and grouped in racemes.

Following the removal of glochids, the fruits are quickly packed and transported to a cool refrigerated area for storage. The refrigeration helps to extend the shelf life and to avoid dehydration and possibility of mould growth.

Figure 1. Harvesting cactus stems or cladodes (nopalitos)

Figure 2. Harvesting cactus stems or cladodes (nopalitos)

1.1 Postharvest handling

Postharvest handling of the cactus fruits is essential for reducing postharvest losses.

• **Heat treatment:** this is used as a way of controlling postharvest decay. It also increases the shelf life of the fruits thus replacing the use of fungicides. The advantages of heat treatment include reduction of the fruits susceptibility to pathogens and chilling injury as well as slowing down the postharvest deterioration. Hot water treatment is carried out by immersion of fruits in hot water 50 to 60° C for about 3 minutes or exposing fruits to hot air (about 37° C for 12 to 24 hours). Experience has shown that in Italy immersion of fruits in hot water at 55° C for about 5 minutes led to an increase in the shelf life to four to six weeks.

• **Waxing:** according to Cantwell (1999) the use of wax reduces water losses considerably. A combination of hot water treatment followed by wax application and use of plastic films has been reported to produce attractive and turgidly fruits with low decay and damage to the fruits.
caused by clusters of sharp spines. This treatment tends to intensify fruits colour and shine and improves any signs of weight loss (Berger et al., 2002).

- **Use of plastic film:** the use of plastic films as packaging materials has shown to reduce dehydration and chilling injury. The most convenient is to use packaging that allows film permeability and water vapor transmission that will prolong the post-harvest life without affecting the quality. Wrapping directly the fruit may increase the incidence of decay and off-flavour production.

Figure 3. Cactus pear showing chilling injury

1.2 Storage and transport
- **Storage:** the effective method of reducing moisture loss is storage of fruits at low temperature. Studies have shown that the use of refrigeration tends to reduce rapid senescence of the pear fruit preventing it from being susceptible to infection of micro-organisms. Since pear fruits are susceptible to chilling injury, a temperature range of 6 to 9° C has been recommended in Italy since lower temperatures are likely to lead to chilling injury.

In preparation for storage, fruits must be packed into cartons with a net weight of 5 kg. It is recommended to wrap each fruit separately using a tissue paper especially when transporting to local market.

- **Transportation:** transportation is an important stage of the value chain and therefore all precautions must be taken to ensure that fruits are delivered to the destination in good quality as expected and required by the customers. In preparation for transportation, good quality trays must be used. In addition, the fruits must be well packaged in a way that they will not be compressed and damaged during transportation. Care must be taken during transportation to ensure that the crates are well arranged and stacked to avoid compression and bruising especially when transporting fruits in rough feeder roads.

Mexico’s main cactus pear production region is Milpa Alta. Cladodes are harvested and packed in baskets for local consumption or in cylindrical bins called pacas. These are 1 m in diameter and 1.7 m tall, contain approximately 3,000 pieces and weigh 250 to 300 kg. The paca is a useful container given the large number of cladodes that can be moved. However, the pacas should not be left for more than a few days at room temperature before unpacking because, like all plants, changes will occur as a result of respiration. The bins are transported in trucks to wholesale markets in Mexico City, where they are stored at outdoor temperatures until sold. This normally occurs within three days of harvest.

For markets further from production zones, cladodes are packed into wooden crates containing 20 kg or in cardboard boxes holding 5 to 10 kg, and transported in refrigerated trucks at 10° C (Cantwell, 1999 and Flores et al., 1995). Producers have to be careful when using this type of
packaging as, cladodes packed in wooden or cardboard boxes are often damaged by spines, which causes the product to brown (Cantwell, 1999).

Figure 4. Cactus pear fruit packed in different ways in cardboard boxes

Figure 5. Cactus fruits being prepared for transportation

2. Pre-processing

Supplies of raw materials to the plant are secured in cooperation with producers to ensure that the crop meets factory input requirements and that harvested materials remain in good condition when stored prior to delivery. Storage in the open air and/or the field is not appropriate once these materials have been harvested. If there are no refrigerated storage facilities available, raw materials may be kept in the open air under a roof or shaded mesh screen for short periods prior to processing. Raw materials should be packed and delivered in open boxes that can be handled easily by one or two people.

