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Development of Holy Basil Storage Using Low Temperatures and Modified Atmosphere Packaging

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ABSTRACT

Holy basil (*Ocimum sanctum* L.) is an herbal produce which rapidly deteriorates after harvesting, thus giving a short shelf life. Different levels of low temperature storage in combination with modified atmosphere packaging were used in this study to extend its shelf life. Holy basil branches of 80 g were packed in 4 different types of bag: a commercial polypropylene film with perforated holes and 3 other various oxygen permeability films, which are very high (PE-3), high (PE-2) and medium (PE-1). All packed sample were stored at 5, 10 and 25°C, then randomly sampled on day 3, 7, 11 for quality checking. The results showed the holy basil stored at 5°C faced with a rapid and severe chilling injury symptom; exhibited by browning spots and water soaking area. At the 25°C storage, basil yellowing and weight loss were very rapid due to high dehydration rate. The optimal temperature for storing holy basil was 10°C. Polypropylene films with holes contribute to faster weight loss and shorter shelf life than the other three packages. Oxygen remained in head space of PE-3, PE-2 and PE-1 bags were found at 18%, 17%, and 11%, respectively while carbon dioxide also were found at 0.7%, 0.8% and 1.8%, respectively. Modified atmosphere packaging at 10°C was found to be able to keep holy basil at a satisfactory quality for 9 days.

Key words: holy basil, modified atmosphere packaging

INTRODUCTION

Holy basil (*Ocimum sanctum* L.) is an herbal produce which has specific aroma. It is used as an ingredient in various types of Thai cooking and the quantity of its export has increased for years. However, holy basil rapidly deteriorates after harvesting, thus giving a short shelf life. There are many reasons for these changes, some are from its internal physiological reactions such as dehydration, respiration and ethylene production, while the others are from external factors include, temperature, humidity and atmospheric composition.

Temperature is the most important factor for quality of post harvest produce because it can affect every metabolic process. High temperature can accelerate chemical reactions and respiration of many produce and leads it to senescence. In contrast, low temperature can prolong produce's storage time and its qualities. In some cases, low temperature may be harmful, especially for the tropical produce which may cause an undesirable symptom known as "chilling injury" (Siripanich, 2001)

Presently, packaging technology has been rapidly developed. One of the packaging advantage functions, which could extend vegetable

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and fruit shelf life, is to control atmospheric composition inside the package. The process is to allow or reduce gas diffusion passing between inside and outside package depending on the produce's needs, thus controlling metabolic rate to maintain the quality of the produce. Packaging material or film is able to interact with gas inside that will modify the atmospheric condition continuously. For example, a decrease in oxygen and an increase in carbon dioxide around the produce create equilibrium to meet with produce needs to prolong its degradation (MTEC, 2005). The required film should have some optimum properties in order to keep the equilibrium of atmosphere inside the package, known as "Equilibrium Modified Atmosphere" (EMA). This kind of mechanism is one of the principle in active packaging technology which reduces respiration rate, dehydration and senescence (Yam and Lee, 2002).

Sweet basil (*Ocimum basilicum*) can be stored in the optimum modified atmosphere packaging at 2%O_2 with below 10%CO_2 (Kader, 2002). Holy basil produces a small amount of ethylene but it is sensitive to ethylene which leads to yellowing and leave abscission (Cantwell and Reid, 2002). Previously, there are only few postharvest researches concerning holy basil, most of which are about sweet basil of *Ocimum sp*. Thus, this research gives information about holy basil storage based on a database of sweet basil. Low temperature can extend the shelf life of holy basil. According to Thomson *et al*. (2001), the optimum temperature to store sweet basil was 12°C. However, lower temperature may cause chilling injury symptom, black or brown spot, water soaking area and microorganism growth (Siripanich, 2001). Furthermore, the storage at 5°C or below can lead to chilling injury (Lange and Cameron, 1994). Lange and Cameron (1998) found that atmosphere modified by increasing carbon dioxide and/or decreasing oxygen can reduce chilling injury in many kinds of vegetable. Storage under modified atmosphere condition can also extend shelf life of various kinds of herb.

