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Postharvest Technology for Fresh Chili Pepper in Cambodia, Laos, and Vietnam

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Introduction

Chili pepper (*Capsicum annuum*) is a popular vegetable valued around the world for its color, flavor, spice, and nutritional value (Berke et al. 2004). Capsaicin (8-methyl-N-vanillyl-6-nonenamide) and other capscicinoids give chili its fiery hot taste. Chili is rich in vitamin C and provitamin A, a good source of most B vitamins, particularly vitamin B6, and high in potassium, magnesium, and iron. Chili is grown throughout Cambodia, Laos, and Vietnam, and is an integral part of most meals, especially in Laos. It is

eaten raw or added to various fresh and cooked dishes to provide the desired pungent or spicy taste; it is also added to processed products such as dried fruit, powder, or paste. Improved varieties and production systems combined with appropriate postharvest techniques to reduce waste and maximize use of the produce can increase the supply of chili for the fresh market and processing industries.

Harvesting and Field Handling

Harvest maturity. Chili is generally harvested when ripe, but it also can be harvested at a



Figure 1. Green and ripe chili at harvest.

green, immature stage (Berke et al. 2004) (Fig.1). Maturity of green chili can be based on size, firmness, and color. For fruit to be harvested ripe, at least 50% color should have developed (Aguilar, undated).

Chili is non-climacteric—it does not ripen after harvest. Chili harvested unripe has no capacity to complete ripening unless postharvest conditions are favorable. In a study by Krajayklang et al (2000), it was found that *Capsicum annuum* L. *paprika* and cayenne chili fruit harvested green or deep green failed to attain full red color under room conditions, while fruit harvested at or after the color break stage (when the color begins to change) developed full red color within 7–9 days. In a study on bell pepper harvested mature-green, the fruit was able to develop deep red color when stored under evaporative cooling conditions (Acedo 1997).

Time of harvesting. Harvesting can be done weekly, preferably during the early part of the day. Harvesting during or just after rain is not recommended, as wet conditions favor microbial growth and enhance fruit breakdown. If chili must be harvested when the sun is up, the fruit should be placed under shade to dissipate heat before it is packed.

Harvesting method. Chili is picked by hand (Fig. 2). The fruit is harvested by removing it from the branch and ensuring that the stem remains intact and attached to the fruit. Only fruit with the required color and size should be harvested. Overripe soft fruit is removed from the plant

and graded out to be used for other purposes, if possible. During harvesting, pickers should wear gloves to protect their hands because the oils (capsaicin) in the fruit can cause severe burns; pickers should take care not to touch their face or eyes. Harvested fruits can be placed directly into plastic field crates or into smaller plastic buckets, which are then transferred to crates at the side of the field. Cotton waist bags also can be used to collect the peppers and carry them to field crates.

Mechanical harvesting is not advisable for chili destined for the fresh market because the machinery may injure the fruit. However, mechanically harvested fruit can be used for processing.

Field handling. The harvested fruit should be kept in shaded conditions, and protected from sun, wind, and rain. Plastic crates are recommended when transporting from the field to the packinghouse to minimize damage. Sacks or mesh bags do not provide sufficient protection for the fruit during transport.

Packinghouse Operations

Cleaning. Chili should be cleaned in the field. Clean chili by gently rubbing the fruit to remove debris and soil particles. If washing has to be employed, the wash water must be clean or sanitized with chlorine (see “controlling decay”). After washing, the fruit must be dried properly to prevent decay.



Figure 2. Hand-picking chili and using a plastic bucket as a harvesting container.

Sorting/Grading. There are no recognized grade standards for chili. Good quality fruit should be of uniform shape, size, and color typical of the variety. Fruit with defects such as cracks, decay, mechanical damage, and sunburn should be sorted out and rejected. Undersized, shriveled, dull-looking, pitted, or softening fruit also should be rejected.

Chili may be classified based on color, such as red, green, and a mixture of red, green, and yellow, and placed together or separate parts of the same container. Each class can be assigned a particular name (e.g. Class or Grade 1, Grade 2, and so on). Other quality specifications may include:

- Free from soil and debris
- No overripe or softening fruit
- Free from microbial infection or insect infestation
- No mechanical damage, splitting, or cracking
- Stems intact and green

Fruit is sorted/graded by hand either on a moving conveyor or on a grading table. Sorting tables for tomato can be modified to suit chili. Sorters or graders must be knowledgeable and experienced to select only the fruit that meets the established standard.

Controlling decay and insect pests. Field sanitation and prevention of wounds on the fruit help to reduce the incidence of disease. Washing in 300 ppm chlorine solution also can reduce disease (Aguilar, undated) and should be followed by proper drying. Waxing with fungicides has been reported to reduce water loss and disease, but this treatment is not recommended as it leaves chemical residues on the fruit.

