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Investigation of the effects of calcium chloride and ultraviolet (UV-C) on storage life of Afghanistan's fig (*Ficus carica* L. cv Safed Kohi)

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Abstract

One of the most important damaging factor on fruits and other horticultural crops is the unsuitable conditions of their post-harvest storage, therefore the aim of this study was application of different chemical and irradiation on qualitative and quantitative shelf life of Kandahar fresh fig fruit that has commercial importance at Afghanistan, Kandahar. In order to study the effect of $CaCl_2$ and UV-C ray application at different storage times on shelf life of fruit (*Ficus carcia* L. cv. Safed Kohi), one laboratory experiment as factorial based on completely randomized design with tree replications was performed at Agriculture Faculty, Ferdowsi University of Mashhad in 2019. First factor included $CaCl_2$ at two levels (0 and 4%), second factor consisted of four levels of UV ray irradiation (0, 5, 10 and 15 minutes) and third factor shelf life time (7, 14 and 21 day). The results of analysis of variance showed that the effects of $CaCl_2$ and UV irradiation on different shelf life time were significant at 1% probability level on all the studied traits in this study. The mean comparisons showed that with increasing shelf life and the time percentage of weight loss of fruits. The treatment with $CaCl_2$ and UV ray cause to decrease this enhancing process, so that application of $CaCl_2$ 4% and UV irradiation for 15 minutes at 21 days of shelf life could decrease 20.79, 69.28, and 67% of these traits, respectively. With increasing shelf life and without $CaCl_2$ usage, the soluble carbohydrate of fruits reduced, but at $CaCl_2$ usage with increasing shelf life also this trait showed increasing process. The results also showed that with increasing the time of shelf life and at 21 day of panel test, fruit thickness, soluble solid substance and total acidity decreased and application of $CaCl_2$ and UV ray for 15 minutes increased fruit thickness and acidity in comparison without using these treatments at 21 days. Soluble solid substance and panel test hence, only UV irradiation for 15 minutes could increase 60.47 and 266.65 % of these traits compared to control. In total, the findings of this study indicated that with increasing shelf life the quality of fruits of figs decreased and also the panel test of it showed that the characteristics of its odor and flavor decreased and market-selecting decreased. Application of $CaCl_2$ and UV ray irradiation at different times especially for 15 minutes could improve these traits and maintain the market-selecting of this fruit for increased time. Therefore, application of these treatments is recommended for maintaining long shelf life of the fruits.

Keywords: irradiation, decay, phenol and soluble solid substance

Introduction

Common fig (*Ficus carica* L.) is a fruit related to the Mulberry family (Moraceae), which has more than 1400 species divided into 40 types (Watson and Dallwitz, 2004). The genus *Ficus*, which consists of 700 species, is mainly found in the tropics (Berg, 2003) [9]. Figs are a very nutritious fruit and are rich in calories (269), its protein and calcium is higher than milk, a considerable amount of iron and the highest fiber content (Sing and Meghwal, 2015). Chemical compounds and flavors are different in the types of figs and reported by Mousavi in 2016 (Mousavi *et al*., 2016). The ripe and freshly harvested fig has soft texture, sweet taste and nice aroma, but its barn for a long time due to the process of ripening, breathing and rapid because of effect of ethylene is difficult (Venditti *et al*., 2005), high sensitivity of perishability (Plaza, 2003 and Venditti *et al*., 2005), skin vulnerability and plasticity and high percentage of dissolved sugars are the other reasons for the prolongation life of this fruit (Kaynak, 1998), but affording to its nutritional and pharmaceutical values, it is necessary to consider effective methods to reduce corruption and increase storage time and the fresh product obtainable to use attendees.

Fig is one of the oldest and most consumed fruits in the world and has been known for human beings in very ancient times (Vicente *et al*., 2004). This fruit has been cultivated for 11000 years and is one of the first plants grown by humans (Kislev *et al*., 2006). Common fig species in Kandahar, Afghanistan are cultivated locally, but for commercial purposes, they are named Safed kohi, Sabz and Seyah. The Safed kohi fig fruit is a reddish green skin with a greenish and creamy blue flesh color, with a very sweet taste, guevara aroma and its high-quality color has been a friendlier market than other species. The growth of its tree is dense, tolerant to salinity and drought and its products are similar to the Kadota cultivar, but has a higher production rate (Samadi and Shirzad, 2013).

