Fresh-cut Asian Vegetables — Pak Choi as a Model Leafy Vegetable

T.J. O'Hare*, A.J. Able†, L.S. Wong*, A. Prasad*, and R. McLauchlan*

Abstract

Pre-prepared fresh-cut salads are becoming increasingly common in the marketplace. Once dominated by lettuce, new vegetables are now being added to increase both flavour and visual appeal. A wide range of Asian brassicas is being sourced as constituents, but short shelf life because of yellowing is a problem to be contended with, and pak choi is a good example of this.

Yellowing in pak choi leaves is associated with a depletion of sugars (the main energy substrate). Increasing the initial leaf sugar level, or slowing the rate of sugar depletion, will directly increase shelf life. Sugars tend to be highest in younger leaves growing close to the tip, and lowest in leaves towards the base of the stem, even though the leaves may look similar in size and appearance. Removal of older leaves will therefore increase the life of a salad. Harvesting later in the day can also increase sugar levels, a result of photosynthesis during the day. Once harvested, leaves require sanitary washing and drying before packaging to avoid postharvest rots. Plastic packaging is vital to prevent wilting of leaves, but may also be used to provide an atmosphere conducive to slowing the rate of sugar depletion. Low oxygen (0.5–2% O_2) and enhanced carbon dioxide (2–10% CO_2) have been found to almost double shelf life in pak choi. However, for modified-atmosphere packaging to maintain an ideal atmosphere, stable temperature management is required, as high temperatures may lead to anaerobiosis and carbon dioxide toxicity of leaves. Common temperatures used for handling packaged salads range from 4° to 12°C. The above findings are for pak choi, but appear to apply also to many other Asian leafy brassicas used in fresh-cut salads.

ASIAN vegetables are a largely untapped resource for use in fresh-cut salads. Pre-prepared salads, both loose and pre-packed, are becoming increasingly common worldwide, catering to the consumer demand for convenience. A wide selection of Asian leafy vegetables can be utilised to add both visual appeal and flavour to salads. Many of these are members of the *Brassica* genus, which tend to have a common problem of leaf yellowing during postharvest handling.

The research literature on the practical use of Asian leafy brassicas is sparse, with much of the work having to be conducted from basic principles. In light of this, our laboratory has conducted extensive trials investigating the use of Asian brassicas in fresh-cut salads (Prasad et al. 1997; Wong et al. 1997; O'Hare et al. 1998, 1999, 2000a,b; Able, Wong et al. 1999, 2000; Able, O'Hare et al. 2000). Because of the wide range of vegetables that can be used as salad constituents, our studies have focused on pak choi (*Brassica rapa* var. *chinensis*) as a model for other Asian leafy vegetables.

* Horticulture Postharvest, Queensland Department of Primary Industries, Gatton Research Station, LMB 7, MS 437, Gatton, Queensland 4343, Australia. Email: <OhareT@dpi.qld.gov.au>.

† Department of Plant Science, The University of Adelaide, Waite Campus, Glen Osmond, South Australia 5064, Australia.

Effect of Physiological Leaf Age

Brassica plants grow in a rosette, with older leaves toward the periphery and younger leaves towards the central growing point. Harvest of leaves for fresh-cut salads normally involves the cutting of leaves from the base of the plant, without actually removing the plant from the ground. This can be done either manually or by machine, but in both cases the harvest will consist of leaves of different physiological ages.

Postharvest Handling of Fresh Vegetables,
edited by Tim O'Hare, John Bagshaw, Wu Li, and Greg Johnson
ACIAR Proceedings 105
(printed version published in 2001)

In pak choi (and in many Asian brassicas) it is not uncommon for older and younger leaves to be similar in appearance, colour, and perhaps even size. Initially, this is of no consequence in a salad mix, but in time the older leaves start to yellow and become more susceptible to bacterial rots. This appears to be a result of the lower initial sugar levels in older leaves. Yellowing is linked to the availability of energy substrates, and since older leaves at harvest tend to have a lower initial supply of sugars, they have a shorter shelf life, yellowing significantly earlier (Figure 1). Consequently, avoiding the inclusion of older leaves in a salad mix increases salad shelf life. While there are several possible approaches to achieving this, it is an area in which more research is needed.

