Recent Trend for Postharvest Storage of Tropical and Subtropical Fruits in China

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ABSTRACT

Tropical and subtropical fruits have been developed very rapidly in China, especially in 1990. The tropical fruit production increased by 8% annually from 5.187 Mt in 1990 to 8.2369 Mt in 1996. A 20% -30% loss of fruits and vegetables has been envisaged annually in China due to decay. Extending of storage life of tropical and subtropical fruits is hence of vital importance to reduce loss. This paper reviews postharvest treatments and storage techniques presently practised in China especially for the main tropical fruits such as citrus, bananas, litchi, longan, pineapple and mango. Tropical and subtropical fruits are mainly treated with hot water or steam and/or chemicals, and then stored or shipped at temperature or modified atmosphere. Chemicals are most common use for postharvest treatment and will also be the focus for present research and development, although natural fresh-keeping agents have started development and experiment due to residual toxicity of chemicals. Natural fresh-keeping agents have a bright future for development. Other postharvest treatments (radiation and ionization) and storage methods (ambient storage, controlled atmosphere storage and hypobaric storage) are under experiment.

Key words: fruit postharvest, fruit storage

Present production of tropical and subtropical fruits

Tropical and subtropical China includes Hainan Province, Tainwan Province, large part of Guangdong Province, and south central parts of Guangxi Zhuang Autonomous Region and Yunnan Province as well as parts of river valleys in the south of Sichuan and Guizhou provinces. The region covers around 0.48 million ha, about 5% of the total state land and supports a population of around 150 millions. Fruit production in this region (exclusive of Taihwan Province, similarly herein-after) has shown a large increase since early 1990s. The Planting area expanded from 1,317,000 ha in 1990 to 2,071,000 ha in 1996 (increase 57% ; South Subtropical Crops Office, 1990-1996).

The fruit production was promoted from 5,1 87,100 t in 1990 to 8,23 6,900 t in 1996, an annual increment averaging 8%. Now the fruit production in this region is responsible for 17.7% of the national total. Of the fruit production, Guangdong Province shares the largest part (46.28%), followed by Fujian Province (20.16%), Guangxi (17.81%), Yunnan (6.76%), Hainan(4.39%), Sichuan (4.17%), and Guizhou (0.43%). The first
three provinces (region) are responsible for over 84% of the fruit production. The most common fruits in this region consist of citrus, banana, litchi longan, pineapple and mango, and contribute to 77% of the total production, while other and miscellaneous fruits account for only 23% of the total in 1996. The most common fruits shared 85% of the total in 1990, whereas other and miscellaneous fruits made up only 15% of the total. This indicates that this region has attached great attention to promotion of fruit production as well as to diversified development of fruits.

Postharvest storage of the fruits

Most of the fruits in this region grow and are mature both in hot and wet seasons, show high physiological activity at harvesting, and are easily subjected to pests and diseases, resulting in short-term storage and high decay of fruits. A 20%-30% loss of fruits and vegetables has been envisaged annually in China due to decay (Pan et al., 1996). So postharvest storage is of great importance in maintaining fruit quality and reducing fruit loss.

Postharvest treatment technology is categorized into two groups: chemical and physical treatment. These two methods are usually combined in practical use. Physical treatment mainly includes heat treatment, coating, irradiation and electro-ionization, the last two of which are now under research and experiment for treatment of tropical and subtropical fruits in China. Coating materials consist of natural resin, wax, shelac, gelatin, starch, etc. Chemical treatment generally involves treatment with chemicals including 2-aminobutane (2-AB), benzimidazoles (Benlate, thiabendazole, carbendazol, etc.), Imazalil, Sporgon, etc., as well as phytohormones such as 2,4-D and gibberellic acid.

Low-temperature and modified atmosphere storage are major postharvest storage methods used presently for the tropical and subtropical fruits in China. Modified atmosphere storage can be conducted at both ambient and low temperatures. The most rapidly developed technology for modified atmosphere storage includes small polyethylene film bags storage, large tent storage by natural lowering of oxygen, large tent storage by filling in nitrogen and rapidly lowering oxygen, and silastic window-based bags or tents. Cold storage has now contributed to some 1/3 of the total storage capacity of fruits in China. However, automatic cold storage is not popular for tropical and subtropical fruits in China due to its high cost, and the cold storage most commonly practised is by adding ice as cold source. Ice-based low temperature storage reduces cost and can be simply operated, easy for extension and application. Other storage methods such as controlled atmosphere (CA) storage and hypobaric storage are under research or experiment. The research and application of postharvest storage for the tropical and subtropical fruits varies with species and varieties, and the treatment and storage for the major fruits are described as follows.