Materials and Method

This project was conducted in the postgraduate laboratory of Horticultural Science and Green Space Engineering department of Faculty of Agriculture, Ferdowsi University of Mashhad, Iran. Factorial experiment was completely randomized with two factors (1) calcium chloride ($CaCl_2$) in 2 levels (4% and Control) and (2) Ultraviolet rays (UV-C) at 4 levels (5, 10 and 15 minutes and control). In this design, a total of 280 fruits and each experiment was performed in three replications. The experiment area was the postgraduate laboratory of Ferdowsi University of Mashhad and the storage room for refrigeration was Department of Food Industries of the same university.

Results and Discussion

Weight loss

The results of this study showed that the effects of calcium chloride and ultraviolet irradiation (UV-C) at different times of storage at the probability level of 1% were significant on the weight loss of fig fruit (table 1). The mean comparison of the data showed that the highest amount of fruit weight (84.30%) was observed in conditions which had not been used for the treatments of calcium chloride 4% and ultraviolet radiation, and the samples were stored for 21 days (Fig. 1). The lowest fruit weight loss (35.1%) was observed in calcium chloride (4%) and UV radiation irradiation and the seventh day storage (except for control treatment).

Table 1: ANOVA analysis of the final results

Change sources		Mean Square						
Treatments	df	Weight Lose	Cracking	Taste Panel	Fruit Deminsion	Soluble sugar	Soluble solides	Acidity
$CaCl_2$ 4%	1	254/44**	1/041**	6632/67**	104/41**	5/89**	25/44**	0/0035**
UV-C	3	163/55**	1/041**	2079/92**	18/19**	1/31**	7/38**	0/0033**
Time	2	160/55**	1/041**	3231/25**	71/76**	0/98**	0/90**	0/21**
$CaCl_2$ 4% x UV-C	3	114/79**	1/041**	2081/25**	4/88**	0/81**	3/87**	0/0017**
UV-C x Time	6	47/76**	1/041**	265/74**	4/24**	0/51**	3/44**	0/0021**
$CaCl_2$ x Time	2	98/34**	1/041**	400/69**	11/95**	0/80**	11/92**	0/0022
$CaCl_2$ x UV-C x Time	6	35/19**	1/041**	251/39**	2/56**	0/48**	3/77**	0/0078**
Error	48	0/02	0/07	29/17	0/47	0/02	0/22	0/0002

Fruit weight loss during the period of storage fresh fruit in accordance with the results of this study in plum (Kermani *et al*., 2014) and Lemon (Hoseini Farahi and Haghani fard, 2017) were observed that this decrease in fruit weight due to loss of water caused by evapotranspiration and reduction of dry matter of fruit due to consumption in breathing process (EL-Badawy, 2012).

Calcium chloride evidences caused the delay of aging and reducing the weight loss of raspberry fruits (Montealegre and Valdes, 1993) of Apples (Lurie and Klein, 1992) and Peach (Abdel Gayed *et al*, 2017) which complies with the results of this research. The application of calcium chloride before and after harvesting of fruits causes delaying their aging and reducing the destruction of fruits and vegetables that the cause of less fruit weight loss in this study can be the same. Also, the effect of attenuation on fruit weight reduction under calcium chloride can be proved that this substance has the capacity to preserve the cell building and thus increases the fruit strength and also causes the activity of the destruction of cell wall and gas exchange enzymes to decrease under weight loss rate is also reduced (Levy and Poovaiah, 1979).

Previous studies in plum and tomato showed that weight loss can be prolonged by UV-C rays (Bal and Celik, 2008; and Mahraj *et al*, 1999) that match the results of this research. Irradiation with ultraviolet radiation in postharvest of fruits causes delayed ripening of fruits and the amount of breathing is reduced, thereby reducing the percentage of dry matter allocation of the plant to breathing (Vicente *et al*., 2004) and consequently reduced fruit weight. It seems that the low fruit weight loss process in this research has also been noted for reasons. The other cause of weight loss in fruits during the storage period could be that the fruits are contaminated with pathogenic agents during the storage period and these factors can reduce the weight of storage (Park, 1999). In addition, by increasing the storage period of fruits, their moisture content decreased and consequently the weight of fruits was reduced by increasing storage days (El-Badawy, 2012).

