CHAPTER 5

General discussion

Fresh vegetables are living tissues, continuously changing after harvest. The changes in fresh vegetables cannot be stopped, but they can be delayed within certain limits. To reduce or delay deterioration of fresh produce, the producer and handler must understand (1) the biological and environmental factors involved in deterioration and (2) use postharvest techniques that delay senescence and maintain the best possible produce quality. The rate of deterioration of harvested vegetables is generally proportional to the respiration rate which is influenced by temperature (Kader, 2002).

Pak-choi is a popular vegetable among farmers because of its short crop duration (harvesting time at 39-42 days after sowing). On the other hand, pak-choi leaves rapidly become yellow indicating senescence within 2-3 days after harvest (Boonyakiat *et al*., 2008). The change of color is related to consumer perception of visual quality especially in leafy vegetables. An investigation of Thai farmers' practices showed that each farmer used a different time in a day from sunrise to sunset to harvest organic pak-choi. In general, the environment at harvesting time including temperature, light intensity, relative humidity, etc. affect produce quality (Mahmud *et al*., 1999; Weston and Barth, 1997; Paull, 1999; Xiangyang and Bagshaw, 2001).

Additionally, senescence is the process whereby plant cells age and finally die, or, in other words, that plant cells have an 'expiration date' (Løkke, 2012). This process is a natural change in plant cells which causes breakdown and unavoidable cell death (King and O'Donoghue, 1995).

In first experiment, we observed the physico-chemical changes occurring during senescence in pak-choi. The produce was harvested from a farmer's greenhouse at different times of the day: morning (05.30-07.30), afternoon (12.00-14.00) and evening (16.30-18.30) in the winter, summer and rainy season. Then the samples were stored at normal room conditions (25-30 °C, 49-70% RH). After storage for 3 days, the results showed that the season affected all parameters, whereas harvesting time only affected reducing and total sugar contents, glucosinolate, vitamin C, respiration rate and ethylene production. Nevertheless, the interaction of both factors affected reducing and total sugar contents, glucosinolate, respiration rate and ethylene production.

Although, shelf life was not significantly affected by season in this research (experiment 1), the level of some physico-chemical processes can predict the rate of vegetable deterioration, especially the respiration rate, because the rate of deterioration after harvest is closely related to the respiration rate of the harvested vegetables (Kader, 2002; Brosnan and Sun, 2001). In addition, the rate of respiration is related to stored food (sugar), which is the main energy substrate in the respiration process. The loss of stored food reserves in the commodity during respiration means the hastening of senescence as the reserves that provide energy to maintain the commodity's living status are exhausted (Kader, 2002). From the current research, evening harvesting is likely to be the optimal harvesting period to maintain produce quality, high storage food (reducing and total sugar content) and showed low respiration and ethylene production rate. From the nutritional standpoint, pak-choi generates the highest glucosinolate content when harvested in the morning. On the other hand, pak-choi harvested in the evening has the highest vitamin C content.

Temperature is the main influence on the deterioration rate of harvested vegetables. For each increase of 10 °C above the optimum, the deterioration rate increases by two-three fold. Temperature management is the most effective tool for extending the shelf life of fresh horticultural commodities. It begins with the rapid removal of field heat, in order to slow down metabolism, by using one of several precooling methods. Vacuum cooling is the fastest and most stable method for reducing heat in produce. The produce will be cooled down rapidly compared to other precooling and commonly used with leafy vegetables (Brosnan and Sun, 2001; Boonyakiat and Ratanapanon, 2005; Kader, 2002; Thompson *et al*., 2002). This was the rationale created for the second experiment; the purpose of this experiment was to investigate the effects of vacuum cooling on quality changes of organic pak-choi during storage in winter, summer and rainy season. The process of vacuum cooling in winter takes a shorter time and lower energy than in summer and rainy season. While pak-choi lose more fresh weight in winter than summer and rainy season. For the physico-chemical changes the results showed that vacuum cooling extended the produce shelf life by one-fold, and this cooling methods delayed the deteriorate or senescence of organic pak-choi in the winter, summer and rainy seasons. The vacuum cooling did not affected weight loss, total sugar, glucosinolate, crude fiber, leaf color, and ethylene production rate after a 3-day storage in each season. While the vacuum cooling had affected reducing sugar content in winter and vitamin C content in rainy season. Only winter season, the vacuum cooling affected on reducing sugar content, vacuumed cooled pak-choi reducing sugar was 4.35±0.43% lower than non-vacuum cooled pak-choi was 6.10±0.27%. It is noteworthy that the content of sugar (total and reducing) was very fluctuated throughout storage in all seasons. That may be because this study used whole pak-choi plant (except root), the sugar content in the inner leaves was significantly higher than outer leaves (Xiangyang and Lianqing, 2000). So these fluctuation may be due to different of the number of leaves in produce sample. For rainy season, vacuum cooling affect vitamin C content, the vacuum cooled pak-choi had 43.42±0.46 g/100 g FW higher than non-vacuum cooled 35.65±1.75 g/100 g FW and these content in vacuum cooled pak-choi tend to be higher than non-vacuum cooled during storage period. The content of vitamin C consist of water loss, this rainy season weight loss of vacuum pak-choi tend to be lower than non-vacuum cooled throughout storage.

Interestingly, vacuum cooling could reduce the rate of respiration; vacuum cooled pak-choi had a two time lower respiration rate than non-vacuum-cooled samples. Respiration rate is the rate of the metabolic processes in the postharvest cell converting photosynthetic reserves to energy, and respiration is a catabolic process, where mainly stored carbohydrates are converted into energy (Løkke, 2012). The loss of stored food reserves in vegetable during respiration means the hastening of senescence as the reserves that provide energy to maintain the vegetable's living status are exhausted (Kader, 2002). Respiration is controlled by enzyme activities which depend on temperature. When temperature increases by 10 ºC respiration increases by 2-3 fold up to 25-30 ºC. Respiration rate is reduced and cell death occurs if the temperature exceeds 30 ºC. So temperature is a main factor affecting decay and relates to shelf life (Finger *et al*., 1999; Løkke, 2012). The shelf life of produce with a high respiration rates tends to be shorter than those with low rate. It is an important parameter in postharvest quality (Kader, 2002 and Løkke, 2012). Precooling beneficial to removes the field heat before storage and reduces the respiration rate as a way to maintain the quality of vegetables (Kader, 2002; Brosnan and Sun, 2001).