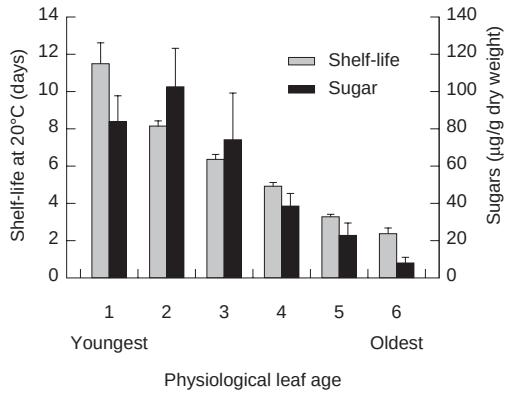

Figure 1. Shelf-life and initial sugar level of pak choi leaves of differing physiological age.

Moisture Loss of Leaves

One of the most obvious problems with pak choi leaves is their propensity to wilt. This becomes exceedingly obvious when leafy salads are dispensed into supermarket display cabinets without the benefit of plastic packaging. Most, if not all, Asian leafy vegetables react no differently from lettuce and other Western leafy salad constituents, and will lose moisture quickly.

Packaged salads tend to retail at higher prices, which may reflect the added cost in manufacture, but they do reduce moisture loss very effectively, and are considerably more efficient than manually misting loose leaves, or treating leaves with an anti-transpirant (Figure 2).

One issue that should be emphasised is that plastic packaging does maintain a very high relative humidity, and hence sanitary washing before packing is essential to avoid bacterial rots. Again, pak choi is no different to conventional pre-prepared salad vegetables in this regard.

Modified Atmosphere Packaging

An additional advantage of plastic packaging is the ability to modify the package atmosphere to extend the life of the salad. With pak choi, yellowing can be retarded by reducing the oxygen concentration to approximately 0.5–2% and increasing carbon dioxide concentration to between 2 and 15% (Figure 3).

This reduces the rate at which sugars are used and can almost double the shelf life of leaves. Exposure to oxygen levels lower than 0.5% and carbon dioxide

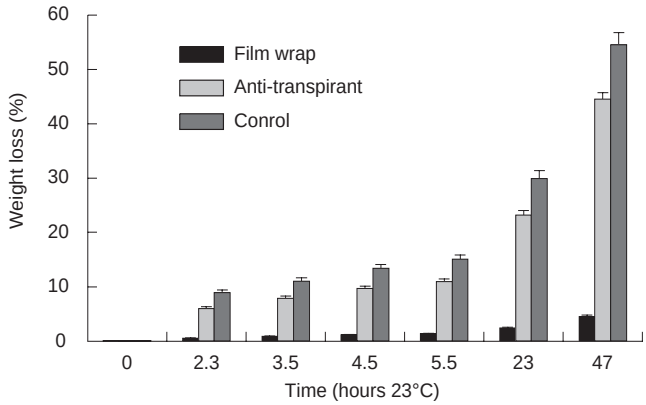

Figure 2. Retardation of moisture loss in pak choi leaves using plastic film and anti-transpirants. Of the two alternatives, film wraps were considerably more effective.

Postharvest Handling of Fresh Vegetables,
edited by Tim O'Hare, John Bagshaw, Wu Li, and Greg Johnson
ACIAR Proceedings 105
(printed version published in 2001)

levels higher than 15% for an extended length of time should be avoided, as the former will result in anaerobiosis and the latter will result in carbon dioxide toxicity, both of which will cause off-odours, and eventually tissue breakdown.

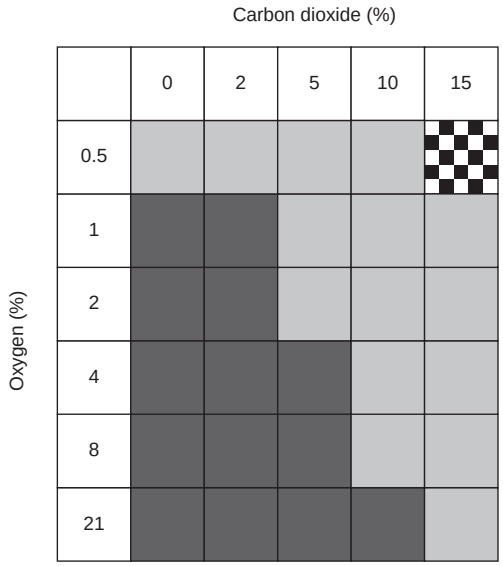

Figure 3. Combinations of oxygen and carbon dioxide capable of delaying leaf yellowing in pak choi (dark grey = no effect; light grey = increase; chequered = toxic to leaves)

