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COLD CHAIN MANAGEMENT FOR MINIMUM HORTICULTURAL POST-HARVEST LOSSES

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ABSTRACT

For fruit and vegetable farmers selling directly to consumers, the ability to quickly chill produce after harvest and safely store it until delivery can make or break the value of a crop. Local food systems can contribute to socially, economically, and ecologically beneficial food production for local communities. In order to deliver quality produce to the consumer, local food systems must utilize rapid cooling and cold storage technology. For majority of farmers, a walk-in cooler is one of their first large capital farm expenses. The level of investment varies as per, capacity of the system, area, country and level of expertise, it may go to crores starting from lakhs. For maximum of farmers it is beyond their financial limits.

Key words : *Cooling, fresh produce, temperature management, shelf life.*

At harvest, horticultural commodities are alive and continue with the metabolic processes such as respiration and transpiration. For fruits which are harvested at physiological maturity, ripening proceeds after harvest. These processes require water, nutrients and energy reserves all of which are cut off at harvest. Other deteriorative processes in harvested produce like ethylene evolution also hastens the rate of ripening and softening hence the fruits become unappealing to consumers. Colour changes occur as fruits are de-greened during synthesis of carotenoids to give the fruit a consumer appealing colour. Water loss from the produce causes them to shrivel (fruits) or wilt (vegetables) after the cells have lost their turgidity. Central to these deteriorative processes is temperature (Vorster *et al.,* 1990). It is estimated that the rate of deterioration of perishables increases two to three-fold with every 10°C increase in temperature (Kader, 2005). A study conducted on sweet cherries that were stored at different temperatures (0°C, 5°C, 10°C and 20°C) and their respiration rates taken showed that respiration rate increased with an increase in temperature (Carlos *et al*., 1993). Therefore, controlling product temperature and reducing the amount of time that a product is at sub-optimal temperature is key to maintaining the quality, improving shelf life and extending marketing period and ultimately reducing postharvest losses.

Temperature control in harvested horticultural produce

Temperature abuse is one of the major causes of the very high losses experienced in horticultural production. It starts right from harvesting to when the product is being marketed and reaching the ultimate consumer (Nunes *et al*., 2003). The rate of deterioration has been estimated to increase by two or threefold with every 10°C increase in temperature within the optimum range for the commodity in question and so temperature abuse is critical and detrimental to all horticultural products (Kader and Rolle, 2004). Its detrimental effects on the shelf life of horticultural products is attributed to increased water loss, respiration rate, softening, ethylene evolution and other physiological processes which increase rate of deterioration of the fruits (Chopra *et al*., 2003). Post-harvest cooling and maintaining a cold chain is thus the most effective way to curb effects of high temperature on perishable horticultural commodities and by maintaining low temperatures conducive for a certain commodity, increase shelf life will be realized (Bachmann, 2000).

Logistics companies and suppliers have invested in cold chains by in pursuit of accessing local markets and opening temperature controlled operations which have helped in strengthening cold chains and prolonging the products shelf life (Rolle, 2006). They also complement their cold storage with other post-harvest technologies like MAP and waxing hence extending the shelf life of their produce, consequently getting longer marketing period.

Cold Chain Management

Knowing the damaging effects of high temperature on horticultural commodities necessitates clear and efficient cold chains at all stages of the supply chain so as to impede the challenge of post-harvest losses due to temperature abuse. The other component is cooling during holding which occurs after pre-cooling, during other activities like sorting and grading, packaging, transportation and even during marketing the produce, optimal temperature needs to be maintained (Ginsberg, 1985). Maintenance of cold chain is therefore very necessary so that we can preserve the commodities at their best possible quality (Kader, 2005).

Generally, cold chain management allows for maintenance of physical and biochemical properties of produce which are desirable to consumers. This is nutritionally important since the nutrients in the produce will be maintained at high levels if they are not exposed to high temperatures. Cold chain management also helps in regulating the market prices of products especially during peak season when there is so much of the specific product in the market such that it causes market glut. With a well-managed cold chain, farmers are able to store some of their produce for extended periods of time and avoid selling them at very low prices which is necessitated by fear of losing the produce due to poor storage facilities (Umali-Deininger and Sur, 2006).

Post-harvest handling practices that affect cold chain

Use of cold chain has been in use since the 1950s with aim of prolonging shelf life of horticultural commodities but it has not been fully adopted in most of the developing countries. Some of the practices that farmers in developing countries can adopt to ensure their produce has reduced chances of succumbing to the high temperatures in the surrounding include the following :

Timely harvesting

Time of harvest affects the amount of field heat that accumulates in the produce. Harvesting during the hot hours of the day causes the produce to accumulate a lot of heat in it. The more the heat a produce picks from its surroundings, the more energy and time it requires to cool it down to manageable temperatures (Cantwell, 1998). Harvesting should be done during the cool hours of the morning when the temperatures are still low or in the evening.