The objective of this study was to evaluate shelf life of fresh holy basil packed in different type of packaging materials and stored at different level of low temperature. Equilibrium atmospheric conditions in the head space of various produce-packages were determined as well as product qualities include physical changes and panel acceptance were also analyzed and compared among the treatments.

MATERIAL AND METHOD

Plant material

Holy basil was sourced directly from Shine Forth Co., Ltd, Pathumthani. Immediately after harvest, the produce was passed into cleaning process and chilling transported to the Department of Packaging Technology, Faculty of Agro-industry, Kasetsart University.

Packages and storage conditions of holy basil

Holy basil was weighed about 80 grams (Jirapong *et al*., 2005) on average, bunched and packaged into 4 types of 20×40 cm^2 bag, including a commercial polypropylene film with 4 perforated holes of 0.7 cm diameters and three other various of oxygen permeability films range from very high (PE-3), high (PE-2) and medium (PE-1), These films were provided by National Metal and Materials Technology Center (MTEC). The average oxygen transmission rates (OTR) of the PE-3, PE-2 and PE-1 films are 9,000 13,000 and 18,000 $cc/m^2/day$, respectively (Illinois Instrument, U.S.A.) while water vapor transmission rate (WVTR) of films are 80, 130 and 180 $g/m^2/day$, respectively (dish method, ASTM E96-95). Packages of holy basil were heat sealed and stored at 5, 10 and 25°C. Relative humidity in storage rooms was maintained at 85, 87 and 90% RH, respectively. Each treatment has 3 replicates.

Measurement of gas composition

The gas composition in headspace of each bag was monitored through a septum using a 3 ml airtight syringe. The percentage of oxygen and carbon dioxide were determined by injection of 3 ml of a gas sample into a GC6890 (Hewlett-Packard, U.S.A.) equipped with a thermal conductivity detector (TCD).

Quality evaluation

Quality of holy basil on day 0, 3, 7 and 11 after storage were determined. Moisture loss of fresh holy basil expressed in percentage of weight loss was determined. Leave color was measured using a chromameter (Minolta CR-310, Japan) expressed as Hunter *L**, *a** and *b** values. Appearance observation evaluated by percentage of leave abscission and chilling injury symptom by CI index scale ranged from 1 to 5, in which: 1 = no damage; 2 = several dark spots; 3 = black stains on 30% of the leaf area; 4 = black stains on 30-50% of the leaf area; and 5 = black stains on more than 50% of the leaf area (Meir *et al*., 1997). The data represent a weighted average of CI assessments, based on CI severity multiplied by the number of damaged leaves. A test panel consisting of 15 untrained judges evaluated quality attributes (i.e. visual, color, aroma, texture and overall quality). Quality was scored on a nine point scale (9 = excellent; 7 = very good; 5 = good, limit of marketability; 3 = fair, limit of usability; and 1 = poor, inedible).

Statistical analysis

The effect of storage temperature and film permeability on quality of fresh holy basil assessed using an analysis of variance (ANOVA) using SPSS 13.0. To determine difference between treatments, Duncan's Multiple Range Test (DMRT) was applied and significant differences were established at $P \leq 0.05$.