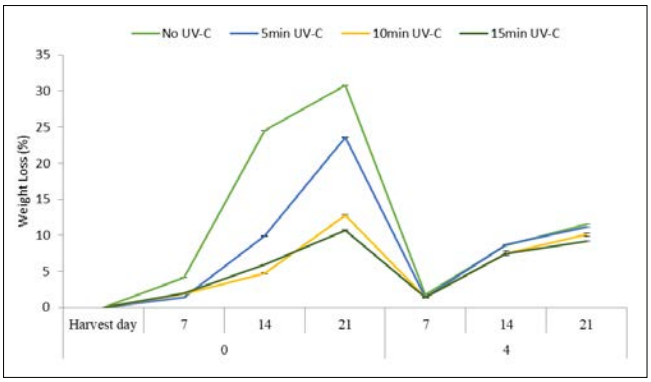

Fig 1: Comparing the effects of calcium chloride triplet and ultraviolet irradiation on fruit weight reduction rate.

Sensory Evaluation (Taste Panel)

The effect of triple calcium chloride, UV radiation and storage time at the probability level of one percent on sensory evaluation was significant (table 1). Sensory evaluation indicates the quality of taste and aroma of fruits. The results of this study showed that with increasing storage time, fruits lose their apparent quality and flavor as the lowest sensory evaluation (20) in the treatment of non-application of calcium chloride, radiation UV-C and 21 days of storage were obtained and the highest level except control treatment was observed in 4% calcium chloride treatment and all irradiation UV radiation levels (Fig. 2). According to the results of this research, research in the past showed that by increasing the storage percentage of brown fruit and decay of peach (Gayed *et al*, 2017), Lemon (Hosseini Farhee and Haghani Fard, 2017) and pear (Arshad, 2014)

increased and its sensory evaluation results indicated a reduction in fruit appearance That the application of calcium chloride was effective in reducing these complications.
Also, according to the results of this study, Antunes in 2003 also showed that with increasing the duration of storage figs, its apparent quality and taste were reduced. Caries is one of the most important factors for reducing the quality of fruits in post-harvest and long-term storage of fresh fruits will cause these products to damage the tissue and change the color of the stain and rot, and the taste of their appearance are also changed that this is evident well in this research.

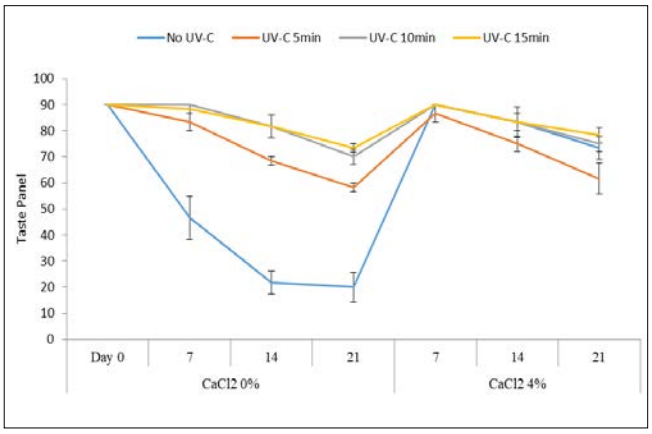

Fig 2: Comparing the effects of calcium chloride triplet and ultraviolet irradiation on the sensory evaluation of fig fruit.

Calcium chloride 4% leads to increased cell wall and the resistance of fruit tissue to damage, and on the other hand, the application of calcium chloride reduces the physiological disorders of fruit (Kermani *et al*, 2014) and, consequently, in this research, the fruits treated with calcium chloride were compared to the controls of percentages. Less decay showed better quality. In addition, fruit brown could be due to accumulation of phenolic compounds in fruit tissue, which in the process of phenolic compounds by polyphenol oxidase enzyme into the oxide of oxidized and brown and dark compounds, and in contrast to the application of calcium chloride, inhibitors of the enzyme activity of polyphenols oxidase is by ion chloride (Reddy and Reddy, 2014). Irradiation-rays (UV-C) reduced the amount of caries in tomato fruit and it caused a better appearance and taste than control, which is consistent with the results of this research (Mansourbahmani *et al*, 2017). One of the factors that causes the fruit to be soft and the fruit is gone towards the decay, increasing the production of ethylene in it, which in the wake of the fruit has a discoloration and it tends to be brown and the taste is changed (Guillen *et al*, 2007). Ultraviolet radiation is known as an inhibitor of ethylene producing agents and consequently reduces the production of ethylene in fruit and reduces the decay of fruit (Bu *et al*, 2013) which causes the reduction of the percentage of caries and preserving the flavor and quality of the treated fruits with UV radiation in this research could also be the reason.

