Chinese Cabbage

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Scientific Name and Introduction

Chinese cabbage, *Brassica rapa* L. (*B. campestris* L.) subsp. *pekinensis* (Lour.) Hanelt, is an annual of the Brassicaceae (Cruciferae) family (Munro and Small 1997). The edible portion includes the leaf blades and stalks. Two head shapes predominate: the wong bok or napa types (which are short and broad) and the michihli types (which are long and tapered) (Wang and Cerkauskas 1999). Chinese cabbage is grown in small acreages in most major temperate vegetable-growing regions and is available year round in most markets.

Quality Characteristics and Criteria

Chinese cabbage should have uniform, tightly formed heads with crinkly, yellow-green leaf blades. Head shape and leaf characteristics can vary, depending on the cultivar. There should be no evidence of leaf wilting or discoloration.

Horticultural Maturity Indices

Determination of maturity in species of *Brassica* is not simple, and no single index of maturity is reliable (Ludford and Isenberg 1987). Harvesting consists of cutting the whole plant at the soil surface when the heads are firm and the outer leaves are bright green (Munro and Small 1997). In some cultivars, the outer leaves may be tied a few weeks before harvest to promote a tighter, upright head. Ludford and Isenberg (1987) cite reports that Chinese cabbage store better when heads are more compact at harvest.

Grades, Sizes, and Packaging

There are no published U.S. standards for grades of Chinese cabbage. The wong bok or napa types are about 20 to 25 cm (8 to 10 in) in length, 15 to 20 cm (6 to 8 in) in diameter, and weigh 1.3 to 4.1 kg (3 to 9 lb). The michihli types are about 38 to 51 cm (15 to 20 in) in length, 7.6 to 12.7 cm (3 to 5 in) in diameter, and weigh 0.9 to 2.3 kg (2 to 5 lb) (Kelley 1999). They are shipped in wax-coated corrugated cardboard cartons and wire-bound crates of various sizes.

Precooling Conditions

Damaged leaves should be removed, and the heads packed into shipping containers and quickly cooled (vacuum or hydrovac cooling, forced-air cooling, or hydrocooling) to maximize shelf-life (Kasmire and Cantwell 1992).

Optimum Storage Conditions

Depending primarily on cultivar, Chinese cabbage can be held for 3 to 6 mo at 0 ºC (32 ºF) and

98% RH (Fritz and Weichmann 1980, Apeland 1985, van den Berg 1987). The storage temperature should be as close as possible to 0 ºC (32 ºF) without freezing (Kasmire and Cantwell 1992). Water loss is reduced and storage life extended when heads are enclosed in perforated plastic bags (Sozzi et al. 1981). Storage life is extended by growing Chinese cabbage during cooler growing seasons and placing the heads upside down during storage (Jin-Cheol Jeong, 1998, personal communication).

Controlled Atmosphere (CA) Considerations

An atmosphere of 1 to 2% O_2 and 2 to 6% CO_2 is effective at extending storage life (Adamicki 1997, Saltveit 1997). Decay increases and offensive odors are produced during continuous exposure to 7.5% CO_2, or 5 to 10 days exposure to 30 to 40% (Herner 1987). Specific CA recommendations depend on cultivar, temperature, and storage duration. CA storage retains green color and ascorbate and sugar content in leaves and decreases decay (Wang 1983, Ludford and Isenberg 1987).

Retail Outlet Display Considerations

Chinese cabbage is displayed as individual heads with the outer leaves removed, frequently with a band around the equator to maintain a compressed head shape. Heads should be kept as cool as possible without freezing and sprinkled with water to minimize moisture loss. Exposure to ethylene should be avoided.

Chilling Sensitivity

Chinese cabbage may be chilling sensitive. A physiological disorder (brown midrib) developed after prolonged storage at 0 °C (32 °F) (Apeland 1985). The critical temperature was 1.5 to 3.0 °C (35 to 37 °F) in the three cultivars studied. A 50% loss of product occurred after about 150 degree-days (°F) below the cultivar-specific critical temperature.

Ethylene Production and Sensitivity

Chinese cabbage produces very little ethylene, <0.1 $\mu L\ kg^{-1}\ h^{-1}$ at 20 °C (68 °F) (Kader 1992), but exposure to less than 0.1 $\mu L\ L^{-1}$ can accelerate senescence in air storage. Levels inside cartons of Chinese cabbage in wholesale markets have been measured at 1.09 $\mu L\ L^{-1}$ (Wills 1998). Ethyelene-induced leaf abscission can be minimized by storage in 1% O_2 (Wang 1983).

Respiration Rates

Temperature	mg $CO_2\ kg^{-1}\ h^{-1}$
0 °C	6 to 14
5 °C	8 to 16
10 °C	15 to 19
15 °C	19 to 30
20 °C	25 to 45

Data from Apeland (1985) and Cantwell and Suslow (2001).

To get mL CO_2 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 tonne per day.

Physiological Disorders

Brown midrib, a physiological disorder causing significant storage losses, is a symptom of chilling injury (Apeland 1985). Elevated levels of CO_2 can increase decay and the occurrence of offensive odors (Herner 1987).

Postharvest Pathology

Geeson (1983) reported the occurrence of leaf spots caused by *Alternaria* spp., bacterial soft rot *(Erwinia carotovora),* and black discoloration of leaf veins, which may be due to *Xanthomonas campestris*.

Quarantine Issues

None.

Suitability as Fresh-Cut Product

Chinese cabbage is suitable as a fresh-cut product packaged in air or modified atmosphere packaging (MAP). Gorny (1997) rates MAP treatment as moderately effective in extending the storage life of shredded Chinese cabbage and provides respiration rates at different temperatures, atmospheres, and varying amounts of shredding (table 1). More recently, Kleiber and Kim (1998) state that MAP is not essential for shredded Chinese cabbage held at 0 or 5 °C (32 or 41 °F), as there is only a transient increase in ethylene production and respiration that peaks after 6 to 12 h and 0 to 3 h, respectively. The shelf-life-limiting factors are browning on cut surfaces and leaf surfaces, as well as appearance of black speck (gomasho). If 1% citrate is used as a dip, a commercially acceptable shelf-life of 21 days at 0 °C (32 °F) or 14 days at 5 °C (41 °F) can be achieved without MA.

Table 1. Respiration of cut Chinese cabbage under various conditions

Temperature	**Atmosphere**	**Degree of shredding**	**Respiration**
			mg CO_2 kg^{-1} h^{-1}
2 °C	air	half head	10
		rough cut (0.5 x 3 cm)	18
		fine cut (0.25 - 1.5 cm)	24

5 °C	air	half head	16
		rough cut (0.5 x 3 cm)	32
		fine cut (0.25 - 1.5 cm)	40
5 °C	5 % O_2 + 5 % CO_2	half head	10
		rough cut (0.5 x 3 cm)	22
		fine cut (0.25 - 1.5 cm)	28
10 °C	air	half head	17
		rough cut (0.5 x 3 cm)	48
		fine cut (0.25 - 1.5 cm)	57
23 °C	air	half head	31 to 36
		rough cut (0.5 x 3 cm)	90 to 99
		fine cut (0.25 - 1.5 cm)	117 to 126

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