RESULTS AND DISCUSSION

Gas composition in bag

Oxygen concentration decreased whereas carbon dioxide concentration increased in all types of bags (Figure 1 and 2). The PE-1 bag, which has lowest OTR, showed the highest atmosphere modification among all three types. Oxygen and carbon dioxide concentration in package was continued to change until equilibrium

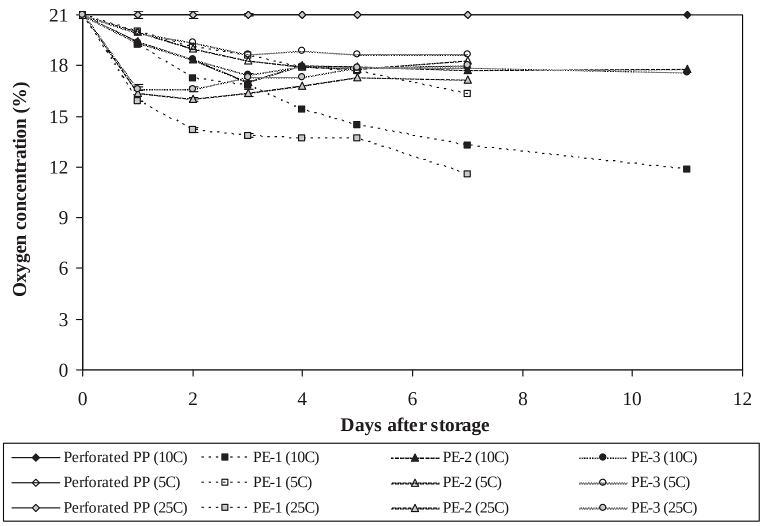

Figure 1 Mean percentage of O_2 in bags keeping holy basil in different temperatures.

point occurred. At 10°C storage temperature, the atmospheric compositions at the equilibrium point in PE-1, PE-2 and PE-3 bags were found at 18%, 17% and 11% of oxygen concentration, respectively while carbon dioxide concentration were found at 0.7%, 0.8%, and 1.8%, respectively. When it approached the equilibrium point, the package of holy basil stored at 25°C had maximum change of gas concentration because at this temperature holy basil has high respiration rate (400 mg CO_2/Kg.hr). In contrast, holy basil kept at lower temperature had less gas modified in bag than those in higher temperature because it has less respiration rate (200 mg CO_2/Kg.hr at 10°C and 300 mg CO_2/Kg.hr at 5°C).

Weight loss during storage

According to various types of bag, weight loss of holy basil in perforated polypropylene at every temperature was higher than those in other bags (Figure 3). This is because the water vapor from the inside of the bag was able to pass through the perforated area to outside atmosphere. This corresponds to the result of Jirapong *et al.*(2005). Furthermore, according to storage temperature, holy basil stored in PE-1, PE-2 and PE-3 bags at 25°C showed higher weight loss than those at lower temperature since high temperature increases respiration rate of holy basil. High weight loss of holy basil caused by biochemical reaction, which is the dehydration to eliminate excess heat, and by low air humidity in storage environment. (Siripanich, 2001)

Change of leave color during storage

Color values were expressed as CIELAB color space units and mean values for lightness (*L**), red-greenness (*a**) and blue-yellowness (*b**) parameters that were calculated for each treatment. Holy basil kept at 5 and 10°C decreased its lightness and greenness values in 7 and 11 days of storage, respectively (Figure 4 and 5) because chilling injury symptom occurred which is conformed to the research of Lange and Cameron (1994). The lightness and yellowness value of holy basil stored at 25°C increased in 7 days of storage (Figure 4 and 6). The reasoning behind this is that sugars are the main respiratory substrate for leaves, and once these have been exhausted to a critical level, the leaf begins to access other substrates including proteins and lipids which make up the chloroplasts within the leaf cells. As these contain

