CARPATHIAN JOURNAL OF FOOD SCIENCE AND TECHNOLOGY

journal homepage: **http://chimie-biologie.ubm.ro/carpathian_journal/index.html**

EFFECT OF STORAGE CONDITIONS ON PHYSICAL PROPERTIES CHANGING OF COMPRESSED KIWIFRUIT

Mohsen Azadbakht[1]✉, Abbas Rezaeiasl[1], Mohammad Javad Mahmoodi[1], Mohammad Vahedi Torshizi[1], Shaghayegh Hashemi Shabankareh[1]

[1]*Department of Bio-System Mechanical Engineering, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran.*

✉*azadbakht@gau.ac.ir*

https://doi.org/10.34302/crpjfst/2021.13.3.9

Article history:
Received:
15 November 2020
Accepted:
12 May 2021

Keywords:
Kiwifruit;
Edible coating;
Storage period;
Moisture content;
Physical properties.

ABSTRACT

In this research, the effect of edible coatings such as grape juice, date juice and white berry juice, moisture in two levels of 90 and 95%, light bulb in two modes of light and without light and storage period of 5, 10 and 15 days on the characteristics the weight, volume and density of the kiwi fruit were investigated and all experiments were performed with three repetitions. For statistical analysis of the obtained data, SAS software was used by factorial experiments and in a completely randomized design. According to the results, the effects of storage period and edible coatings factors on all independent factors had a significant effect. For all dependent factors, the best values were observed in grape syrup coating, which had the least changes in weight, volume and density. The greatest changes in weight, volume and density have also been observed in white berry cover. Also, the light and moisture factors had a positive effect on changing volume and density in kiwi fruit. The highest rate of change was 9.38% for weight loss, 4.68% for volume reduction and finally, the highest percentage for density reduction was 7.5%. In general, among the coatings used, the use of grape juice as a coating has caused the least amount of changes in weight, volume and density, and the light bulb factor has had a positive effect on volume and moisture on density.

1. Introduction

Kiwifruit belongs to the Actinidiaceae family, Actinidia genus and it is one of the garden products (Mohammadian & Eshaghi Teymoori, 1999) .In today's world, is used other uses from kiwifruit that other uses are like canned kiwifruit, pulp a kiwifruit, kiwifruit frozen, drinks kiwifruit, materials extracted from kiwifruit (such as protease, mucilage, kiwifruit aroma) and dried kiwifruit slice (Romero-rodr, 2014). Kiwifruit is a rich source of vitamin C and black kernels in kiwifruit has vitamin D, also kiwifruit has other vitamins like A, B1,B2, B3 and other vitamins in B group and it has folic acid, polyphenols, iron and copper and phosphorus (Gall et al. 1994; Jolie et al. 2010).The phenolic compounds by antioxidant properties prevent from low density lipoprotein oxidation that this happen, prevent from free radical in fruit (Azadbakht & Vahedi Torshizi, 2020; Galvis Sánchez et al. 2003; Lu et al. 2010). On the other hand, agriculture products are under effect of various processes and factors from harvest time until consumption time. This process can be simple process like cleaning, separating, washing, moving and weighing or complementary and transformational processes that have effect on product properties (Torshizi and Azadbakht 2020; Azadbakht et al., 2019). Therefore physical, mechanical, chemical and biological properties cognition and how to maintain or change them for the intended