Cracking rate
The results of analysis of variance showed that the effect of calcium chloride and UV radiation in storage time was significant in the amount of fruit cracking at the probability level of one percent (table 1). Comparison of the mean of data showed that the cracking of fruits was observed only in the treatment without application of calcium chloride, lack of UV radiation irradiation, and on the 21st day of the warehouse (33.3%) and in other treatments, cracking (table 2). Preserving the quality of fresh fruits especially figs has direct dependence on quality change indices of fruits during maintenance and storage (Flaishman *et al*, 2008). Besides, Kong in 2016 considered that the lateral cracking of the skin and the end of the fruit receptacle occurs during the growth and evolution of fruit, which reduces the growth, quality characteristics and the well-being of the post-harvest market, to prevent the damage of the above mentioned fig Brown (cv. Brown Turkey), (cv. Black mission) and Sierra (cv. Sierra) were examined by Regulated Deficit Irrigation 55% in two years. As a result, the above-mentioned treatment did not significantly affect the quality characteristics of fruits during harvest, except for Turkish brown cultivar which showed a decrease in the fruit volume in a season of 21%. The results of post-harvest and cold storage of treated fruits showed that the black cultivar had a significant effect on the incidence of caries with lateral cracking and the end of receptacle during harvest, but the amount of injuries decreased in Turkish and Sierra Brown cultivars, respectively, 50 and we added 18 percent, which confirms the results of this investigation.

Table 2: Comparison of the effect of calcium chloride triple and UV radiation on the percentage of fig fruit cracking

		Cracking Rate (%)			
$CaCl_2$(%)	UV-C (min) / Time (day)	0	5	10	15
0	Control	0^b	0^b	0^b	0^b
	7	0^b	0^b	0^b	0^b
	14	0^b	0^b	0^b	0^b
	21	33.3^a	0^b	0^b	0^b
4	7	0^b	0^b	0^b	0^b
	14	0^b	0^b	0^b	0^b
	21	0^b	0^b	0^b	0^b

As a result of this study, the chemical treatments of calcium chloride and ultraviolet irradiation and their interaction were observed to have positive and significant effects on the stiffness and preservation of the skin of the fruit. The investigation of Bal in 2012 that had done on black figs, acknowledges the result of the present research.

Soluble Sugar and Total Soluble Solids
The effects of calcium chloride, UV radiation and time on soluble sugar content were significant (table 1). The mean comparison of the data showed that the soluble sugar in calcium chloride treatments was more than 4% of the treatment without calcium chloride, as the highest (36.2 mg/g of fruit fresh weight) was obtained in 3% calcium chloride treatment, UV radiation irradiation for 15 minutes and seven days of storage. The lowest soluble sugar was obtained in the treatment without application of calcium chloride and irradiation UV radiation and twenty-one day of fruit storage (Fig. 3).

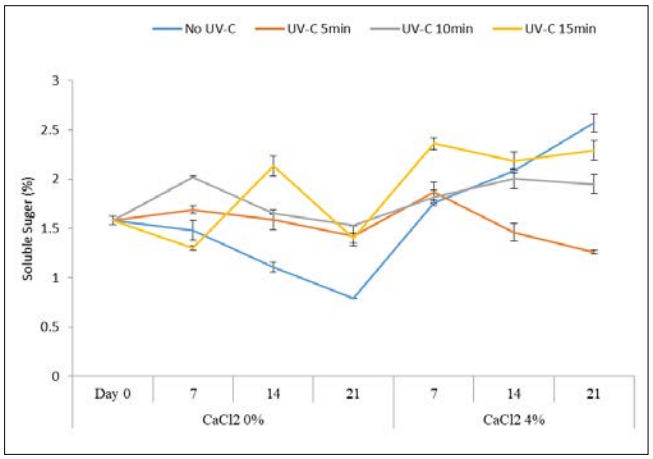

Fig 3: Comparing the effects of triple calcium chloride and ultraviolet radiation on the soluble sugar of figs.

The effects of calcium chloride percentage and UV-C radiation and time at the probability level of a percentage on soluble solids were significant (table 1). By increasing the storage time to 21 days, the dissolved solids in the fruit decreased and the lowest (36.11%) was observed in no calcium chloride treatment without irradiation radiation and 21 days of storage, irradiation UV rays for 15 minutes increased 47.60 percent (Fig. 4).