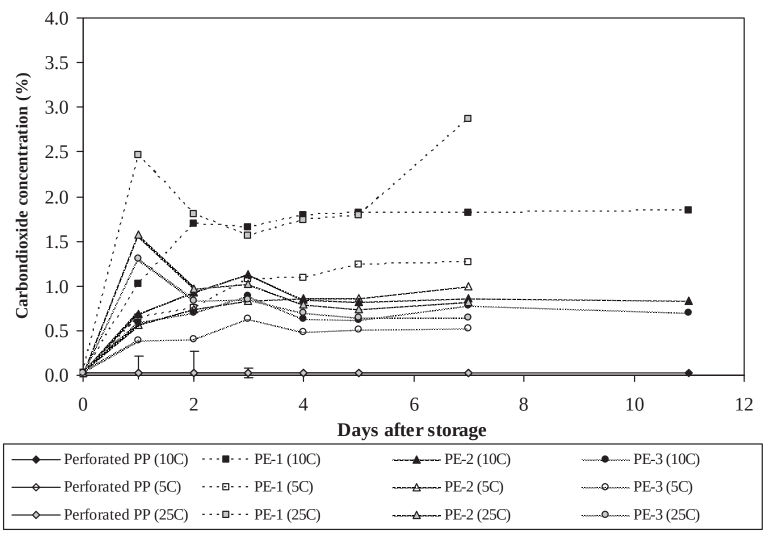

Figure 2 Mean percentage of CO_2 in bags keeping holy basil in different temperatures.

the chlorophyll which make leaves green, their destruction leads to degreening and associated yellowing (O'hare *et al.*, 2002)

Abscission of leave during storage

After 7 days of storage it was found that only basil stored at 25°C has falling leaves, especially holy basil in modified atmosphere bag. This is because holy basil is sensitive to ethylene. Only little accumulation of ethylene can cause abscissions of leaves (Cantwell and Reid, 2002). Holy basil has moderate ethylene production about

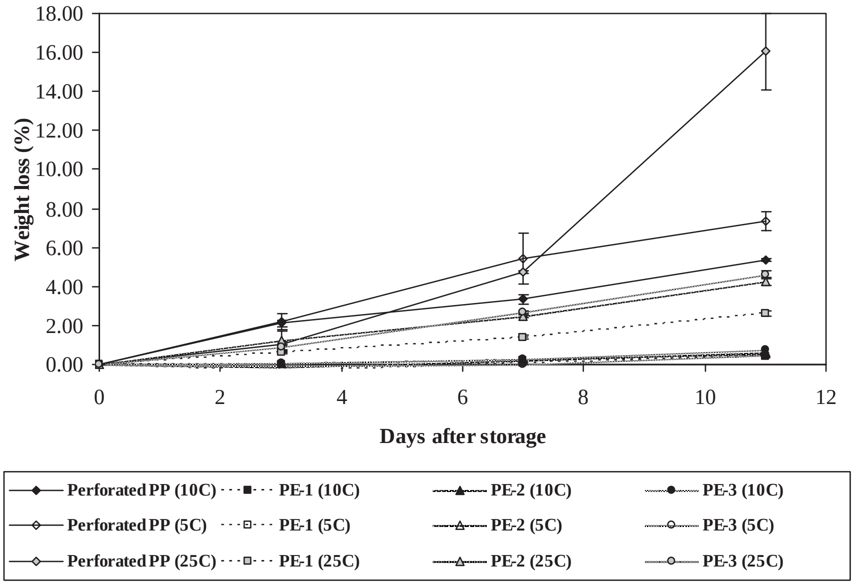

Figure 3 Weight loss expressed as mean percentage of the original weight of holy basil stored at different temperatures.