purposes of the process can be useful for saving quantitative and qualitative properties product. Every year, many agricultural and horticultural products waste in various stages, especially post-harvest stage, so that, the amount of these wastes in third world countries are more than industrial countries due to inattention to the principles of storage of agricultural products under development and evolution of scientific methods of storage and damages caused by pests. Mechanical damages to crops between harvest and consumption are the main quality loss factors and marketability (Azadbakht et al., 2020; Azadbakht, Vahedi, et al., 2019). If the damage to agricultural products on farms and gardens is increased, it will cause a large amount of waste in agricultural products, so that according to the World Food Organization, the amount of this wastage is in Latin American countries to 33% and 40% in Africa. Mechanical damage to agricultural products between harvest and consumption are the main factor in reducing the quality and marketability. In general, the damage reduces the quality of the product and increases its waste due to corruption (Yurtlu and Erdoğan 2005; Wei 1998). Also, the appearance of fruits affects their value in the market. Therefore, it is important to control the fruits well after harvest to prevent any physical damage, which will maintain the proper appearance of the fruit and increase exports (Ganiron, 2014). Different researchers have reported on the effects of coating on different characteristics of fruits, Dalir et al (2018) did an experimental on effect coating by gum seeds contain cinnamon extract in persimmon storage that the results showed using of this coating was saved qualitative properties in storage period and sensorial properties of persimmon fruit decreased lower than without coating mode. Hasani et al (2012) investigated effect of edible coating on basic oil containing cheese protein and rice seed oil for saving kiwifruit physical and chemical properties that stated using of edible coating had better weight loss and hardness than control sample (Hassani et al., 2012). Pradhan et al (2009) had researched effect moisture content on physical properties in jatropha fruit and observed that using of different moisture content changed density and some physical properties like length, width and thickness in jatropha fruit (Pradhan et al., 2009). Azadbakht et al (2019) studied on effect of loading and storage period in pear fruit on some physical properties have reported that storage period had a direct relationship by weight loss percentage and volume loss percentage and increasing storage period increased weight and volume loss (Azadbakht, Vahedi, et al., 2019). Aguiló-Aguayo et al (2013) investigated effect of light and storage period on amount of physical and mechanical properties in tomato, the physical result showed that use of fluence light caused decreasing firmness and weight percentage at storage period and was a meaningful different between sample control and the sample by light mode (Aguiló-Aguayo et al., 2013).

The aim for this research is the investigation physical properties in kiwifruit at different situation; because it is a damage-sensitive fruit and the physical properties change under storage period and these specifications are an important factor in the marketability and maintenance of this product. Also using of coating for storage period increase the durability of this product and according to the high importance of fruit appearance quality, in this investigation, effective use of a coating, light mode, and storage period is investigated on maintaining the quality of weight, volume and density of kiwifruit, because weight changes are caused by the removal of moisture in the fruit, this can reduce the marketability of the fruit.

2. Materials and methods

2.1. Sample preparation

The medium-sized kiwifruit (Hayward cultivar) with length, width, and thickness about 61.5, 49 and 43.5 mm respectively, were prepared from a garden in Golestan province, Iran. They were immediately brought to the laboratory of the Biosystems Mechanical Engineering Department at Gorgan University of Agricultural Sciences and Natural Resources. 108 kiwifruits with uniform appearance and size were selected in the commercial maturity stage and with completely healthy skin. They were

then subjected to quasi-static loading. The purpose of using quasi-static pressure was to investigate the effect of the desired factors in the damaged fruits on the desired parameters. Obviously, damaged fruits are most prone to physical tissue damage. Then, the fruits were completely immersed in pasteurized solutions of grape juice, dates and berries (at a concentration of 10% by weight for 1 min) and then dried in air.

The samples were placed in containers and transferred to the refrigerator with the ability to change light conditions and ambient humidity (Figure 1.A). Some of the samples were placed inside an oven dryer to measure humidity and measured according to standards (Azadbakht & Vahedi Torshizi, 2020). The amount of moisture measured for kiwifruit was 82.1±0.5%. The samples were then prepared to measure their chemical properties.

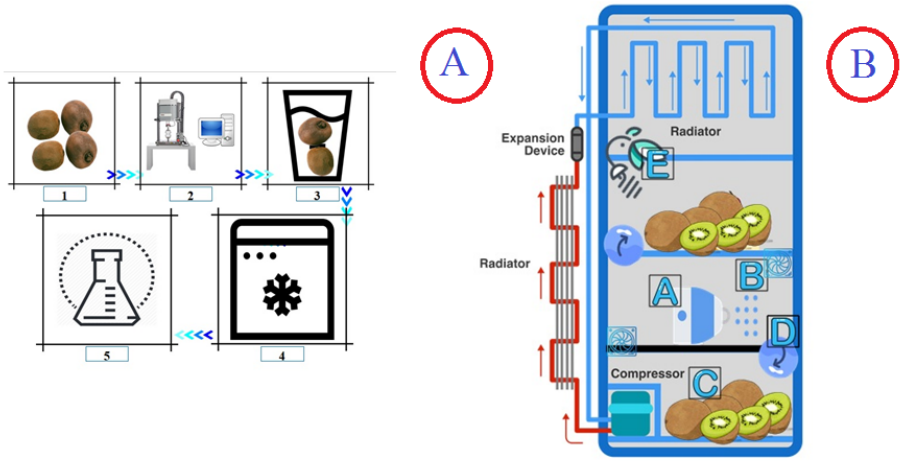

Figure 1. Overview of the test steps
Part A:
1) preparation of samples; 2) application of quasi-static load; 3) immersion of samples in solutions; 4) storage of samples in the refrigerator; 5) measurement of chemical properties of samples.
Part B:
Schematic of the refrigerator and related facilities
A) Ultrasonic humidifier module and water tank; B) Air conditioning techniques; C) Location of screens; D) Air direction; E) Low consumption refrigerator

