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Research Article

Comparison of some edible coatings and paper bag on preservation of cucumber (*Cucumis sativus* L.) during storage

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ABSTRACT- To investigate the effect of some edible coatings on weight loss and storage life of two thorny cucumber cultivars including Tiba' and 'Kurage' cultivars, this research was conducted in a factorial experiment using a completely randomized design with three replications. The experiment comprised five treatments including three edible coatings (olive oil, almond oil and liquid paraffin), packing in brown paper bag without any edible coating and control treatment. All of the treated samples were placed in a thin plastic container having eight holes and control samples were placed in a plastic box solely. Packages were stored at 10 °C and 85-90% RH for 14 days. The results showed that 'Tiba' cultivar had higher firmness than 'Kurage' cultivar. Cucumbers coated with almond oil had the least weight loss in comparison with other coating materials, but the differences between two cultivars were not significant. The highest color difference was belonged to the paper bag treatment which had the significant difference with control and the other coating treatments. Cucumbers placed in paper bag resulted in the highest greenness value. In conclusion, both thorny cucumber cultivars covered with coating materials showed the best appearance and luster shape which was related to the effects of edible coatings on reducing water loss, chlorophyll degradation and softening.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the most important vegetables and belonging to the family of Cucurbitaceae. Cucumbers contain approximately 95% water, 3.6% carbohydrates, and 0.65% protein, and are low in calories (150 kcal kg⁻¹). Cucumbers are generally good sources of nutrients including pantothenic acid (B5), vitamin C, and magnesium (Bahnasawy and Khater, 2014). Cucumber quality reduces after harvest because of the water loss, shrivelling and also yellowing. Therefore, its shelf-life in the market is limited to 2~3 days. One of the main objectives of postharvest technology in vegetable crops is to delay senescence process. Changes in the peel color are natural in horticultural commodities as a part of the aging and the natural senescence process (Funamoto et al., 2002). Changes in color can be accelerated by stresses, such as chilling injury, ethylene exposure and decay. However it can also occur naturally during storage. Unlike climacteric fruits such as tomato and bananas that need to undergo ripening to reach commercial maturity, this process is unfavorable for cucumbers (Gennadios and Weller, 1990) since it reaches commercial maturity at a physiologically immature stage. It was reported that there was a remarkable relation between the rate of green color and cucumber preservation quality

(Schouten et al., 2002). The senescence symptoms of cucumber can be retarded by edible coating and cold storage. However, this crop is a chilling sensitive product and thus should not be stored at temperatures lower than 7-10°C for a long-term (Snowdon, 1990). If cucumbers are stored at lower temperatures, chilling injury may occur and it is generally followed by an increased tendency to decay, mainly when the temperature is raised (DeEll et al., 2000). The application of edible coatings can improve the physical strength of food products, reduce dust particles, and improve visual and tangible features on product surfaces (Cuq et al., 1995; Cisneros-Zevallos et al., 1997). The coatings can also protect food products from moisture loss, microbial growth on the surface, light induced chemical changes, oxidation of nutrients, etc. Edible coatings can act as obstacles against oils, gases, or vapors and as carriers of active substances such as antioxidants, antimicrobials, colors and flavors (Gennadios and Weller, 1990; Krochta and De Mulder-Johnston, 1997; Miller et al., 1998). These functions improve the quality of food products, resulting in shelf-life extension and safety improvement. Besides, edible coatings can be used as active films when applied to maintain the overall quality of the fruits during storage (Al-Juhaimi et al., 2012).

The objective of this research was to investigate the effect of some coating materials on weight loss, firmness, color and chlorophyll content of two thorny cucumber cultivars during storage and enhancing their longevity which made it suitable for export.

MATERIALS AND METHODS

Plant Materials and Coating Treatments

Thorny cucumber fruits of 'Tiba' and 'Kurage' cultivars prepared from Research Institute of Kerman Province, Kerman, Iran, in 2014. These thorny cucumbers are highly productive and bearing. Fruits were thoroughly washed with water and disinfected with sodium hypochlorite (1.5%) to remove the dirt. The cucumber fruits were drained and air dried at room temperature. They coated with some edible coatings such as edible stock solutions of paraffin, almond oil and olive oil. Almond and olive oils are natural oils; whilst the liquid paraffin is a mineral oil. Also, some of them were packed in brown paper bag. Finally, all of the treated fruits were packed in clamshell packages, each having eight 8 holes (5 mm diameter), and untreated cucumbers were placed in clamshell packages and considered as control treatment. Edible coating materials and liquid paraffin were sprayed on cucumbers with a 500 ml hand sprayer. Packages were weighed before storage at 10 °C and 85-90% RH for 14 days. Three replications were considered for each treatment and ten uniform thorny cucumbers were used in each replicate. Characteristics such as weight loss, firmness, chlorophyll a, b and total chlorophyll contents of the peel and color values were measured.