Pre-cooling of harvested produce

Its importance is to remove field heat from the produce before other handling operations are conducted so as to relieve the product of heat that could lead to faster deterioration if it stays longer in the commodity (Cantwell, 1998). The longer the commodity stays heated, the higher the rate of deterioration hence shorter shelf life (Kader, 2002). Pre-cooling enhances shelf life by suppressing enzymatic degradation, reducing respiration rate and ethylene evolution, slowing down water loss and inhibiting growth of disease causing microorganisms on the produce. Produce that has not been pre-cooled immediately after harvest, deteriorates faster even after being stored at low optimum temperature. Pre-cooling is also essential in reducing the load on the cold storage facility hence little amount of energy will be required to cool the produce to required temperatures (KMUTT, 2007). Pre-cooling can be done by sprinkling water on the harvested commodities if they are not sensitive to water e.g. fruits like mangoes, apples and oranges (hydro-cooling), forced air cooling where cold air is pushed through produce containers so as to take away the heat and by room cooling.

Transportation

Refrigerated trucks mostly used by commercial farmers are expensive initially when purchasing and costly to operate. However, the small scale farmers should have a well considered means of transport to avoid temperature abuse, e.g. when using a pickup or a lorry the top should be well covered so that the produce is not exposed to direct rays of sunlight.

Cooling options for harvested perishable produce

(i) Hydro-cooling : This is done by cooling a warm produce by sprinkling chilled water on the produce. It is not only more efficient and faster (15 times) than air, but also increases relative humidity around the produce hence reducing the rate of water loss. However, the method can only be used on commodities that are not water sensitive e.g. mangoes, apples, carrots, cucumbers and oranges. Since the water comes into contact with the produce, it should be sanitized to avoid microbial growth (Kader, 2004).

(ii) Forced air cooling : It is achieved by passing cold air through vents in the storage containers that cools the produce as it picks up heat. However, it leads to high water loss due to reduced relative humidity around the produce. Its efficiency is 75-90 times higher than that of room cooling. The method has been used successfully in cooling products like, avocado, melons, cucumber, coconuts, banana and mangoes (Kader and Rolle, 2004).

(iii) Room cooling : In this option, produce is packed in a cold room and cold air allowed to flow through. It is a very slow method but energy efficient and can't be used for products that require rapid cooling like strawberry but has been successfully applied in storage of less perishable products like onions, potatoes and citrus. It is mostly used for products that are sensitive to chilling injury.

Technologies for cold storage of harvested perishable produce

(i) Conventional cold rooms : The conventional cold room has two major components which are an insulated room and a refrigeration system. The refrigeration system's two main components are the evaporator unit which is inside the cold room and the compressor unit which is outside the cold room. These components are connected using a refrigeration piping. The cooling is facilitated by a refrigerant and controlled by thermostat which ensures the temperature is maintained near the desired set point.

(ii) Low cost alternatives to conventional rooms : The technological options for small holder farmers are the low-cost cold storage (LCCS) methods, being emphasized for use to lower and or maintaining temperature at low levels during storage. Once adopted, the LCCS technologies will allow for storage of horticultural products at a lower cost and this will increase farmers income becoming more economically empowered.

Evaporative Cooling Technologies

The charcoal cooler and zero-energy brick cooler use the principle of evaporative cooling. The charcoal cooler is made by building a structure whose walls are filled up with charcoal held in by wire netting while the ZEBC is made of a double wall of bricks and the space in between filled with sand (Das and Chandra, 2001). The pads (charcoal and bricks) are wetted by a constant supply of water. As warm dry air passes through the wetted pads, water evaporates taking with it heat from the environment within the chamber hence cooling the air around the product, consequently cooling the product itself. Produce stored in the cool chambers has shown reduced weight loss, better firmness and reduced deterioration rate (Bhatnagar *et al.*, 1990).

The effect of cooling could be felt up to the fourth day after removal from charcoal cooler (Younan, 2004). In Rwanda, temperature in the charcoal cooler where passion fruits were store was 7^0C lower in comparison to the temperatures outside the storage chamber. Site selection is important in setting up an evaporative cooler. The area should have adequate water to ensure the charcoal is wet at all times for it to be effective (Ngoni, 2000).

No electrical energy is needed to operate such coolers hence they provide better solutions for the small holder farmers who reside in areas without power supply (Singh and Satapathy, 2006).

CONCLUSION

The use of cold is not a cure-all or a one-size-fits-all proposition, but is an important component of an agricultural handling system or value chain in its entirety. Each type of fresh produce and/or food product has a specific and limited storage potential related to its physiological nature and lowest safe storage temperature, and the use of the cold chain can help reach this potential and reduce perishable food losses. Misuse of cold will lead to higher food losses along with added financial losses associated with the costs of cooling, cold storage, cold transport and refrigerated retail market displays.

There is a need to promote the use of cold chains as a means to prevent the waste of limited natural resources. The resources required for agricultural production (i.e. land, water, fertilizers, fuels, other inputs) are becoming more scarce and costly, and 25% to 50% of the resources used to grow these foods are being wasted when perishable foods are lost before consumption. Investments in the cold chain prevent the loss of foods after they have been produced, harvested, processed, packaged, stored and transported to markets, which greatly reduces the need for increased production to meet the predicted growth in future demand. Reducing food waste also saves the water, seeds, chemical inputs and labor needed to produce the food that is currently being lost. As local and global resources become scarcer and more expensive, preventing food losses will become even more cost effective than it is at today's resource prices. Public and private sector investors need to take into consideration how investing in the use of the cold chain can generate savings due to the reduced need for constantly increasing food production to meet rising consumer demand for perishable foods.

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