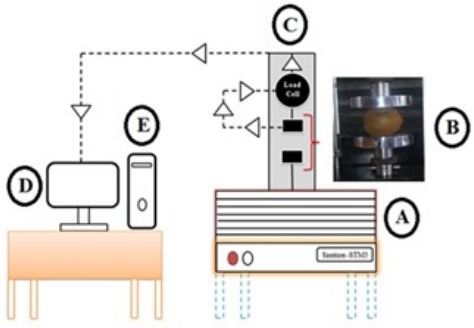

Figure 2. Static quasi-load diagram of kiwifruit
(A) The force-deformation device (Indestrone). (B) Jaw's thin edges. (C) Load Cell. (D) Computer. (E) Information save.

2.2. Quasi-static loading

To apply the quasi-static load on the wide edge, a force-deformation device with the brand name Santam-STM5 with a load of 500 Newtons was used. Two circular plates were used to test the pressure (Figure 2). This test was performed at a speed of 5mm/s with a power of 30N in three repetitions. To perform this experiment, the kiwifruit was placed horizontally between two plates and subjected to quasi-static pressure (Azadbakht, Vahedi Torshizi, et al., 2019).

2.3. Sample storage conditions

To store kiwifruit samples, a refrigerator equipped with a humidifier system with the ability to adjust the overall humidity of the refrigerator's internal environment was used (Figure 1.B). The desired moisture was prepared by an ultrasonic humidifier module 400mL.h (with 24v DC voltage, 19W power, and 450mA current) and was uniformly integrated into the refrigerator by two channels and two fans with dimensions of 10×10 cm. The moisture emission module depends on different levels of the independent moisture factor and has a humidity control sensor to start working by reducing the amount of moisture. The refrigerator used had internal dimensions of 60×80×60 cm and had two separate and completely equal parts. Each part was completely insulated in terms of light, and in one part of it, a low-energy lamp was placed. The energy-saving lamp was powered by city electricity and had a power of 30W. The brightness of the lamp was 1800 lumens and affected the specimens throughout the storage period. The distance between the light source and the samples was 30 cm. Samples were stored for 5, 10, and 15 days.

2.4. Investigate the physical properties

In this research have investigated weight, volume and density properties for kiwifruit at first, after coating all samples weight measured by a scales accuracy 0.01 and for measuring samples volume used fluid displacement method and it was done before coating, at finally the density of all samples was calculated by dividing the mass by the volume. Due to the reduction in experiment error, all samples were selected in the same size and then all samples were placed at packs and kept for 5, 10 and 15 day at storage. Then, during the 5-day storage period, the samples were taken out of the storage and the weight, volume and density were measured again. This was also done for the 10 and 15 day storage periods. Finally, the percentage of change in weight, volume and density of the samples was calculated compared to the first day of storage and the percentage of changes in weight, volume and initial density was obtained.

2.5. Statistical Analysis

First, the fruits were subjected to quasi-static loads and three different coatings were applied to them, including solutions containing grape juice, dates, and berries. The kiwifruit specimens were then stored. Warehouse conditions included 90% and 95% humidity, ambient light conditions were completely dark and light with the use of energy-saving lamps and storage periods of 5, 10, and 15 days. After the storage period, the qualitative properties of the kiwifruit samples were measured, weight loss, volume loss and density loss percentage. All experiments were performed in three replications and the results were analyzed using factorial experiments and in a completely randomized design using SAS statistical software.

3. Results and discussions

The ANOVA results for weight loss percentage, volume loss percentage and density loss percentage have been showed in table 1. According to this table, the interaction coating and storage period factors signified at the statistical level 1% and the light independent factor didn’t has a meaningful effect for weight loss percentage, volume loss percentage and density loss percentage in kiwifruit after storage. Also for the moisture content amount was obtained a statistical level 1% just for density loss percentage in kiwifruit and interaction moisture×light hadn’t meaningful effect for any dependent factors and interaction moisture×coating signified for density loss percentage at the statistical level 1% and the interaction light×coating only signified for

volume loss percentage at the statistical level 1%. At finally effect light×storage period was meaningful for volume loss percentage and for coating×storage time was obtained significant effect for every dependent factors.