Physical Properties

The firmness of cucumbers was determined by TA-TX2 Texture Analyzer (TA.XT2, Texture Technologies Corp., NY). At least two sides of two fruits per each packages were punctured with a 3 mm diameter ball probe at a speed of 1 mm/s (Tapia et al., 2008).

Changes in cucumber color were assessed by a Minolta colorimeter (Chroma Meter, Minolta, Japan). Means of two replications at geometric center were used to determine the color coordinates, L* (lightness), a* (greenness), and b* (yellowness). In this coordinate system, the L* value is a measure of lightness, ranging from 0 (black) to +100 (white); the a* value ranges from -100 (greenness) to +100 (redness), and the b* value ranges from -100 (blueness) to +100 (yellowness). The total color difference (ΔE^*) was determined using the following equation (Romano et al., 2008):

$$\Delta E^* = \sqrt{(L^* - L^*_0)^2 + (a^* - a^*_0)^2 + (b^* - b^*_0)^2} \quad (1)$$

Weight loss of stored samples was recorded by weighting the samples before and after storage with a digital balance (GM-300P, Taiwan) and percentage of fruit weight loss was calculated by the following equation:

$$\text{Weight loss (\%)} = \frac{\text{fruit weight before storage (g)} - \text{fruit weight after storage (g)}}{\text{fruit weight before storage (g)}} \times 100$$

Chemical Composition

Chlorophyll content was measured according to the method described by Costache et al. (2012) with some modifications. Extraction was performed with 80% acetone and the yielded solution was centrifuged at 8000 rpm for 10 min and the absorbance was read with a spectrophotometer (Model UV-120-20, Japan). Chlorophyll a, b and total contents (mg. g⁻¹ fresh weight) were calculated according to the following equations:

$$\text{Chl.}_a = (19.3 \times A_{663} - 0.86A_{645}) V/100W$$

$$\text{Chl.}_b = (19.3 \times A_{645} - 3.6A_{663}) V/100W$$

$$\text{Chl.}_T = \text{Chl.}_a + \text{Chl.}_b$$

where Chl._a is chlorophyll a, Chl._b is chlorophyll b, Chl._T is total chlorophyll, A is absorption value, V is the ultimate volume of extract and W is weight of the sample.

Data Analysis

This experiment was conducted in a factorial experiment using a completely randomized design with three replications. Data were analyzed using SAS, 9.1 software and means were compared using LSD (Least Significant Difference) at $P \leq 0.05$.

RESULTS

Firmness

The effect of cultivar and coating materials on firmness of thorny cucumber is shown in Table 1. The highest firmness belonged to the 'Kurage' cultivar coated with edible paraffin and it was shown significant difference with other treatments.

Weight loss

Coating 'Kurage' and 'Tiba' cultivars with almond oil resulted in the lowest weight loss compared with other treatments and control (Fig. 1).

