Research article

Assessment of the Shelf-life of Cucumber under Three Low Cost Storage Methods

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Abstract Cucumbers, harvested from Saang district, Kandal province, Cambodia were wrapped with low density polyethylene (LDPE) or high density polyethylene (HDPE) or in the open before they were stored in two types of storage conditions (evaporative cooling system (ECS)(80 USD), designed in the faculty of Agro-Industry, Royal University of Agriculture and in ice foam box (2.375 USD) filled with an amount of ice for cooling the cucumbers or in ambient condition (1.5 USD) in order to seek for appropriate and low cost methods to maintain the quality and enhance shelf-life of cucumbers. The shelf-life of cucumbers were determined based on weight losses, fruit shriveling, changes in color, titratable acidity (TA) and total soluble solids (TSS). Of the storage treatments, keeping fruit in both type of polyethylene film in ice foam box filled with husk-covered ice was the most effective way in reducing weight loss, maintained higher TA, TSS and the color changes as well as retarding fruit shriveling than that of the other treatments. Fruit stored in the open at ambient condition had the highest weight losses and shortest shelf-life due to rapid yellowing and shriveling. Regarding the cost of storage, ice foam box was significantly reasonable accepted in term of gaining better quality (benefit) comparing to the higher weight losses and unmarketable quality of other treatments.

Keywords cucumber, shelf-life, quality, evaporating cooling system, ice foam box

INTRODUCTION

Cucumbers (*Cucumis sativus*) of Cucumbitaceae family are one of the famous vegetable consumed freshly and as processed food in Cambodia. The fruits were harvested in immature stage based on the fruit size and skin color. They are used as salad, fresh slicing vegetable and pickling for daily diet (New Guyana Marketing Corporation, 2004). These fruits normally suffer high moisture losses, rotting, and change color quickly from green to yellow during storage. They are also bruised or injured under mechanical forces in case of improper handling which cause of short shelf-life and unmarketable quality after harvesting. Improper storage condition of cucumbers both at low temperature (below 10°C) and at ambient temperature rapidly results in water loss, decay, and yellowish color in several days that lead to unacceptable quality in the market (Mikal, 2010).

So far, to improve the storage condition of many vegetables to recast in Cambodia, evaporating cooling system (ECS) has been set up and introduced to the vegetable grower for

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preserving the vegetables quality. The system has shown the effectiveness in many aspects since its temperature is decreased lower than the ambient at least 3 to 5°C while its RH is higher than ambient from 20 to 40%. It is very effective to extend the color changes and decay during storage time of vegetable such as chili, eggplant and leafy vegetables (Buntong, 2010). However, the combination treatment with film wrapping or other modified packaging materials were not fully tested for such kind of cucumber vegetable. It is known whether vegetables stored in low or high density polyethylene can maintain the shelf-life and quality of vegetable better than those stored in ambient temperature because of polyethylene films that can acts as moisture and oxygen barrier and delay the respiration of the vegetables (ITDG, 2010). As a result, cucumbers can be stored longer than those in the ambient condition for a few days (Buntong, 2010).

In this study, in order to seek for appropriate and low cost methods to maintain the quality and enhance shelf-life of cucumbers, cucumbers harvested from Saang district were wrapped with either low density polyethylene (LDPE) or high density polyethylene (HDPE) or left in the open before they were stored in two types of storage conditions (evaporative cooling system (ECS), designed in the faculty of Agro-Industry, Royal University of Agriculture and in ice foam box filled with an amount of ice for cooling the cucumbers) or in ambient condition.

OBJECTIVE

The objective of this study was to find out the appropriate and low cost methods that effectively maintain the quality and prolong self-life of cucumbers.

METHODOLOGY

Fruit sampling

Cucumber (*Cucumis sativus)*, for the age about 45 days after planting, were harvested from Saang district and immediately brought to the postharvest laboratory located in the faculty of Agro-Industry, Royal University of Agriculture, Phnom Penh, Cambodia.

Storage materials and conditions

Initially, they were washed with the 100 ppm concentration of chlorine for eliminating microbial contaminations and preventing fungal infections; then sorted only for uniform size, maturation, color and non-injured cucumbers (FAPRT, 2011). Before storing the fruits in different containers (evaporating cooling system, ice foam box and the ambient condition), they were wrapped with low density polyethylene (LDPE) or high density polyethylene (HDPE) or in the open.

Evaporating cooling system (ECS), made from zinc and iron film and covered by wet tissues along with dropping-water system, to conduct heat that kept the temperature between 24-28 ^{o}C with relative humidity between 76-94%.