Table 1. Variance analysis of weight loss percentage, volume reduction percentage and density reduction percentage.

Independent factors	WLP		VLP		DLP	
	MS	F value	MS	F value	MS	F value
Moisture content	0.328	1.18ns	0.067	0.82 ns	62.77	160.29**
Light	0.004	0.02ns	0.070	0.86 ns	0.003	0.01 ns
Edible coating	45.45	163.65**	16.46	199.47**	23.61	60.30**
Storage period	229.64	826.75**	33.39	404.61**	157.18	403.88**
Moisture content× Light	0.0006	0ns	0	0 ns	0.023	0.06 ns
Moisture content × Edible coating	0.053	0.19 ns	0	0 ns	4.36	11.14**
Moisture content× Storage period	0.015	0.06 ns	0	0 ns	7.33	18.73
Light× Edible coating	0.020	0.07 ns	1.12	13.57**	0.155	0.40 ns
Light× Storage period	0.004	0.01 ns	0.4	4.964*	0.128	0.33 ns
Edible coating× Storage period	8.56	30.83**	5.96	72.27**	4.711	12.03**

WLP= Weight loss percentage, VLP= volume loss percentage, DLP= Density loss percentage, MS=Mean square. ** Significant at the statistical level of 1%, * Significant at the statistical level of 5%, ns no significant

3.1. Weight loss percentage

Considering Table 1, it was concluded that the independent factors of vegetation cover and storage period had a significant effect on the dependent variable of weight loss percentage at the level of 1%. Also, due to the large amount of average squares (MS) obtained, the independent storage period factor has a greater impact than other independent factors on the amount of weight loss percentage.

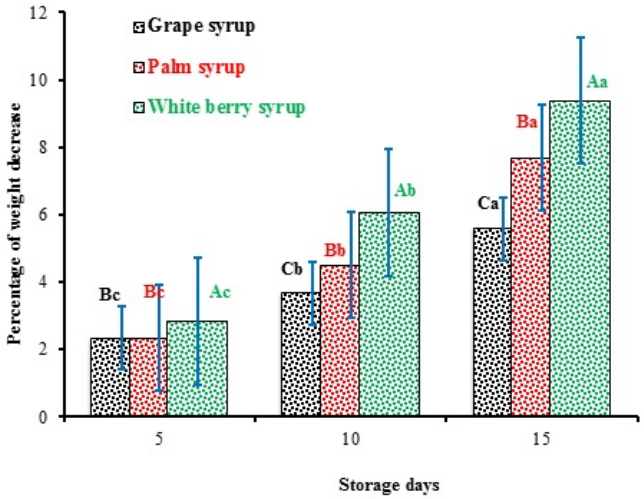

Figure 3. Interaction coating and storage time on amount weight loss percentage.
Similar large letters indicate no meaning in a fixed storage period, similar small letters indicate no meaning in a fixed edible coating.

Figure 3 shows the results of the interaction of storage time and cover the various covenants on the percentage of weight loss. According to the figure, it can be said that with the increase of storage days, the percentage of weight loss has increased. The reason for this is the removal of moisture during storage for kiwifruit. Also, the use of coverage has had a significant effect on reducing the percentage of weight loss. According to the figure, except for 5-day storage, which did not show a significant difference between grapes and dates, there was a significant difference between all coatings in the two storage periods of 15 and 10 days. From between using of three coating in this investigation, the grape coating had the lowest weight loss and this happen showed that this coating had positive effect on weight loss.

