

## **RAPID COOLING OF FRESH VEGETABLES**

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For the modern vegetable producer to have access to the higher quality, higher value vegetable markets, product cooling is not an option. Many markets now demand that produce is cooled within hours of being cut and this cooling yields many benefits to the grower and customer alike.

From the moment that a vegetable is cut in the field, it begins the process of dying. It is therefore essential that the product is cooled to remove the field heat as soon and as quickly as practicable. Benefits from such cooling are:

- Reduced rate of ageing, resulting in longer shelf life
- Reduced water loss, maintaining the appearance and the weight of the produce
- Slower growth and spread of disease
- Increased marketing flexibility, enabling the grower to decide on when to sell
- Ability to meet customer requirements.

However cooling is an increasingly expensive and complex pastime. For the grower to get the best value for money from the system used, it is important that he understands the benefits and limitations of the various options for cooling and is aware of the most appropriate method for his produce. The correct system is the one that gives the desired rate of cooling, at the same time as reducing the losses such as dehydration and presents the produce in the way that is most appropriate to the grower and the customer.

### ***Cooling Rate***

Much emphasis has been placed on the rate at which the heat is removed from the produce. Highly perishable produce can deteriorate during slow cooling. However practice and research has shown that little extra benefit can be gained from reducing the cooling time much below those traditionally recommended, and pursuing the “ultra-low” cooling times results in extremely high capital costs for cooling equipment. Table 1. below shows some typical cooling times for a range of fresh vegetables

## Table 1. Design Cooling Times

(Source MAFF Reference Book 324, Refrigerated Storage of Fruit and Vegetables)

VEGETABLE	DESIGN COOLING TIME
Asparagus	3 hours
Calabrese	3 hours
Spinach	3 hours
Runner Beans	8 - 12 hours
Lettuce	8 - 12 hours
Spring onion	8 - 12 hours
Spring cabbage	8 - 12 hours
Cauliflower	8 - 12 hours
Brussel sprouts	8 - 12 hours
Carrots	12 - 18 hours
Leeks	12 - 18 hours
Tomato	12 - 18 hours
White cabbage	280 - 400 hours
Onions	300 - 500 hours

### ***Cooling Methods***

The cooling method must be selected based on the following:

- required cooling time
- type of produce
- throughput required
- the degree of holding post cooling required
- the type of packaging

The main cooling methods are:

- Hydrocooling
- Vacuum cooling
- Air cooling, conventional cold stores
- Wet air cooling with positive ventilation

Tables 2 & 3 below summarise the comparison of these systems.

## **Hydrocooling**

This is a continuous process, often part of a vegetable handling line, in which the produce is immersed or drenched in cold water. This has the obvious benefit that there is not loss from the crop due to dehydration, though there should be a clean water rinse after cooling. This process is only suitable for a small range of produce where wetting is not a problem. Examples are carrots, water cress, leeks, parsnips and tomatoes. Due to the close contact with the cooling medium, the system offers very fast cooling times, down to 20 minutes and offers other advantages such as no risk of freezing and a continuous process. However there is an increased risk of disease spread; problems with effluent disposal; high electricity usage and does require an additional cold storage area to hold the produce post cooling.

## **Vacuum Cooling**

This is a batch process which relies on the cooling effect of the evaporation of water from the produce and as a result does result in weight loss. About 1% for every 5C temperature reduction. This system is most suited to leafy vegetables with large surface area and free water. Crops such as white cabbage or bulky crops are not well suited. As with hydrocooling, very rapid cooling times can be achieved, down to 20 minutes depending on the produce to be cooled and the packaging used. Other benefits are that packaged produce can be cooled and the system is relatively simple to operate. Disadvantages include the weight loss; high power requirement; possible freezing of all or part of the produce; noise when operating within a packing area and the need for a post cooling holding store.