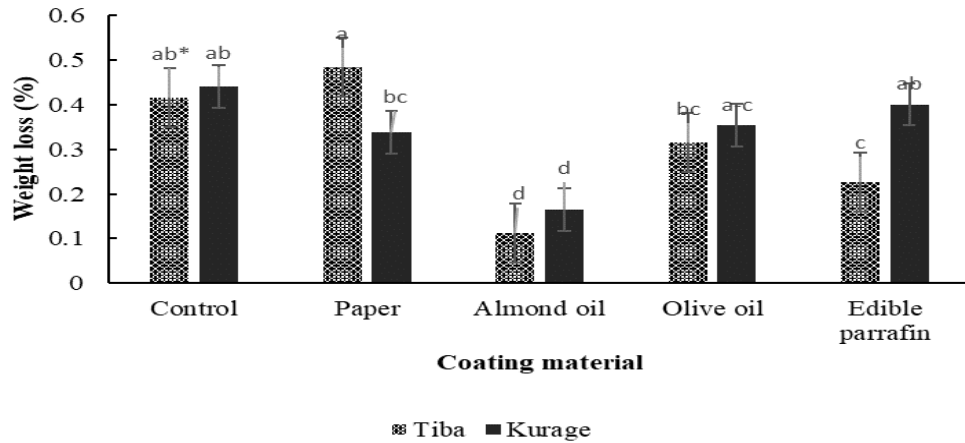
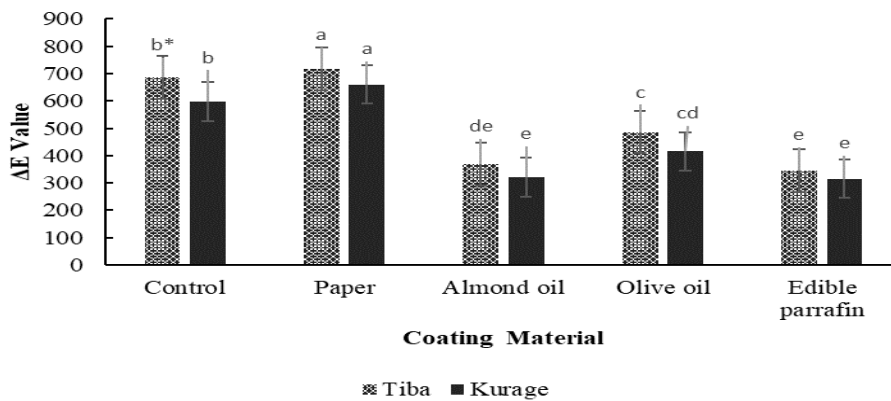
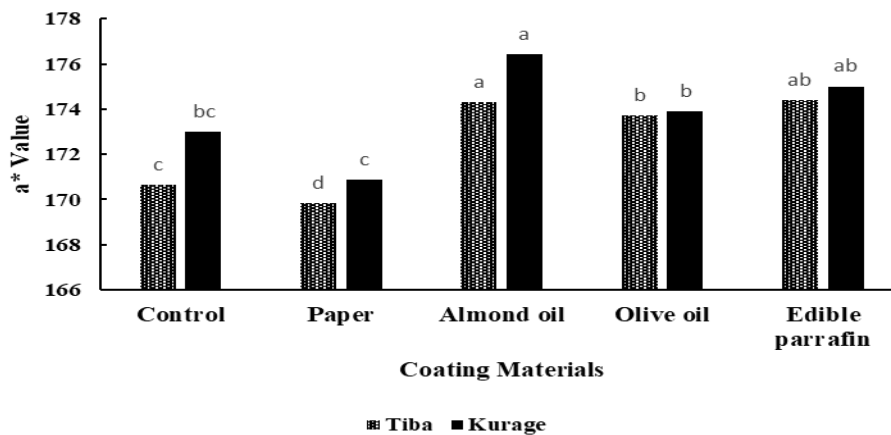
Color Values

The ΔE values of the cucumber cultivars are illustrated in Fig. 2. Brown paper covering had the most ΔE in both cultivars and showed significant difference with other coating materials (Fig. 2). The mean comparison between two cultivars showed that 'Tiba' cultivar had higher ΔE in comparison with 'Kurage' cultivar (Data not shown). Besides, liquid paraffin resulted in the least total color difference (ΔE^*) (Fig.2).

Effect of coating materials on a* (greenness) value of two cucumber cultivars is shown in Fig. 3.

Table 1. Effect of coating materials on firmness (kg cm^2) of two cucumber cultivars after 14 days of storage at 10 °C.

Cultivar	Coating materials					Mean
	Control	Paper bag	Almond oil	Olive oil	Edible paraffin	
'Tiba'	1.50±0.34bc*	1.40±0.14c	1.50±0.44bc	1.42±0.23c	1.54±0.34abc	1.54A
'Kurage'	1.50±0.34bc	1.60±0.55ab	1.50±0.47bc	1.46±0.19c	1.65±0.65a	1.47B
Mean	1.50AB	1.50AB	1.50AB	1.44B	1.60A	

**Fig. 1.** Effect of coating materials on weight loss of two cucumber cultivars after 14 days of storage at 10 °C.
*Means with the same letters are not significantly different at 5% level, LSD.**Fig. 2.** Effect of coating materials on ΔE value of two cucumber cultivars after 14 days of storage at 10 °C..
*Means with the same letters are not significantly different at 5% level, LSD.**Fig. 3.** Effect of coating materials on a^* of two cucumber cultivars after 14 days of storage at 10 °C.
*Means with the same letters are not significantly different at 5% level, LSD

The highest a^* value was recorded in 'Kurage' and 'Tiba' cucumbers coated with edible paraffin and almond oil; whilst, the lowest value was recorded in cucumbers placed in paper bag (Fig.3). In addition, 'Kurage' cultivar showed higher greenness than that of with 'Tiba' cultivar (Data not shown). 'Kurage' cultivar placed in brown bag had the highest b^* (yellowness) after 14 days. The lowest yellowness was observed in 'Kurage' cultivar coated with almond oil without any significant difference with some other treatments (Table 2).