This result was similar result by García an et al (1995) on apple fruit that stated the turgor pressure is a reason for the changing weight loss in storage; also cell's wall is a semipermeable membrane for water and fruit ingredients and based on Osmotic property, water can move through cell's wall into cell, while fruit ingredients don't move and will stay in cell's wall (Singh et al., 2014). Furthermore, water infiltration inside cell causes swelling and turgor pressure on the inside of the cell wall and this pressure creates a stress between cells in inside cell wall that if this stress to the texture and cell wall be more stress than cell wall tension, the cell wall will change and the cell wall failure will begin and by changing in cell wall, the weight fruit will change and decrease (Alvarez et al., 2000). Any changes in the turgor pressure, subsequently changes the mechanical properties of the cell wall and consequently all the tissue. In other words, over time and during product storage, by decreasing the turgor pressure at the cellular level, the stresses due to mechanical blows in the product tissue are reduced and therefore the product's vulnerability is reduced (Garíca et al., 1995). The another factor for weight loss is decomposition of starch or cell wall polymer compounds that it is a factor in removing moisture of fruit and as a result, it reduces fruit weight that Tucker (1993) expressed this reason (Tucker, 1993). The highest weight loss percentage was obtained at the 15-day storage period in white berry coating with amount 9.388% and the lowest amount weight loss percentage was in the 5-day storage period in grape coating with amount 2.335%.

3.2. Volume loss percentage

Considering Table 1 and comparing the mean squares (MS) of the two factors of coverage and storage, it was concluded that the storage time factor had a greater effect than the coverage factor on the percentage of volume reduction.

The result for interaction storage period and edible coating have showed in figure 4..A According this figure an incremental trend for the percentage reduction in the volume of kiwifruit samples during storage has been. There were a significant difference between all storage periods for all coatings. So according the figure, the edible coating has created a significant difference for volume loss percentage at a fix storage period, In all of storage period were a significant result between all edible coating and grape syrup had the best and lowest changing volume for kiwifruit, however can explain that the most of kiwifruit texture has a water texture and during the storage, this water will be remove due to environmental factors and it has direct effect on weight and volume loss for fruits (Strik & Cahn, 1998).

On the other hand, creating pressure and loading increase the rate of destruction of the internal structure and will increase the loss of interstitial water in the product that this happen reduces the volume of product (Harker & Hallett, 1994). The highest amount for volume loss was 4.468% at storage period by 15 days and white berry coating, also the lowest amount had obtained at grape syrup coating and 5 days by 0.82% changing for volume loss. This result was similar by Azadbakht et al on investigation pear volume (Azadbakht, Vahedi, et al., 2019).

The interaction light and edible coating on volume loss have been observed in figure 4.B and based on this figure, the light in turn on mode had decreased volume loss, however the turn on mode for light didn't have a significant different. Also when the light was turn off,

between all of coating has obtained a significant different and for turn on mode wasn't significant different between grape and palm syrup, but these had significant different by white berry coating. The maximum and minimum amount for volume loss were 2.652 and 1.059 % that showed in turn off mode by white berry coating and turn on mode by grape syrup coating for kiwifruit. In figure 4.C have showed interaction light and storage period for volume loss percentage that the storage period dependent showed by increasing storage period the amount volume loss had a significant different and according this figure, using light mode dependent didn't has any significant different through 5 and10 day of storage period, but in 15 day of storage, the light mode had a significant different for turn on and turn off mode. The highest volume loss amount was 2.967% at 15 day of storage period by turn off mode and the lowest amount observed at 5 day of storage period and turn on mode by 0.951%.