Citrus fruits: Citrus fruits harvested are 2,4-D in mixture with other chemicals. The commonly used chemicals include benzenimidazoles as TBZ, Benlate, Carbendazol, thiophanate, etc. (500-1000 ppm); Imazalil (500-1000 ppm); Sporgon (250-500 ppm) (Pan et al., 1996). Coating (mainly with wax, shelac, sucrose ester, etc.) is also used for treatment but coated fruits are not recommended for long-term storage to prevent off-flavor. Shelac, the most popular coating material presently used in China, is sometimes mixed with 2,4-D and Carbendazol or thiophanate (South Subtropical Crops Office, 1998). Medicinal plants are used to treat sweet orange fruit with steamed liquid from lesser galangal (Alpinia officinale) ; Wang and Xi, 1996).

The treated fruit are usually stored at an ambient temperature, which is the most popular method at present. Citrus fruits can be stored for
upto 3 - 4 months in underground cave, underground house or ventilating house, etc. (Pan et al., 1996). Ventilating house storage is widely used in citrus producing areas. Improved ventilating house storage is better than natural ventilating house storage and has been popularized in sweet orange producing areas of Sichuan, Jiangxi, Hunan, Guizhou and Yunnan provinces (Shi, 1992).

Low temperature storage is seldom used for citrus fruit due to high cost of the cold store, although treated fruit can be stored for up to four months at suitable low temperature and relative humidity (Pan et al., 1996). Citrus fruits stored in a large PE or PVC tent filled in with N₂ and draining O₂ gave a good result after 4 months of storage. NA storage is hence worthy of extension (Hu et al., 1991).

**Bananas (Musa spp.):** Banana fruit harvested are usually dipped for 0.5 - 1 min in chemical solution. The chemicals include Carbendazol, thiophanate methyl, Benlate, Imazalil, TBZ, GrS, F₃, etc. (Sun, 1998). The treated fruits will suffer cold injury at the temperature below 11°C, and they are hence recommended for storage for some three weeks at 13°C and RH 85-95% and then at 16-21°C for 1-2 weeks for ripening. Ethylene absorbents (potassium permanganate) are also used and placed in PE bags containing treated banana hands, and the hands can be stored for 1-3 months at an ambient temperature. The suitable shipping conditions for banana fruits are under 13-15°C and RH 90-95% (Pan et al., 1996).

**Litchi (Litchi chinensis sonn.):** Litchi fruit harvested are usually treated with 0.1% TBZ, or TBZ + Aliett (0.5% each), dipped cold or hot (52°C) for 2 min. The fruit treated d with 0.02-0.04 mm PE bag and sealed, and then stored or shipped for 6 days at ambient temperature but for 25-30 days at 3-5°C and RH 85-95% with pre-cooling (Pan et al., 1996). Other treatments include Benlate or Carbendazol or Sporgon + Aliette at 1000 ppm each for 2-3 min, cytokinin and gibberellic acid at 100 ppm each for 1 min, or 0.5% phosphatidylcholine + 2.5% sodium bicarbonate for 2 min.. Chemicals are generally prepared with ice water if pre-cooling is needed (Wang et al., 1997). The fruit can also be treated with sulphur as fumigant at 100 g/m³ for 30 min, then dipped with 3%HCl for 15 min, packaged with 0.05 mm PE bags after cooling of the fruit, scaled and stored at a room temperature of 27-32°C (28.3°C by average), and the storage life extended to 10-15 days (Chen et al., 1998). Treatment with extracts from medicinal plants (such as galangal, stemona and giant knotweet) was conducted produced some good results (Zhou and Zhen, 1997).

Low temperature CA storage is now under research and experiment. It is reported that storage of Nuomici fruit at 1-3°C with 5% O₂ and 5%CO₂ had a 91% marketable fruit after 30 days while the optimum atmosphere combination for Huaizhi fruit was 10% O₂ and 10% CO₂.