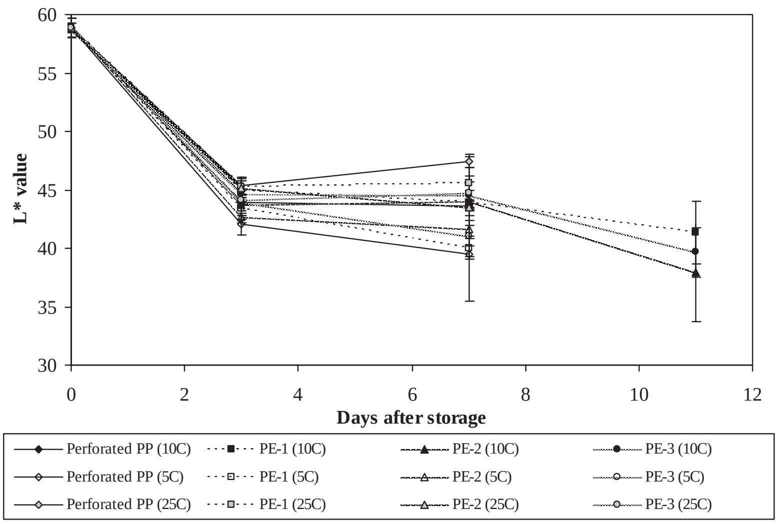

Figure 4 Mean of lightness (L*value) of holy basil leaves stored at different temperatures.

6 µl C_2H_4/Kg.hr at 25°C. Furthermore, ethylene affected yellowing of leave that related with its color value. However, holy basil that was stored at 5 and 10°C has some leave abscissions

Chilling injury symptoms

Chilling injury symptom of holy basil was scored by CI index. After 3 days of storage at 5°C, it was observed that chilling injury symptom noticeably appeared. Browning spots and water soaking area were severely shown. Regarding to respiration quotient (Q_{10}) of holy basil, significant changes were related to temperature range. At the 5-10°C range, mean Q_{10} = 0.52; at 10-25°C range this value almost triplicate, (Q_{10} = 1.55). Chilling injury symptom occurred which is conformed to the research of Bron *et al.* (2005). Chilling injury symptom was most likely to occur in perforated polypropylene bag more than in modified atmosphere bag which is related to the result of

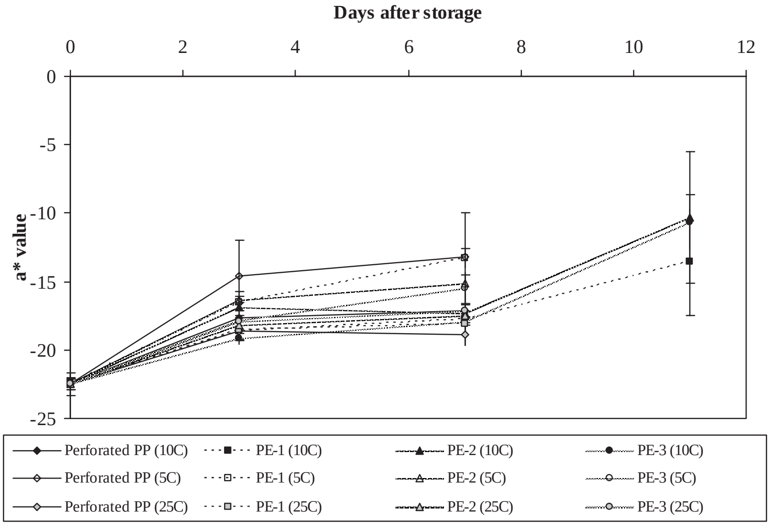

Figure 5 Mean of a*value of holy basil leaves stored at different temperatures.

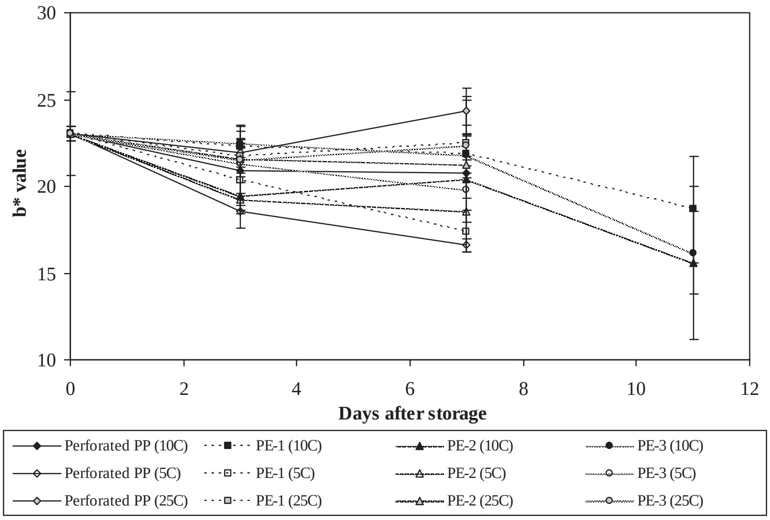

Figure 6 Mean of b*value of holy basil leaves stored at different temperatures.