Ice foam box designed in faculty Agro-Industry is the low cost materials that can be used as storage equipment for maintaining cucumber quality. The ice foam box was filled with 21kg of ice and covered with rice husk to reduce ice melting with the temperature between 17-21 ^{o}C and relative humidity 60-70%. Husk rice is traditionally used for keeping ice from melting and easily find in local area. It is a good material to reduce the interaction between heat and cool air of ice in box that decrease melting and stabilize temperature cold (17 to 21 °C) and RH (60 to 70%). The husk rice have low water and moisture permeability, low value of equilibrium moisture content, low value of the coefficient of temperature conductivity (below 0.036 $W.m^{-1}.k^{-1}$), high resistance to damage of fungi (Valche et al, 2009). Ice foam box is the well-organized and effective equipment used for reducing moisture loss, color changes and decay as polyethylene was used in ECS condition for this study. In addition to storing cucumbers in ECS and ice foam box, fruits were also stored in ambient condition at (temperature at 28-29^{o}C and relative humidity at 80-86%).

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Experimental design and treatments

Split plot design was applied in this research. The fruits were packed in Open, LDPE and HDPE and stored in different containers including ambient, ECS and ice foam box. The summary of treatments is as in table 1.

Table 1 Treatments of experimental cucumbers

Treatments	Packaging materials	Storage conditions	Replications
T_1	Open	Ambient	3
T_2		ECS	
T_3		Ice foam box	
T_4	LDPE	Ambient	
T_5		ECS	
T_6		Ice foam box	
T_7	HDPE	Ambient	
T_8		ECS	
T_9		Ice foam box	

Fruit analysis

Throughout the storage, all treatments were tested and recorded every two days with four parameters-weight losses (WL); color changes (a* and L value) done by using color reader CR-10; Titratable Acidity (TA) tested by titrating NaOH concentration with phenophtelenine and Total Soluble Solids (TSS) were tested by using refractometer. Recorded data were analyzed by using Microsoft Excel 2010.

Weight losses: Weight losses was determined by weighting and recording every 2 days for all treatments, calculated as a percent of the initial weight following equation 1.

$$WL\ (\%) = (W_o - W_i) / W_o \times 100 \qquad (1)$$

Where W_o is the weight on the first day of storage and W_i is the weight in the tested day (Moalemiyan & Ramaswamy, 2012).

Color changes: Color reader CR-10 was used to assess external color of cucumbers. External color readings were taken on screen of color reader CR-10 before storing in equipment on the following day of observation. Individual fruit was measured at three point along the axis of the furit for three fruit in a replication.

Total acidity (TA): TA contents was determined by titrating NaOH concentration 0.1N along with phenophtelenine as indicator and calculated by following euquation 2.

$$C_{Total\ acidity}\ (g/L) = (V_{NaOH\ titration} \times F \times C_{NaOH} \times M) / V_{sample} \qquad (2)$$

Where $C_{total\ acidity}$ is the concentration of acid in cucumber (g/L); V_{NaOH} is volume of sodium hydroxide; C_{NaOH} is concentration of sodium hydroxide of titration (N), and M is molecular weight of ascobic acid ($C_6H_8O_6$) (g/mole).

Total soluble solids (TSS): Total soluble solid was determined by using refractometer. The cucumber was extracted and its juicy part was put on the refractometer prism and read for its value of total soluble solid in Brix degree.

RESULTS AND DISCUSSION

Weight losses

An evaluation of the postharvest quality of cucumbers was conducted after the fruit had been stored in different conditions. Figures 1, 2 and 3 had shown that moisture losses of opened cucumbers in

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the three conditions decreased orderly from 0 day to 10 days. Ambient lost 21% more than ice foam lost 17.75%, while ECS had RH higher than ambient (20-40%) and lost only 3.09% during 8 days with fewer changes for wrapped HDPE cucumbers. RH of ambient was lower than ECS, but higher than RH of ice foam box which caused possible higher weight loss (5.7%) for HDPE cucumber in ice foam box as ambient lost 0.95% in 10 days. However, water loss of wrapped LDPE cucumber of ambient condition dramatically rose (6%) as water loss of wrapped LDPE cucumber of ECS and ice foam box slightly changed when the temperature and RH of them was probable in the remaining of moisture contained in cucumber.

