Strawberry

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Scientific Name and Introduction: Strawberry, *Fragaria* x *ananassa*, is a perennial of the Rosaceae family. The edible portion, not a true berry, is a multiple fruit comprised of many achenes (seeds) and receptacle tissue. Fruit are produced on short-day and day-neutral plants in many growing areas. However, the major production in the U.S. is in California, Oregon and Florida.

Quality Characteristics and Criteria: A high quality strawberry fruit will be uniformly red in color, firm, flavorful, and free of defects and disease. Sugar content does not increase after harvest; therefore, harvest fully-ripe for best flavor. For acceptable flavor, a minimum 7% SSC and/or a maximum 0.8% TA are recommended (Kader, 1999).

Horticultural Maturity Indices: Maturity is based on surface color. The U.S. minimum is ½ or ¾ of berry surface showing red or pink color, depending on grade. The California minimum is 2/3 of berry surface showing red or pink color.

Grades, Sizes and Packaging: U.S. No. 1 grade consists of strawberries with calyx (cap) attached which are firm, not over-ripe or undeveloped, of uniform size, and free of decay and damage. Each fruit must have at least 3/4 of its surface showing pink or red color. U.S. No. 2 grade consists of strawberries free from decay or serious damage and with at least 1/2 of each fruit showing pink or red color. U.S. Combination grade is a mixture of U.S. No. 1 and 2, with at least 80% meeting U.S. No. 1 grade. Strawberries are often packaged by pickers in the field into either 1-dry-pt or 1-dry-qt open mesh baskets, or clear clamshell containers. The mesh baskets or clamshells are held in a corrugated fiberboard tray holding about 4 to 5 kg (9 to 11 lb).

Pre-cooling Conditions: Strawberries are extremely perishable, and it is important to begin cooling within 1 h of harvest to avoid loss of quality and reduction in amount of marketable fruit (Maxie et al., 1959). Temperature management is the single most important factor in minimizing strawberry deterioration and maximizing postharvest life. Forced-air cooling is highly recommended, although room-cooling is used in some cases (Mitchell et al., 1996).

Optimum Storage Conditions: Store at 0 °C (32 °F) with 90 to 95% RH. Strawberry fruit can be stored for up to 7 days at 0 °C (32 °F), depending on disease pressure.

Controlled Atmosphere (CA) Considerations: MAP for shipment with 10 to 15% CO_2 reduces growth of *Botrytis cinerea* (Wells and Uota, 1970) and reduces respiration rate (Li and Kader, 1989), thereby extending postharvest life. Use of whole pallet covers for MA is the most common method (Mitchell et al., 1996). Off-flavors can develop if higher CO_2 atmospheres are used.

Retail Outlet Display Considerations: Refrigerated display greatly extends shelf-life and maintains quality. Covered baskets maintain higher RH around berries, reducing water loss and shrivel.

Chilling Sensitivity: Strawberry fruit are not sensitive to chilling temperatures and should be stored as cold as possible without freezing.

Ethylene Production and Sensitivity: Strawberries produce very low amounts of ethylene at < 0.1 μL kg^{-1} h^{-1} at 20 °C (68 °F) and do not respond to ethylene (Mason and Jarvis, 1970). Removal of ethylene from storage air may reduce disease development (El-Kazzaz et al., 1983).

Respiration Rates:

Temperature	mg CO_2 kg^{-1} h^{-1}
0 °C	12 to 20
10 °C	50 to 100
20 °C	100 to 200

To get mL kg^{-1} h^{-1}, divide the mg kg^{-1} h^{-1} rate by 2.0 at 0 °C (32 °F), 1.9 at 10 °C (50 °F), and 1.8 at 20 °C (68 °F). To calculate heat production, multiply mg kg^{-1} h^{-1} by 220 to get BTU per ton per day or by 61 to get kcal per metric ton per day.

Physiological Disorders: Perhaps because of rapid marketing and very short storage, few physiological disorders occur after harvest. CO_2 injury, particularly when > 15% CO_2 is used, is manifested as a bluing of the skin (Ke et al., 1991), whitening of inner fruit tissues (Gil et al., 1997), and fermentative off-flavors.

Postharvest Pathology: Disease is the greatest cause of postharvest loss. The most common decay is Botrytis rot, also called Gray Mold, caused by *Botrytis cinerea* (Ceponis et al., 1987). The disease can begin pre-harvest, remaining as latent infections, or begin postharvest. This fungus continues to grow at 0 °C (32 °F). However, growth is slow at this temperature. Rhizopus rot caused by *Rhizopus stolonifer* is another important disease of strawberry. This fungus cannot grow at temperatures below 5 °C (41 °F). Postharvest fungicides are not used on strawberries; therefore, prompt cooling, storage at 0 °C (32 °F), preventing injury, and shipment at 0 °C (32 °F) under high CO_2 are the best methods for disease control. Damaged fruit should be eliminated from baskets to prevent spread of disease to healthy berries (nesting) (Sommer et al., 1973).

Quarantine Issues: Methyl bromide fumigation is routinely used for strawberries shipped from the U.S. to Japan and Australia to eliminate live insects. For California, two-spotted spider mite and western flower thrips are the main pests of quarantine concern for exported fruit.

Suitability as Fresh-cut Product: Strawberries are suitable, and slices have a shelf-life of about 7 days at 2.5 °C (36.5 °F) and 5 days at 5 °C (41 °F) (Rosen and Kader, 1989; Wright and Kader, 1997).

Special Considerations: Strawberry fruit are very delicate and easily damaged. Since the harvest crew is responsible for grading, packing, and gentle handling, their training is critical to packing a quality product.

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