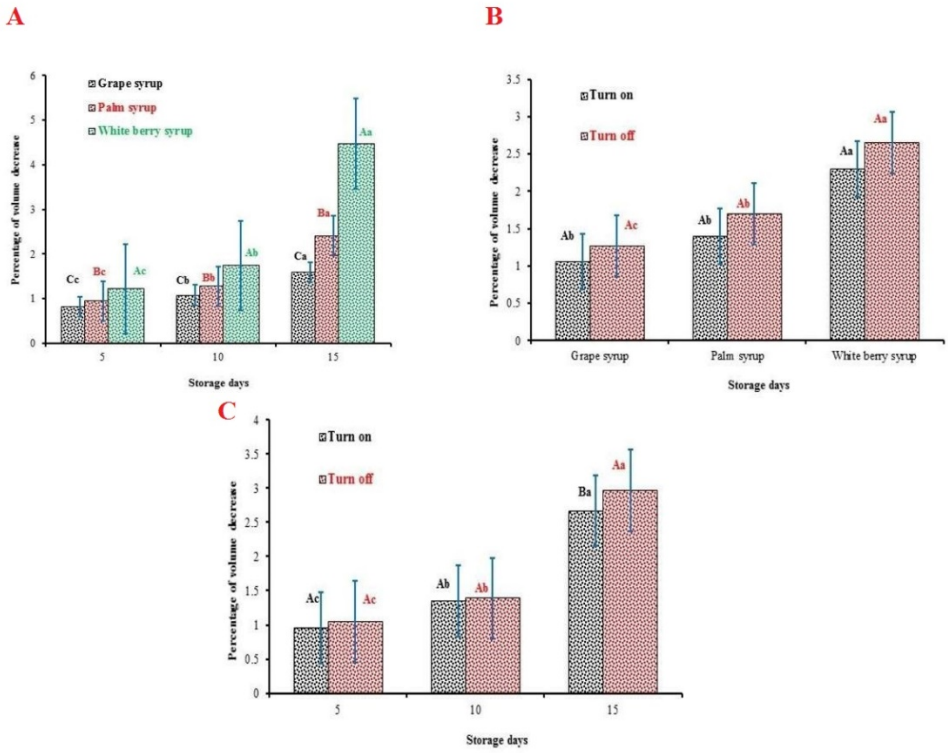

Figure 4. Interaction different conditions on amount volume loss percentage.
A) Interaction coating and storage time on amount density loss percentage; B) Interaction coating and light on amount density loss percentage; C) Interaction light and storage time on amount density loss percentage. Similar large letters indicate no meaning in a fixed storage period, similar small letters indicate no meaning in a fixed moisture content.

3.3. Density loss percentage

According to Table 1, it was concluded that independent factors of fruit moisture content, vegetation cover and storage period had a significant effect on the dependent variable percentage of density reduction at the level of 1%. Also, due to the large amount of mean squares (MS) obtained, the independent storage period factor has a greater effect than the other independent factors on the amount of density reduction percentage.

The density loss percentage amount for interaction storage period and edible coating is showed in figure 5.A and according this figure can explain that increasing storage period increased the density loss percentage in kiwifruit

and was a significant different between all storage period's days. Also in fifth day of storage day wasn't a significant different between all coatings and in tenth day of storage period has showed a significant different between coatings and for fifteenth day, between palm and white berry syrup coating didn't obtained a significant mode. In figure 5.B has been showed interaction storage period and moisture content on density loss percentage. This figure showed that the increasing storage period increased the density loss percentage and between all of storage period's day were a meaningful different and also for each storage period's day were a meaningful different between moisture level, Also the moisture level had a positive effect on density changing in kiwifruit and prevented from more decreasing density. The interaction effect for storage period and moisture content has been showed at figure 5.C that it showed, using edible coating had a meaningful effect on density loss and using grape syrup coating caused that the lowest density loss obtained for kiwifruit and also in moisture content in 95% didn't obtain any meaningful different for palm and white berry coating but the grape syrup had a meaningful effect between both of moisture content.