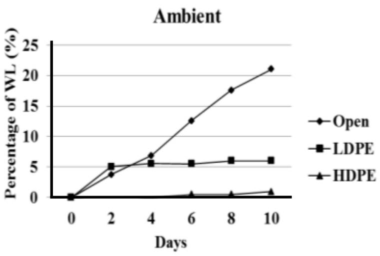

Fig. 1 Percentage of weight in Ambient

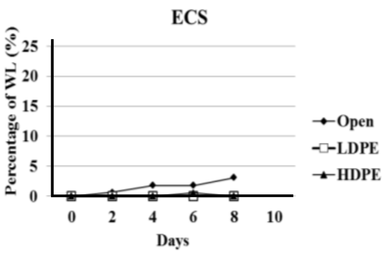

Fig. 2 Percentage of weight loss in ECS

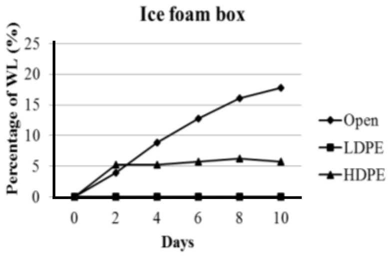

Fig. 3 Percentage of weight loss in Ice foam box

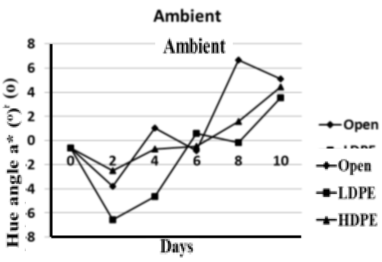

Fig. 4 a* value of cucumber stored in Ambient

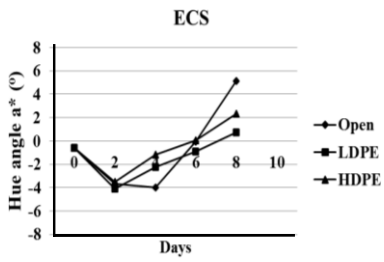

Fig. 5 a* value of cucumber stored in ECS

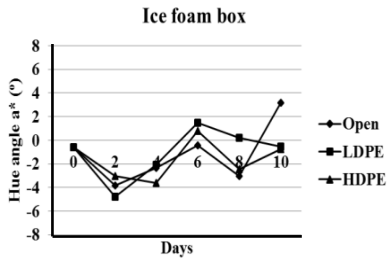

Fig. 6 a* value of cucumber stored in Ice foam box

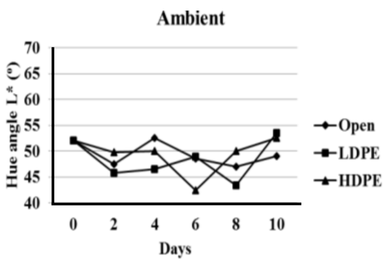

Fig 7. L value of cucumber stored in Ambient

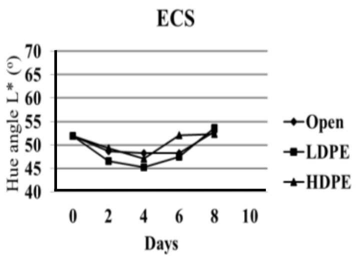

Fig 8. L value of cucumber stored in ECS

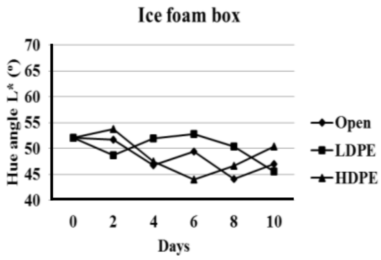

Fig 9. L value of cucumber stored in Ice foam box

Color changes

Peel color of cucumber originally remained dark green at ambient and in ECS after 6 days of storage. Although the previous stages retained original color, its color kept changes very quickly becoming yellow as shown in the fig. 4 and 5. For ice foam box, cucumber peel color was relatively dark green from the initial day to the end of storage period, with a bit changes a*=1.46, 0.81 for LDPE and HDPE respectively on the 6th day of storage. The open cucumber stored in ice foam box was in yellow (color a*=3.17) on the 10th day while others remained green color.

The L value of color's of cucumber at Ambient and Ice foam box get result of insignificant change in color L comparing to original brightness color L= 52, accept for ECS condition. It is more changed in the L value that reached to L= 48.27, 45.29, 47.12 for Open, LDPE, HDPE respectively at 4th day storage.