As it is shown in Fig. 4, the highest lightness belonged to the control treatment in 'Kurage' cultivar and the least L^* value was observed in 'Tiba' cultivar covered with edible paraffin.

Chlorophyll Content

No significant differences were found in chlorophyll contents of both cultivars in all of the treated samples (Table 3).

Table 2. Effect of some coating materials on b^* value of two cucumber cultivars after 14 days of storage at 10 °C.

Cultivar	Coating materials					Mean
	Control	Paper bag	Almond oil	Olive oil	Edible paraffin	
'Tiba'	11.53±0.78bc*	13.60±0.84ab	6.56±0.44de	8.23±0.58d	6.15±0.60de	9.21A
'Kurage'	11.07±0.74c	14.11±0.86a	5.79±0.40e	6.91±0.60de	6.02±0.55e	8.77A
Mean	11.30B	13.85A	6.18C	7.57C	6.08C	

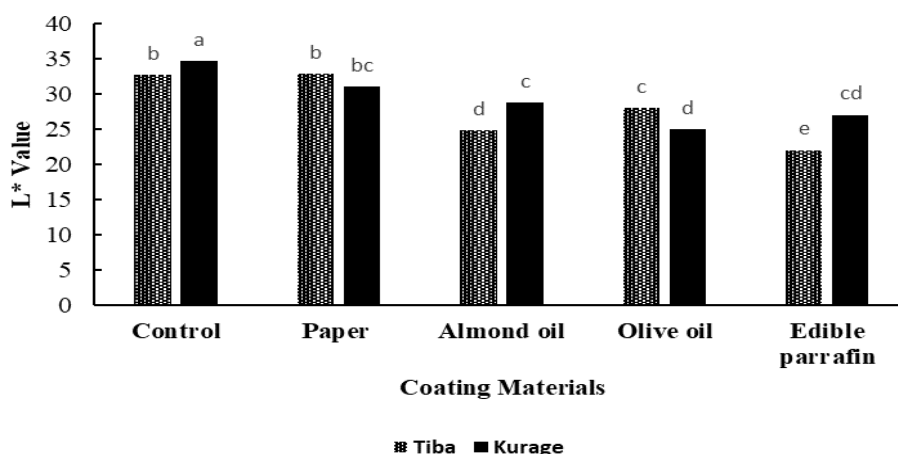


Fig. 4. Effect of coating materials on L^* of two cucumber cultivars after 14 days of storage at 10 °C.

*Means with the same letters are not significantly different at 5% level, LSD

Table 3. Effect of some coating materials on chlorophyll a, b and total contents (mg g^{-1} FW) of two cucumber cultivars after 14 days storage at 10 °C.

cultivar	Coating materials	Chl. _a	Chl. _b	Chl. _T
'Kurage'	Control	3.23 a	2.12a	5.35a
	Paper bag	3.52a	2.45a	5.97a
	Almond oil	3.44a	2.22a	5.66a
	Olive oil	3.32a	2.12a	5.44a
	Edible paraffin	3.44a	2.22a	5.66a
Tiba	Control	3.25a	2.14a	5.39a
	Paper bag	3.44a	2.35a	5.79a
	Almond oil	3.55a	2.12a	5.67a
	Olive oil	3.34a	2.24a	5.58a
	Edible paraffin	3.36a	2.33a	5.69a

*Means in each column with the same letters are not significantly different at 5% level, LSD.

DISCUSSION

Fruits and vegetables lose water to the surrounding air in the form of water vapor through a process called transpiration. This entails the movement of water from fruit cells to the surrounding atmosphere following a gradient of high water vapor pressure (~100% RH in fruit intercellular spaces or internal atmosphere) to low water vapor pressure (lower humidity of the storage environment). For this reason, fresh produce is often stored under conditions of high RH (90%-98%) to minimize water loss, and shrivelling. Edible coatings such as almond oil, olive oil and liquid paraffin can retard the movement of water vapor but become more permeable to water vapor and gases under conditions of high RH (Baldwin, 2007). The difference among these edible coatings related to their nature, so that almond and olive oils are natural oils; whilst the liquid paraffin is a mineral oil. Generally, weight loss increased gradually during storage period. The primary mechanism of moisture loss from fresh fruits and vegetables was reported to be by vapor-phase diffusion driven by a gradient of water vapor pressure at different locations (Yaman and Bayındırlı, 2002). Besides, it was shown that respiration causes a weight reduction, since a carbon atom is lost from the fruit in each respiration cycle (El-Anany et al., 2009). However, in this study it was shown that coating process caused a significant decrease in weight loss compared to that of untreated cucumber. Untreated cucumbers had significantly ($P<0.05$) higher weight loss at the end of the storage period, while both cucumber cultivars coated with almond oil had significantly ($P<0.05$) lowest weight loss (Fig. 1). Reduction in weight loss was probably due to the effects of coatings as semi permeable barriers against oxygen, carbon dioxide, moisture and solute movement, thereby respiration, water loss and oxidation reaction rates reduce (Baldwin et al., 1995). The obtained results were in agreement with the findings by Garcia *et al.* (1998) for strawberries coated with starch-based coatings. Similar data were reported by Bai et al. (2003, refer to El-Anany *et al.*, 2009) on 'Gala' apple, coated with 10% zein (natural corn protein). The results were in agreement with the findings of Srinivasa et al. (2006) for tomato and bell pepper packed in cartons covered with either eco-friendly chitosan film or synthetic petroleum based low-density polyethylene (LDPE) film. They reported that

