Freezing Injury

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The Physiology of Freezing Injury

Fresh fruits and vegetables are living entities in the sense that their respiration process and individual cell activity continue after they are harvested. With their normal food supply from the plant, bush or tree cut off, they start to use their own stored constituents for the energy needed to continue respiration and cell activity. Retarding this "self consumption" is one of the reasons for refrigerating fresh fruits and vegetables. This natural respiration process, involving a series of chemical reactions, is slowed down by lowering the temperature of the product. Freezing injury occurs when fresh fruits and/or vegetables are exposed to temperatures below their freezing point, normally in the range of 25-30°F (-4 to -1.1°C). Generally speaking, the higher the soluble solids or primarily sugar content of the commodity, the lower the freezing point will be.

Cold temperatures can injure the cells, and the temperature at which this occurs depends upon the natural resistance to cold of the particular fruit or vegetable. In most instances the injury occurs at the point where ice crystals begin to form in the cells, although in a few cases the damage begins at temperatures somewhat above the freezing point. The ice crystals are capable of rupturing the cell wall, thereby allowing cell fluids to escape and resulting in moisture loss, quality degradation or flavor changes.

If fruits or vegetables are accidentally exposed to freezing temperatures for a short period of time, damage may be avoided if products are left completely undisturbed until they have warmed up to temperatures above their freezing point. By not moving a product, crystallization may be avoided even if the temperature drops several degrees below the freezing point, a situation commonly known as “super-cooling.” Once the temperature goes below the freezing point of a product, even slight vibrations can cause immediate crystal formation and danger of injury such as loss of textural integrity upon thawing.

Damage Caused by Freezing

The damage caused by ice crystal formation is both physical and chemical. There are two processes that cause damage to cellular structure and lead to loss of firmness. The first is when crystals puncture cell membranes, leading to turgor loss. The second is when crystals break up the cell wall structure, leading to tissue breakdown and release of degradative enzymes. Tissues damaged by freezing generally lose rigidity, become mushy upon thawing, and appear water-soaked.

There are varying degrees of sensitivity to freezing injury peculiar to each type of fruit or vegetable. For example, parsnips and tomatoes have about the same freezing point, but parsnips can be frozen and

thawed without damage, while tomatoes are severely damaged by freezing. Leafy lettuce is very susceptible to freezing injury, while cabbage and kale can withstand several light freezes without significant damage. For the least sensitive fruits and vegetables that are not seriously damaged by freezing, thawing at 30°F (-1.1°C) seems to be most satisfactory. Fast thawing at higher temperatures results in more tissue damage. Since freezing renders products highly susceptible to bruising, they should be thawed with as little handling as possible. Successful salvage should be followed by immediate utilization of the product to avoid decay of specimens with undetected injury.

Differences among cultivars and maturity stages at harvest, as well as growing conditions, influence the freezing injury point of each type of fruit or vegetable. Because of this, only average temperatures can be used in stating an injury point, and the higher limit is normally reported. More details are available in USDA Agricultural Handbook No. 66, published in 1986.

Freezing Points and Susceptibility of Fresh Produce to Freezing Injury

The following table contains information on the approximate temperature at which freezing occurs and the sensitivity to freezing injury of common fresh fruits and vegetables. In the most susceptible list are those products likely to be injured by even one light freezing. The moderately susceptible are those that will recover from one or two light freezings. The least susceptible commodities will tolerate several light freezings without significant damage.

	Freezing Point					
	Most Susceptible		Moderately Susceptible		Least Susceptible	
	°F	°C	°F	°C	°F	°C
Apples			29	-1.7		
Apricots	30	-1.1				
Artichokes (globe)			30	-1.1		
Asparagus	31	-0.6				
Avocados	31.5	-0.3				
Bananas	31	-0.6				
Beets (topped)					30	-1.1
Berries (except cranberries)	30	-1.1				
Broccoli			31	-0.6		
Brussels Sprouts					30.5	-0.8
Cabbage					30.4	-0.9
Cantaloupes			30	-1.1		
Carrots			29.5	-1.4		

Cauliflower			30.6	-0.8		
Celery			31	-0.6		
Cherries (sweet)			29	-1.7		
Coconuts			30.4	-0.9		
Corn (sweet)			31	-0.6		
Cranberries			30	-1.1		
Cucumbers	31	-0.6				
Dates					3.7	-15.7
Eggplant	30.6	-0.8				
Figs (fresh)			27.6	-2.4		
Grapefruit			30	-1.1		
Grapes (American)			30	-1.1		
Grapes (Vinifera)			28	-2.2		
Kale					31	-0.6
Kiwifruit	29.0	-1.7				
Lemons	29.4	-1.4				
Lettuce	31.7	-0.2				
Lima Beans	31	-0.6				
Limes	29	-1.7				
Mangoes			30.3	-0.9		
Nectarines	30.4	-0.9				
Okra	29	-1.7				
Onions (dry)			30.6	-0.8		
Onions (green)	30.4	-0.9				
Oranges			30.6	-0.8		
Parsley			30	-1.1		
Parsnips					30	-1.1
Peaches	30	-1.1				
Pears			29.2	-1.5		
Peas			31	-0.6		
Peppers	30.7	-0.7				
Persimmons			28.1	-2.1		
Plums	30.5	-0.8				
Pomegranates			26.6	-3.0		

Potatoes (sweet)	30	-1.1				
Potatoes (white)	31	-0.6				
Radishes			30.7	-0.7		
Rhubarb			30.3	-0.9		
Rutabagas					30	-1.1
Salsify					30	-1.1
Snap Beans	31	-0.6				
Spinach			31.5	-0.3		
Squash (summer)	31	-0.6				
Squash (winter)			30.5	-0.8		
Tangerines			30	-1.1		
Tomatoes	31	-0.6				
Turnips					30	-1.1
Watermelons			31.3	-0.4		

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