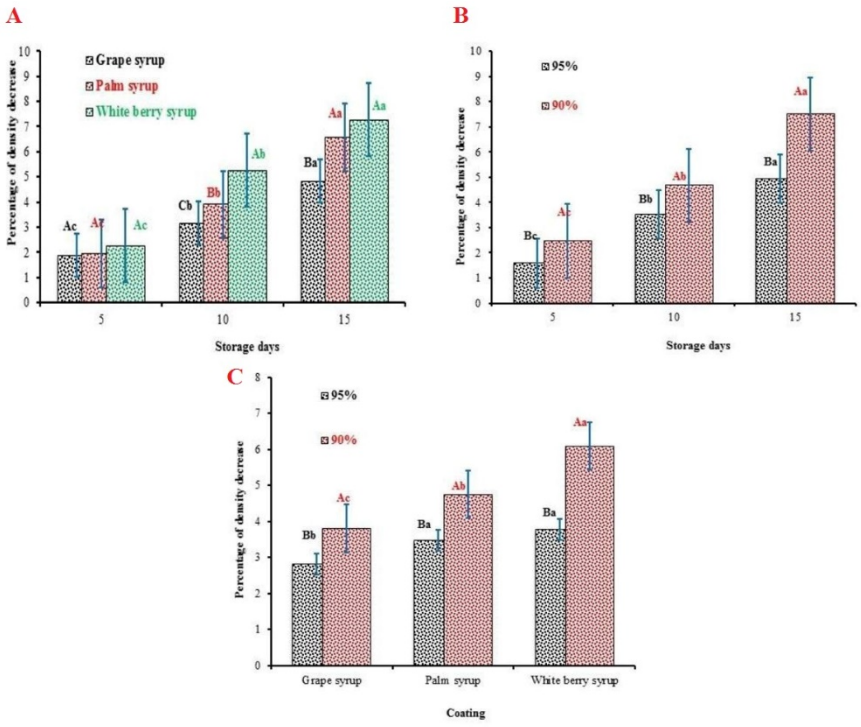

Figure 5. Interaction different conditions on amount density loss percentage.
A) Interaction coating and storage time on amount density loss percentage; B) Interaction moisture and storage time on amount density loss percentage; C) Interaction coating and moisture on amount density loss percentage.
Similar large letters indicate no meaning in a fixed storage period, similar small letters indicate no meaning in a fixed moisture content.

These had a meaningful different by grape syrup that it showed grape syrup had positive effect on decreasing density loss and this coating delayed the kiwifruit ripening and this mode saved the water in fruit and decreased changing texture, so the changing density was lower than other coating (Crisosto et al., 2001). Bakhshi et

at (2011) did an investigation on apple and had a similar result by this research and stated that the pectin destruction between cells cause that the density amount reduce, after the pectin destruction, it distribute around the cell and small walls connect together and this mode create a big space between cells that this happen decrease density amount (Bakhshi Khaniki et al., 2012). The highest and lowest amount density loss were 7.273 and 1.88% by white berry and grape coating respectively.

The reason for this can be stated as follows that the products begin to lose moisture for balancing moisture content with the environment, which it reduces the weight of the samples and according that, the moisture content has a straight relation with density fruit, so by decreasing weight of fruit, the density had decreased that this happen have increased density loss percentage in kiwifruit. And this happen showed that using of injecting moisture at storage environment had a positive and meaningful effect for preventing from density loss in kiwifruit. The maximum and minimum density loss percentage amounts were 7.5% and 1.589% in storage period 15 and 5 respectively.

In comparing every three syrups were a meaningful different between moisture 90 and 95 % and the moisture had a positive effect and increasing moisture has been decreased the density loss. Pradhan et al. (2009) also stated that the use of moisture had an effect on jatropha fruit density (Pradhan et al., 2009).

4. Conclusions

The use of moisture and turn on mode light has not been able to have a significant effect on the rate of weight loss of samples and the interaction of these two factors with each other as well as cover factors and storage time has not been significant for the percentage of weight loss of samples. But the factor of moisture and turn on mode light has had a significant effect on the percentage of decrease in volume and density of kiwifruit. From between using of factors, storage period was the most important than other dependent factors and after storage period, the edible coating was the most effective for preventing kiwifruit changes in this research. Also, the use of edible grape juice cover compared to the other two coatings has been able to have the greatest effect on the process of reducing the physical changes of kiwifruit, and after that, date juice has had a greater effect. Also, the use of moisture had a positive effect on preventing the decrease in the density of the samples and 95% of the moisture in this study was useful for kiwifruit. To reduce the sample volume, light in this study was able to make a significant difference compared to when this light is not used.

5. References

Aguiló-Aguayo, I., Charles, F., Renard, C. M. G. C., Page, D., & Carlin, F. (2013). Pulsed light effects on surface decontamination, physical qualities and nutritional composition of tomato fruit. *Postharvest Biology and Technology*, *86*, 29–36.

Alvarez, M. D., Saunders, D. E. J., & Vincent, J. F. V. (2000). Effect of turgor pressure on the cutting energy of stored potato tissue. *European Food Research and Technology*, *210*(5), 331–339.

Azadbakht, M., Vahedi Torshizi, M., & Mahmoodi, M. J. (2019). The use of CT scan imaging technique to determine pear bruise level due to external loads. *Food Science and Nutrition*, *7*(1).

Azadbakht, Mohsen, Rayeni Moghbeli, H., & Vahedi Torshizi, M. (2020). Investigating the Various Effects of Pear Packaging Box Design Factors Subject to Stress Forces. *International Journal of Fruit Science*, *20*(1), 39–58.

Azadbakht, Mohsen, Vahedi, M., & Mahmoodi, M. J. (2019). The relation of pear volume and it's bruised volume by CT scan imaging. *Journal of Food Measurement and Characterization*, *7*(3).

Azadbakht, Mohsen, & Vahedi Torshizi, M. (2020). The Antioxidant Activity Components Change of Pears Subject to Static and Dynamic Loads. *International Journal of Fruit Science*, 1–21.