chitosan and LDPE films extended the storage life of both tomato and bell pepper through reduction in water loss and modification of the internal atmosphere (Srinivasa et al., 2006; Al-Juhaimi et al., 2012). Softening of fruits is due to deterioration in the cell structure, cell wall composition and intracellular materials (Al-Juhaimi et al., 2012). It is a biochemical process involving the hydrolysis of pectin and starch by enzymes e.g. wall hydrolases. Low levels of O₂ and high levels of CO₂ limit the activities of cell wall enzymes and allow retention of the firmness during storage (Al-Juhaimi et al., 2012). These findings are in line with Park et al. (1994) reported that respiration and O₂ consumption of corn-zein coated tomatoes were lower than those of non-coated ones (Park et al., 1994). Reduction in respiration rates of coated cucumber could be responsible for delaying softening which resulted in retention of firmness during storage (Al-Juhaimi et al., 2012). In this study, it was shown that application of coating materials intensified the greenness of both cucumber cultivars and decreased yellowing during storage. It was reported that the development of fruit color is influenced by the internal gas environment (Buescher, 1979) including levels of CO₂, and ethylene. Low levels of oxygen inhibit ethylene production (Hoa, 2002). It seemed that application of coating materials could decrease O₂ penetration and resulted in better quality of cucumber.

CONCLUSION

It was concluded that both thorny cucumber cultivars coated with almond oil and edible paraffin showed the best appearance and luster feature which were related to the effect of these materials on reducing water loss and delay in chlorophyll degradation and softening. We strongly recommended coating thorny cucumber with almond oil and edible paraffin before transportation.

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کاربرد برخی پوشش‌های خوراکی بر نگهداری خیار در مدت انبارمانی

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مواد پوششی

چکیده- به منظور بررسی تاثیر برخی پوشش‌های خوراکی بر کاهش وزن و عمر انباری دو رقم خیار خاردار "کوراژ" و "تیبیا"، پژوهشی بصورت فاکتوریل در قالب طرح کاملاً تصادفی با سه تکرار طراحی شد. این پژوهش دارای ۵ تیمار شامل سه پوشش خوراکی (روغن زیتون، روغن بادام و پارافین خوراکی)، بسته‌بندی در کیسه کاغذی قهوه‌ای بدون پوشش خوراکی و تیمار شاهد بود. کلیه نمونه‌های تیمار شده در ظروف پلاستیکی، هر کدام باهشت سوراخ، برای تهویه پیچیده شدند و تیمار شاهد فقط در ظروف پلاستیکی قرار داشت. بسته‌ها در دمای ۱۰ درجه سانتی‌گراد و رطوبت نسبی ۸۵-۹۰٪ به مدت ۱۴ روز در انکوباتور انبار شدند. نتایج نشان داد که رقم تیبا سفتی بیشتری نسبت به رقم کوراژ داشت. خیارهای تیمار شده با روغن بادام کمترین کاهش وزن در مقایسه با سایر مواد پوششی داشتند، اگرچه اختلاف معنی‌داری بین دو رقم دیده نشد. بالاترین تفاوت رنگ مربوط به تیمار بسته‌بندی در کاغذ بود که تفاوت معنی‌داری با شاهد و سایر تیمارهای پوششی داشت. خیارهای بسته‌بندی شده در کاغذ بیشترین درجه سبز بودن را داشتند. بنابراین، هر دو رقم خیار خاردار پوشیده شده با مواد پوششی، ظاهر و درخشندگی بالاتری داشتند که مرتبط با اثر پوشش‌های خوراکی بر کاهش وزن کمتر، کاهش از بین رفتن کلروفیل و تاخیر در نرم شدن بود.