Another safe and simple treatment is the hot water dip. Dipping chili in 53-55°C water for 4 min can effectively control botrytis rot without causing fruit injury. Heat treatment also has been used to control insect pests. However, this method has not been tried against the chili insect borer, infestations of which can persist during storage of dried fruit. In mango, dipping

in 46°C water for 90 min for big-sized fruits (500-700 g) and 75 min for smaller fruit (<500 g) effectively controlled fruit fly (Sanchez 2000). In citrus, dipping in 44°C water for 100 min provided quarantine security against Mexican fruit fly (Shellie 2000). Right after heat treatment, the produce must be cooled in water. The use of heat treatment in chili for insect pest control must be examined and optimized.

Ripening treatment. Peppers do not ripen after harvest and produce very low levels of ethylene at 0.1 to 0.2 $\mu\text{L kg}^{-1} \text{h}^{-1}$ at 10°C and 20°C, respectively (Cantwell 2005). The use of ethylene to enhance ripening or color change is not recommended because it stimulates respiration and causes the fruit to soften. The most effective way to color peppers is to hold partially colored fruit at 20-25°C with >95% RH. Simple evaporative coolers may promote deep red color development (Acedo 1997).

Precooling. After harvest, precooling can be employed to remove field heat from the fruit and slow down metabolism. It is an important step in cold chain management. For chili produced in the tropics, rapid cooling to 10°C at high RH would be sufficient, as a lower end-point temperature could injure the fruit. Precooling can be done using forced air, hydrocooling, or vacuum cooling. Hydrocooling is simpler and cheaper than the other methods, but care should be taken to prevent development of decay from inadequate drying after treatment. Precooling is advisable prior to cold storage.

Packaging. Different kinds of packaging containers are used for chili for in domestic markets, including bamboo baskets, wooden crates, plastic crates, and plastic bags (Fig. 3). Plastic crates offer better protection against physical injuries than the other containers due to their smooth surface, rigidity, and ease in handling. If bamboo baskets or wooden crates are used, protective measures must be applied such as using liners (e.g. fresh leaves, old newspaper) and proper strapping or binding of the container. Baskets of produce should not be stacked on top of one another unless a rigid divider is provided in-between layers in

a stack. Plastic or mesh bags and sacks are not recommended unless they are placed in a rigid container.



Figure 3. Plastic crates (A) and bags (B) as packaging containers for chili.

For export, it is best to pack chili in telescopic cartons. Two sizes are used with internal dimensions of 20 x 51 x 34 cm and 16 x 37.7 x 27.9 cm. If the larger carton is used, a central divider should be included. If staples are used in carton construction, care should be taken to ensure the staples are fully closed to prevent fruit damage.

Storage

If cold storage facilities are available, peppers can be stored at 10°C with 85-90% RH (Kitinoja and Kader 2004). The fruit can last for 2-3 weeks.

Chili can be damaged when stored below 10°C; symptoms include surface pitting, water-

soaked areas, decay (especially *Alternaria*) and discoloration of the seed cavity. Symptoms can appear after a few days at 0°C or a few weeks at 5°C. Sensitivity to cold varies with the cultivar; ripe fruit is less sensitive than green fruit. When stored above 13°C, chili is subject to accelerated ripening and bacterial soft rot infection. Because peppers are sensitive to ethylene, chili should be stored away from ethylene-producing fruit such as bananas, avocados, melons, etc. and ripening rooms. Decaying fruit produces significant amounts of ethylene that may enhance ripening and decay of other fruits. Chili in storage should be inspected periodically and decayed fruit culled.

Where no cold storage facilities are available, fruit should be sorted, packed, and marketed within 24 hours of harvest. This is particularly important for varieties that exhibit short shelf life. Simple methods to maintain freshness and extend shelf life can be employed, such as modified atmosphere (MA) storage or packaging



Figure 4. Polymeric films for modified atmosphere packaging and storage of chili.

made from polymeric films, particularly commercially available products such as polyethylene and polypropylene bags (Kader, undated) (Fig. 4).

In a study on the chili cultivar 'Jinda,' it was found that high-density polyethylene bags were more effective in prolonging shelf life than polypropylene and polyvinyl chloride films (Suwannasopon 2004). The fruit was still of acceptable appearance at the end of the 28-day storage period at 10°C.

Evaporative cooling storage is a simple method with potential for chili, particularly for red color development. Its effectiveness in extending shelf life and promoting red peel color development of mature-green harvested fruit has been demonstrated in bell peppers (Acedo 1997).

Transport and Market Handling

Chili is susceptible to mechanical damage, particularly if transported in sacks or bags (Fig. 5). Any cracks, splits, or punctures will cause the

fruit to deteriorate rapidly. Discoloration, decay, and finally, tissue breakdown, are the common symptoms of damage. Except for ripening treatment, transport, and market handling, recommendations for tomatoes can be applied to fresh chili.

At the market, keep chili dry. Do not allow rain or other moisture to collect on the fruit. Protect from dust and insects to ensure the fruit is wholesome and clean.

For more information on growing peppers, consult AVRDC International Cooperators' Guide: *Suggested Cultural Practices for Chili and Sweet Peppers.*

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Figure 5. Fruit transported in sacks is easily bruised. Rigid plastic containers are better; they protect the fruit from cracking and splitting. Handle chili carefully during transport to avoid damage to the fruit. Cracks or splits promote the growth of bacteria and mold, which lead to rapid decay.

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