Figure 6. Wooden boxes with cactus being loaded into a truck

Figure 7. Paca: transport system for tender cladodes

Once the raw material has been delivered to the processing plant, it is formally received and checked for quality on the following points:

• cleanliness and ripeness of the fruit;
• uniformity of size and freshness of cladodes;
• uniformity of the varieties of fruit received;
weight of the fruit or nopalitos received (indicating source, names of producers contracted, company farms, etc.).

### 2.1 Removal of spines

Spines can be removed from cactus pear fruits manually or mechanically.

- **Manual removal** is typically undertaken in the field immediately after harvesting. A bed of straw is prepared on the ground (sometimes a net or plastic sheet is used) and the fruits are laid out on it. A worker with a broom removes the spines by brushing the fruits back and forth to rub them against the straw. Care is required to avoid damaging the skin of the fruit and to prevent soil contamination. Soil and/or straw contaminants have to be removed at the processing plant.

- **Mechanical removal** of spines is usually undertaken in the open air, before the fruits are delivered to the plant. In hot countries shade is provided with a raschel-type plastic mesh spread over the de-spining equipment to make the working area pleasanter and to prevent the fruits from warming. Different equipment designs have been developed for removing the spines. The same equipment can be used either on the farm or as the first stage of processing at the factory. The aim is the same: to remove the spines from the fruit. Spines are removed by running the fruits over rollers covered with hairs or brushes that are sufficiently hard to remove the spines without damaging the fruit. Brushes are typically made from nylon bristle, horsehair or cloth that is thick and firm but not rough.

The spines from cactus pear fruit are fine and small and can stick to the skin, eyes and clothing, sometimes causing severe irritation. Once removed, the spines are captured by an air-blower and deposited in a container attached to the equipment. This prevents contamination problems for people working nearby. There are different type of equipment used for the removal of spines from cactus pear fruit. The air-suction unit can be seen on top of the equipment. The fruit is sorted by hand before the spines are removed by the de-spining equipment. Operators typically use gloves to protect their hands. Spines are removed from nopalitos manually using sharp knives as they arrive at the processing plant.

![Figure 8. Brushing cactus pears to remove the spines](image)

![Figure 9. Mechanical removal of spines of cactus pear fruit](image)

### 2.2 Sorting and washing

Fruit is sorted and washed as it enters the plant. Fruit that is damaged, spoiled, overripe, green, miscoloured, misshapen or not uniform in any way is rejected at this stage. Figure 10 shows a simple table with workers sorting by hand. After sorting and before processing, the fruit must be washed with clean water that has preferably been chlorinated (200 ppm). This can be done...
by immersing the fruits in tanks made from plastic or a similar, easily washable, non-contaminating material.

The choice of equipment depends largely on plant throughput and the scale of production. For example, the production line of a microenterprise will contain equipment that is typically modular, simple, small-scale, manually operated and easy to clean. Wooden equipment or utensils should not be used for handling the fruit because of the safety and hygiene requirements of food processing. Plastic or stainless steel equipment and utensils are preferable.

Depending on the quantity of fruit washed, the water should be changed frequently to keep it clean and avoid contaminating the fruit. This is the final procedure before peeling the fruit, which is usually done by hand using sharp knives. The easiest way to peel cactus pear fruit is to cut off the ends, make a slit lengthwise and remove the peel in one piece. This also removes the section of inner skin under the fine epidermis.

However, the inner skin is incorporated into some processes to boost yield without affecting the product’s flavour or aroma. It is difficult to remove the thin outer epidermis any other way and most plants remove it along with the peel.

Peeling, and all other operations involving direct contact with the fruit, should be done using clean hands. Gloves are also used. At this stage, workers should wear masks and caps. Over time workers develop great skill and dexterity with peeling and are able to work quickly and precisely.

The spines of nopalitos are removed manually using sharp knives as part of the cleaning process. Over time workers become highly skilled at spine removal and work quickly without damaging the nopalitos. After the spines have been removed, depending on the process, the edges are trimmed with a knife and the remaining material is chopped into different-shaped pieces. The pieces are washed in chlorinated water to protect tissue from oxidation, remove any dirt and prevent browning. The product is then ready for processing.