**Longan (Dimocarpus longan):** The well-considered storage process is that the harvested fruit is treated with chemicals such as TBZ, Imazalil, 2-AB, Carbendazol, etc. + plastic or cardboard boxes lined with PE bags (5-10 kg/box), or with fumigants (such as SO₂) + low temperature MA storage. The treated fruit is generally stored for eight days at an ambient temperature and 40 days at a low temperature (3-4°C) (He et al., 1997). Chemicals such as SO₂, sodium hydrosulphite, HSJ-1, HSJ-2, 2-AB, FISB-1 and FISB-2 are considered widely used. Longan fruit bunches can be dipped into 100°C water for 5 - 15 sec, dried with cool air, packaged with PE bags, placed into boxes and stored in cold store at 2 ± 1°C for 22 days.

Longan fruit is very sensitive to storage temperature. The optimal temperature ranges between 0 and 5°C, and the temperature should not be higher than 8-10°C (Pan et al., 1996).

**Pineapple (Ananas comosus):** The cut end
of the pineapple fruit stem is dipped with 10% benzoic acid solution or with Shirlan (salicylanilide), Imazalil, Benlate or TBZ, and fruit rot caused by *Thielaviopsis paradoxes* (de Seynes) v. Hohnel can be controlled. The freshly harvested fruit treated with 500 ppm NAA and 100 ppm GA$_3$ have a storage life of 41 days at an ambient temperature with effective control of fruit decay, whereas the untreated fruit only have a storage life of 12 - 15 days. Semi-yellow smooth Cayenne pineapple fruit dipped with 101ppm 2,4,5-T and stored at room temperature had an extended storage life of 6 - 14 days. Treated fruit can be stored for 4 weeks at 11-13°C or 8-9°C and RH 85-90%. Low oxygen and high nitrogen can reduce the respiratory strength of pineapple fruit and delay ripening by 1 - 3 days. But fruit colour is changed and hence this storage is not commercially at present.

**Mangoes (Mangifera indica):** Harvested fruit should be pre-cooled as soon as possible to lower the temperature to 30 ± 2°C and treated within 24 hr (South Subtropical Crops Office, 1998). The mango fruit harvested are treated in 52 -53°C hot water for 10 - 15 min or in chemical hot water for 10 min, and then washed in running water for cooling the treated fruit. Chemical treatment includes use of TBZ, Sporgon or Benlate at 1000 ppm. Heat treatment washes away the natural wax layer of the fruit, and wax should be used as coating to reduce loss and improve the appearance of the fruit. For commercial recommendation the treated fruit are washed with chlorine water and coated with mixture of wax and chemicals (at two-fold or more dose). This method is easy, simple and very effective. Chemical treatment delays ripening when GA$_3$ is added at 20 ppm. The treated fruit can be packed with soft tissue paper or 0.01 mm PE small bag for individual fruit or with bags containing chemicals (Pan et al., 1996).

Mango fruit is prone to cold injury at low temperature. The minimum low temperature ranges between 10 and 12.8°C for most of the cultivated varieties and cold injury will occur at less than 10°C (South Subtropical Crops Office, 1998). But there are some exceptions. For example, the critical temperature for Zhihua mango fruit 5°C and they are commercially recommended for storage at 8°C for 40 days (Pan et al., 1996).

The treated fruit stored at 13°C under CA or MA of 5-6% O$_2$ and 2-5%CO$_2$ for 26 days can be placed at an ambient temperature for normal ripening, and the ripening fruit can also be moved back for storage at low temperature for 10 - 14 days (Wang, 1991). The mango fruit can be packed with PVC bag with the air reduced to 0% for 5 - 7 days before when there is no CA storage equipment available, and stored in the cold store at 13°C (Pan, et al., 1996). Mango fruit stored for 25 - 35 days at 13°C and 75 - 50 mm Hg or 35 days at 50 mm Hg and then placed at an ambient temperature can be ripen normally after 3-5 days. At less than 50 mm Hg mango fruit loses water and shrivel (Wang, 1991).

**CONCLUSIONS**

Tropical and subtropical fruits will develop rapidly in this region and postharvest storage will play a more important role in maintaining fruit quality and reducing fruit loss. Postharvest chemical treatment should be based on the recommended levels because excessive dosages leave toxic residues hazardous to human health. Natural fresh-keeping agents, safe and nontoxic, will be the trend for future development. Fruit storage should be practised according to fruit storage characteristics and economic feasibility. Cold storage is costly and not recommended for the fruit to be marketed locally.
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