lightness decrease in basil leaves. Chilling injury symptom of holy basil that was kept at 10°C was violently occurred after 11 days of storage (Figure 7). In modified atmosphere packaging, chilling injury occurred slower than in perforated bag because gas composition in bag was changed by increasing of carbon dioxide and decreasing of oxygen in order to control chilling injury symptoms (Lange and Cameron, 1998).

Sensory evaluation

Sensory evaluations of quality acceptance include appearance, color, aroma, texture and overall acceptance were used to evaluate shelf life of holy basil. Acceptance of the panel was scored by 9-point scale, treatment that had lower than 5 point was rejected in terms of acceptance. The result showed that after 7 days each holy basil kept at 10°C in any bags and holy basil in the perforated polypropylene bags at 25°C were still in the acceptable conditions. Holy basil stored in every bag at 5°C and the basil kept in modified atmosphere bags at 25°C were unaccepted after 4 and 5 day storage, respectively. No significant different was found among block (panelist) in the randomized complete block designed (RCBD) evaluate.

Referring to the result above, the optimal storage temperature for holy basil is 10°C. Sample in polypropylene film with holes showed faster weight loss and shorter life than those in other three packages. The various qualities mentioned above at 10°C storage condition should be able to control by using modified atmosphere bag include PE-1 PE-2 and PE-3 with at a satisfactory quality and extend shelf life for 9 days.

CONCLUSION

From the results, holy basil stored at 5°C faced a rapid and severe chilling injury symptom while at 25°C of storage basil was affected from dehydration that led to yellowing and rapid weight loss. Thus, the optimal temperature for storing Holy basil is at 10°C. At this temperature holy basil kept in the commercial polypropylene film with holes showed faster weight lost and shorter life than that kept in other

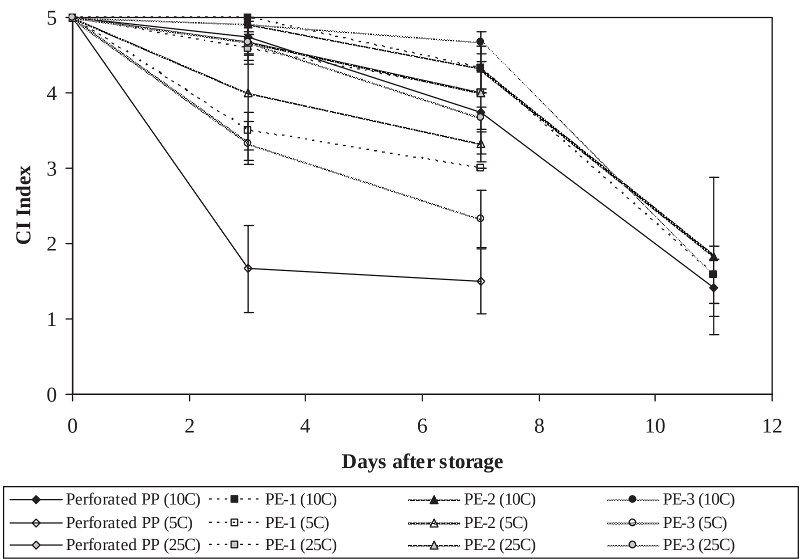

Figure 7 Mean score of chilling injury (CI) of holy basil leaves stored at different temperatures. (5 = no CI symptom, 1 = very high CI symptom)

three packages. It is concluded that the modified atmosphere packaging at 10°C is able to keep holy basil at satisfactory qualities and prolong maximal shelf life of holy basil in this study.

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