## **Air cooling**

In conventional cold stores, produce is cooled by exposure to cold air around the crop. Air in the room is cooled with a direct expansion (DX) refrigeration system. Typically cooling times are not as good as those of previous methods, though this can be enhanced by the use of forced ventilation via a letter box wall or velum sheet. In this way some soft fruits may be cooled in less than 2½ hours, however other crops such as Brussels or Cauliflower may take 24 hours or longer. The use of this type of cooling enables the produce to be cooled and stored. Typically the produce being placed on the ventilation wall until cooled and then being moved to another part of the store for holding, making space warm produce on the wall. This system tends to be less heavy on power consumption

The operation of the DX cooler has the natural effect of removing moisture from the air as it passes over the evaporator, this can be reduced to a minimum by the careful design of the cooler however some moisture and hence weight loss is inevitable. Humidification systems may be used to reduce the losses by the introduction of water into the air. Systems such as ultrasonic nozzles have been used, though care must be taken to avoid excessive frosting on the coil face and water being deposited out on the produce. Evaporative humidification is a good alternative in which the water is transferred into the air in vapour form. Care must also be taken to avoid freezing of the produce.

## **Wet air cooling**

This is an alternative to simple direct expansion cooling. Many systems are available for achieving this, such as the ice bank system and many other forms branded by various manufacturers. The principal is that the produce is cooled by air that has been cooled by close contact with water that has in turn been cooled by a refrigeration system. The ice bank uses melting ice, which offers the advantage of storing the cold over night using low rate electricity and then melting the ice during the day for the product cooling process. This system of cooling is suitable for most crops other than those that require low humidity storage, such as dry bulb onions and produce that is required to be stored much lower than 1C. When combined with a forced ventilation system, the cooling times can be as low as 2 hours, though bulkier and packaged crops will take longer, eg. 10 - 17 hours. Due to the high relative humidity of the cooling air, the weight losses from such systems are minimal. As with the Dx system above, the cooler provides both cooling and holding facilities. Freezing of the crop is not possible, though care must be taken with crops that are sensitive to chill damage.

Due to the wet air used, any packaging must be water resistant, hence waxed face packs or plastic trays are required. Power consumption is generally high.

## Table 2 Comparison of Cooling System Costs

(Source MAFF Leaflet 860, Rapid Cooling of Horticultural Produce)

SYSTEM	CAPITAL COST	RUNNING COST	THROUGHPUT (24 hr day in brackets)
Hydrocooling	100%	100%	30 T
Vacuum cooling			
- 2 pallet	132%	100%	10 T
- 5 pallet	180%	100%	25 T
Conventional cold store			
-small	36%	76%	4 (10) T
-medium	64%	76%	8 (25) T
- large	100%	76%	14 (40) T
Wet air cooling			
-small	68%	106%	4 (10) T
-medium	104%	106%	8 (25) T
- large	160%	106%	14 (40) T

### Table 3 Cooling System Selection

(Source MAFF Leaflet 860, Rapid Cooling of Horticultural Produce)

PRODUCT	HYDROCOOLER	VACUUM COOLER	DX AIR COOLING	WET AIR COOLING
Asparagus	+++	+	++	++
Green beans	++	+	+	+++
Brussels	+	++	+	+++
Beetroot	++	*	+	+++
Cabbage - Leaf	+	+++	+	+++
Cabbage - head	*	*	++	+++
Calabrese	+	++	+	+++
Carrots	+++	*	+	++
Cauliflower	+	+	+	+++
Celery	++	+++	+	++
Chinese cabbage	*	++	+	+++
Marrow	*	*	++	+++
Leeks	+++	+	++	+++
Lettuce	*	+++	+	++
Onions -dry	*	*	+++	*
Onions salad	+++	++	+	++
Parsnips	+++	*	+	++
Peas	++	+	+	+++
Potatoes - new	*	*	++	+++
Radish	+++	*	+	+
Rhubarb	*	+	+	+++
Sweet corn	+	++	+	+++
Watercress	+++	+	*	+
Cucumbers	+	*	++	+++
Mushroom	*	+++	+	++
Sweet peppers	*	*	++	+++
Tomatoes	+++	*	++	++
+++ = Most suitable	++ = Suitable	+ = Less suitable	* = Generally not suitable	