Conventional modified atmosphere packaging requires strict temperature management of the handling system, as increases in temperature will lead to a change in the package atmosphere. The change can either shift the atmosphere away from the ideal (and shorten shelf life), or shift the atmosphere into oxygen and carbon dioxide concentrations that are toxic to the product. Packages are normally designed to operate within a narrow temperature range, and are usually marketed between 4°C and 12°C.

Conclusions

Asian leafy vegetables appear to be amenable to use as salad constituents. They should be treated similarly to other leafy vegetables in that they require sanitary washing and will lose moisture if not packaged adequately. Unlike lettuce, the shelf life of many Asian brassicas is limited by leaf yellowing rather than browning. However, atmospheres for retarding yellowing are similar for that used to extend lettuce shelf life, and hence mixing of vegetables should not be restricted.

Acknowledgments

This work was partly funded by ACIAR Project PHT/1994/016 and Rural Industries Research and Development Corporation (RIRDC) Project 239A.

References

Able, A.J., O'Hare, T.J., Wong, L.S. and Prasad, A. 2000. Extending the shelf life of broccoli florets and pak choi leaves. In: Johnson, G.I., Le Van To, Nguyen Duy Doc, and Webb, M.C., ed., Quality assurance in agricultural produce. Proceedings of the 19th ASEAN/1st APEC Seminar on Postharvest Technology, 9–12 November 1999, Ho Chi Minh City, Vietnam. Canberra, ACIAR Proceedings No. 100, 444–450.

Able, A.J., Wong, L.S., Prasad, A., and O'Hare, T.J. 1999. Postharvest physiology of pak choy (*Brassica rapa* var. *chinensis*). Australasian Postharvest Horticulture Conference Proceedings, 3–8 October 1999, Waitangi, New Zealand, 33.

Able, A.J., Wong, L.S., Prasad, A., and O'Hare, T.J. 2000. Physiological leaf age and senescence of pak choy leaves. 'Combio 2000', 11–14 December 2000, Auckland, New Zealand.

O'Hare, T.J., Able, A.J., Wong, L.S., and Prasad, A. 1999. Retardation of yellowing in broccoli florets and pak choy leaves by 1-methylcyclopropene. Australasian Postharvest Horticulture Conference Proceedings, 3–8 October 1999, Waitangi, New Zealand, 34.

O'Hare, T.J., Wong, L.S., and Prasad, A. 1998. Extension of postharvest shelflife of fresh-cut pak choy, tatsoi, mizuna and choy sum by atmosphere optimisation. 4th Australian Horticulture Conference, 14–17 October, Melbourne, 36.

O'Hare, T.J., Wong, L.S., Prasad, A., and Able, A.J. 2000a. Impact of exogenous and endogenous factors in the shelflife of fresh-cut leafy Asian vegetables. 4th International Conference on Postharvest Science, 26–31 March 2000, Jerusalem, Israel (in press).

— (2000b). Atmosphere modification extends the postharvest shelflife of fresh-cut leafy Asian brassicas. Proceedings of the 3rd ISHS International Symposium on Brassicas, 5–9th September 2000, Wellesbourne UK. Acta Horticulturae, 539, 103–107.

Prasad, A., Wong, L.S., and O'Hare, T.J. 1997. Temperature storage of minimally processed Asian leafy vegetables. Australasian Postharvest Conference, 1997, Hawkesbury, New South Wales, 322–325.

Wong, L.S., Prasad, A., and O'Hare, T.J. 1997. Shelf-life extension of minimally-processed Asian vegetables using controlled atmospheres. Australasian Postharvest Conference, 1997, Hawkesbury, New South Wales, 211–214.

Postharvest Handling of Fresh Vegetables,
edited by Tim O'Hare, John Bagshaw, Wu Li, and Greg Johnson
ACIAR Proceedings 105
(printed version published in 2001)