Azadbakht, Mohsen, Vahedi Torshizi, M., & Mahmoodi, M. J. (2019). The use of CT scan imaging technique to determine pear bruise

level due to external loads. *Food Science & Nutrition*, *7*(1), 273–280.

Bakhshi Khaniki, G., Ghorbanli, M., & Mirbagheri, S. (2012). Biochemical Changes of two Cultivars of Golab and Shafiabadi Apple at Harvesting Time and After Storing. *New Cellular and Molecular Biotechnology Journal*, *2*(5), 59–65.

Crisosto, C. H., Slaughter, D., Garner, D., & Boyd, J. (2001). Stone fruit critical brusing thresholds. *Journal of the American Pomological Society*, *55*(2), 76.

Gall, H., Sterry, W., Dermatol-, O., & Abtei-, D. (1994). Kiwi fruit allergy : A new birch food allergy. *Clinical Immunology*.

Galvis Sánchez, A. C., Gil-Izquierdo, A., & Gil, M. I. (2003). Comparative study of six pear cultivars in terms of their phenolic and vitamin C contents and antioxidant capacity. *Journal of the Science of Food and Agriculture*, *83*(10), 995–1003.

Ganiron, T. U. (2014). Size properties of mangoes using image analysis. *International Journal of Bio-Science and Bio-Technology*, *6*(2), 31–42.

Garíca, J. L., Ruiz-Altisent, M., & Barreiro, P. (1995). Factors influencing mechanical properties and bruise susceptibility of apples and pears. *Journal of Agricultural Engineering Research*, *61*(1), 11–18.

Harker, F. R., & Hallett, I. C. (1994). Physiological and mechanical properties of kiwifruit tissue associated with texture change during cool storage. *Journal of the American Society for Horticultural Science*, *119*(5), 987–993.

Hassani, F., Garousi, F., & Javanmard, M. (2012). Edible Coating Based on Whey Protein Concentrate-Rice Bran Oil to Maintain the Physical and Chemical Properties of the Kiwifruit (Actinidia deliciosa). *Research*, *10*(1), 26–34.

Jolie, R. P., Duvetter, T., Houben, K., Vandevenne, E., Van Loey, A. M., Declerck, P. J., Hendrickx, M. E., & Gils, A. (2010). Plant pectin methylesterase and its inhibitor from kiwi fruit: Interaction analysis by surface plasmon resonance. *Food Chemistry*, *121*(1), 207–214.

Lu, H., Zheng, H., Lou, H., Jiang, L., Chen, Y., & Fang, S. (2010). Using neural networks to estimate the losses of ascorbic acid, total phenols, flavonoid, and antioxidant activity in asparagus during thermal treatments. *Journal of Agricultural and Food Chemistry*, *58*(5), 2995–3001.

Mohammadian, M. A., & Eshaghi Teymoori, R. (1999). Farming, Cultivation and the Nutritional Value of Kiwi. *Iranian National Publication, Tehran, Iran*, *118*.

Pradhan, R. C., Naik, S. N., Bhatnagar, N., & Vijay, V. K. (2009). Moisture-dependent physical properties of jatropha fruit. *Industrial Crops and Products*, *29*(2–3), 341–347.

Romero-rodr, M. A. (2014). *Original article Comparison of different peeling systems for kiwifruit (Actinidia deliciosa , cv Hayward)*. 107–113.

Singh, F., Katiyar, V. K., & Singh, B. P. (2014). Analytical study of turgor pressure in apple and potato tissues. *Postharvest Biology and Technology*, *89*, 44–48.

Strik, B. C., & Cahn, H. (1998). *Growing kiwifruit*.

Torshizi, M. V., & Azadbakht, M. (2020). *Study on Firmness and texture changes of pear fruit when loading different forces and stored at different periods using artificial neural network*. *15*(6), 113–132.

Tucker,G.A. (1993). *Introduction//Biochemistry of Fruit Ripening/Eds GB Seymour, JE Taylor, GA Tucker*. London: Chapman and Hall.

Wei, L. X. W. (1998). A Study on Compressive Properties of Apple [J]. *The Journal Of Northwest Agricultural University*, *2*.

Yurtlu, Y. B., & Erdoğan, D. (2005). Effect of storage time on some mechanical properties and bruise susceptibility of pears and apples. *Turkish Journal of Agriculture and Forestry*, *29*(6), 469–482.