3. Value added products

3.1 Dehydrated products:

Drying or dehydration of the cactus fruit means removal or reduction of water. It is the process of removing water/moisture by heat application or using other energy sources like sun or wind. This is one of the oldest technologies that is cheapest and easiest to use.

One advantage of dehydrated products is that they do not usually contain additives and for this reason are considered safe, natural foods. The dehydration method which is essentially a drying process can
be used to produce thin films or leather which is a dried tasty, chewy product. The leathers are produced after peeling the fruits and then removing the seeds. The pulp is then collected in clean containers and dehydrated in thin films to produce leathers. This is one of the cactus pear products that can be produced.

Figure 11. Simple flow chart for dehydration of cactus pear fruit

3.2 Jam:
Jam is another popular product that can be prepared from cactus fruit. The preservation of cactus fruit by jam making can be done at a small scale. Generally, jam is prepared by boiling the fruit pulp with sugar, pectin and citric acid to ensure sufficient gelling. Preservatives such as sodium sorbate or potassium benzoate are used to conserve quality.

The process of making cactus fruit jam is summarized below:

- Peel the fruits normally using hand and a sharp knife.
- Cut the fruit into pieces.
- Using a sieve with 1 mm diameter perforations, separate seeds and collect the resulting thick juice. The types of sieve used for separating tomato seeds from pulp are useful and, for small-scale applications, a centrifugal sieve typically used for home preparation of juices can be used.
- Place the seedless pulp in a tank.
- Add sugar (55 to 60 percent), pectin (if required, depending on the characteristics of the fruit being used), citric acid (0.8 to 1.0 percent) and preservatives, such as sodium benzoate (1 g [kg] to 1) and others in accordance with the dosage permitted by national regulations.
- Concentrate the mixture in an evaporator or using open pot.
- Continue concentrating until you reach 65 to 67° Brix.
- Pack the prepared jam in clean, dry jars which have been cleaned prior to preparation of the jam.
- The jars are capped while they are hot (85 to 90° C) using twist-off or similar caps. The caps are self-pasteurized by inverting the jars containing the hot product for 10 to 15 minutes.
- After filling, the jars pass through a cooling system to prevent overheating and associated organoleptic and nutritional deterioration of the product. Cooling is by water spray until the temperature drops to 30 to 40° C, which is sufficient for the jars to dry before passing to the final operations.

Figure 12. Flow chart for the preparation of the cactus fruit jam
3.3 Juice:
Cactus pear can be used to prepare nutritious juice especially if prepared while observing the good manufacturing practices (GMP). The juice is popular in countries like Chile. The juice processor need to be aware of the high pH, low acidity, high sugar content, delicate aroma and susceptibility to deterioration. The steps used in the preparation of juice are indicated below:

- First, the fruit is peeled.
- The whole fruit is milled to reduce the size of the fruit.
- The seeds and pulp are then separated through sieving.
- Fruit is then pumped into the extraction system for pressing. Many different types of presses are used, including: a hydraulic press inside a frame into which the fruit is placed wrapped in cloth with an appropriate mesh size; a hydraulic press with tube membranes of variable porosity; high capacity belt presses and so on.
- After pressing, the juice is pumped into a tank where it is diluted with water (20:80 ratio of water to juice).
- Depending on the Opuntia species, acidity may need to be adjusted up to 0.1 percent.
- Addition of food additives such as sodium sorbate is done to enhance the shelf life. Sugar (up to 12 to 13° Brix) and preservatives are added (sodium benzoate and/or potassium sorbate, or a mixture of both, at 500 mg (kg) to 1 or to levels set by national regulations).
- The juice is then pasteurized using a High Temperature Short Time (HTST) approach and packed immediately into glass bottles which are then stored in a cool place. Both bottles and caps need to be sterilized before use.

- The bottles are then labelled, packed in boxes and kept in storage rooms until shipped to market.

4. Validation of the practice
The content of this practice was developed following the practices applied in Mexico, Italy, Chile and the United States.

5. Further reading

- Rural infrastructure and agro-industries division “Agro-industrial utilization of cactus pear.

6. Agro-ecological zones
- Subtropics, warm/mod cool

7. Objectives fulfilled by the project
- Women-friendly
- Resource use efficiency
- Pro-poor technology