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Total acidity (TA) and total soluble solids (TSS)

Changeable decline of TA value (1.26-0.88 g/L) of opened cucumbers in each condition had no significant differences (0-6 days). ECS had higher RH (20-40%) and lower temperature (1-2 °C) than ambient that leaded to senescence very quickly and its TA declined in 1.31 g/L at 8 days. HDPE cucumbers in ambient condition and ice foam box had similar TA value (1.26-0.80 g/L) in 4 days, then TA of ambient values 1.05 g/L, when TA of ice foam box values 0.73 g/L developed to senescence in 10 days. TA of HDPE cucumbers in ECS were slightly different in TA value (1.26-0.83 g/L) in 6 days then it would reach to aging when its TA was 1.18 g/L in 8 days. Low density polyethylene, which was a good moisture barrier and had high gas permeability resistance, wrapped cucumbers up. They were remarkably varied in the three conditions. In 6 days, TA of ECS dropped sharply in 0.94 g/L which was higher than TA of ice foam box (0.66 g/L), when the lowest TA of ambient values was 0.71 g/L in 4 days.

Total soluble solids interactively changed and slowly increased in all fruit treatments stored in three equipments (shown in fig. 13, 14 and 15), but fruit stored in ice foam box had the highest TSS value. TSS value increased higher in ambient-stored fruit as in open and as followed by HEPD. LEPD showed the minimal increase in TSS value of stored-fruit with ECS and ice foam box.

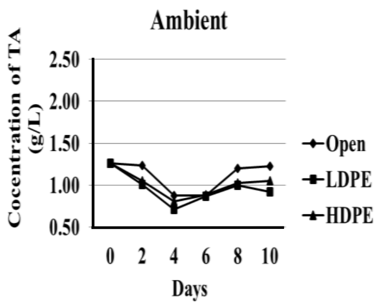

Fig. 10 Concentration of TA of stored-cucumber in Ambient

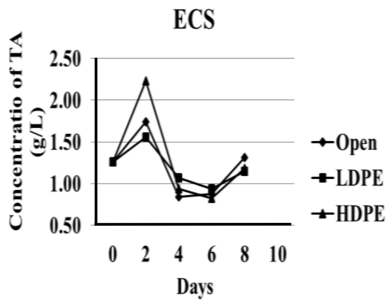

Fig. 11 Concentration of TA of stored-cucumber in ECS

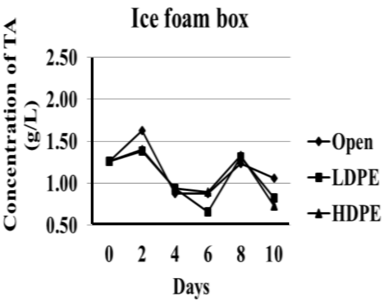

Fig. 12 Concentration of TA of stored-cucumber Ice foam box

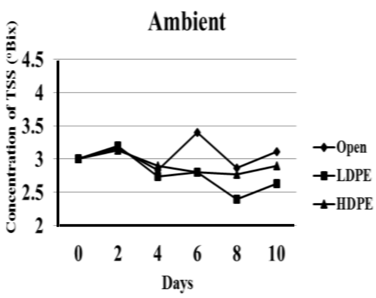

Fig. 13 Concentration of TSS of stored-cucumber in Ambient

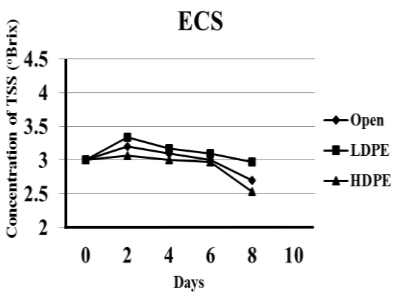

Fig. 14 Concentration of TSS of stored-cucumber in ECS

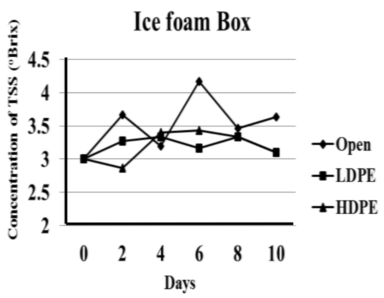

Fig. 15 Concentration of TSS of stored-cucumber in Ice foam box

CONCLUSION

Wrapped-cucumber with LDPE was effective when used with ice foam box and ECS for reducing water losses. However, ambient was ineffective in storing fruit which made both moisture losses and color changes remove high. ECS and ambient could maintain water losses from wrapped-cucumber with LDPE, but it could not maintain color changes, TSS increase or TA decrease that developed to senescence very fast. Water losses, color changes, TA, and TSS of wrapped-cucumber of LDPE stored for 10 days in ice foam box was better than the ECS and ambient condition. According to the result and discussion, ice foam box used in this storage method was

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effectively available to buy, convenient for storing fruit, and cost-saving (only 2.375 USD per set).

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