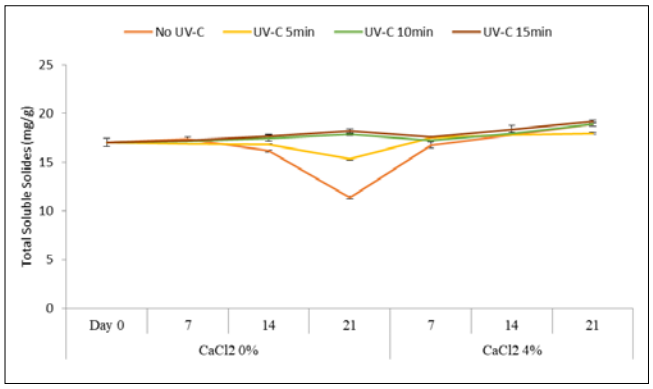

Fig 4: Comparing the effects of calcium chloride triplet and ultraviolet irradiation on the percentage of soluble solids of fig fruit.

The result of the study of Irfan in 2013 showed that reduced the amount of sugar in the fig fruit with calcium chloride in the period of 14 days' storage from 88% to 35/13%, which was consistent with the results of this study. Also, by increasing the storage days, the amount of soluble solids was reduced in accordance with the results of this study (Shokrollah fam *et al*., 2014). Sugars are counted as the most important constituents of fruits, which, along with flavor and aroma, also act as a natural preservative, according to the percentage of its existence in the composition of fruits. Figs are one of the fruits that contain a high percentage of the sugar, but the synthesis process of sugars will be changed to the ratio of stop handling after harvesting.

The cause of reduction of sugar and soluble solids in this study can be such that with increasing the duration of fruit storage and due to the fruit breathing in postharvest after harvesting and the effect of breaking the carbohydrates and fillers, protein hydrolysis and the decomposition of glycol-polysaccharides units (Bu *et al*., 2013) [10]. But the results of the researches of Burdon and others in 2007; Gayle and others in 2012 and Bal in 2012, which showed the fruit of kiwi and figs, the cause of the increase of dissolved solids and soluble pectin, phenolic compounds of fruits, which are dissolved in the final stages of the solution. It can still be caused by the reduction of the moisture and the monetary hydrolysis of the polysaccharides, which confirms the results of this investigation. In contrast, it seems that the treatment of calcium chloride and irradiation UV radiation by reducing the front-facing of the excess of these compounds and increase them from the untreated samples.

Total acidity

The effects of calcium chloride 4%, irradiation UV radiation and storage time on percentage of total acidity at the probability level of one percent were significant (table 1). The results showed that fruit acidity decreased with increasing duration of storage. In the storage, most of them were observed except for control treatment on the seventh Day (27.0) and there was no significant difference between the treatments without calcium chloride and calcium chloride 4% and the lowest was observed in the day and first storage, which irradiation the UV radiation to a certain extent. Total 8). In accordance with these results, the decrease of acidity was observed by increasing storage days in sweet Lemon (Hoseini Farahi and Haghani Fard, 2017) and Plum (Fam *et al*., 2014).

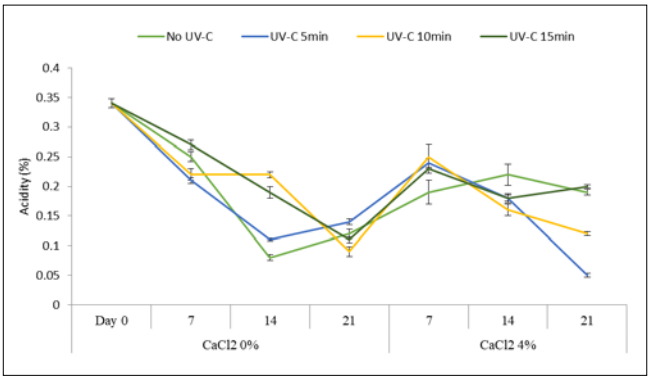

Fig 5: Comparing the effects of calcium chloride triplet and ultraviolet irradiation on the acidity percentage of fig fruit.

Acidity is directly associated with the concentration of organic acids in fruit, which is an important trait in maintaining the quality of fruit and reducing the acidity of fruits during the storage period can cause the fruit to store its organic acids as its primary metabolic materials uses (Martinez-Romero *et al*., 2002). It could also be because the amount of breathing in stored fruits increases with increasing the days of storage, and this increases in severity of breathing causes the consumption of organic acids of fruit and thus reduces the acidity of the whole fruits (Nafussi *et al*., 2001). It seems that the treatment of fruits with calcium chloride has been prevented by reducing the amount of fruit breathing from excessive consumption of organic acids as well as solids of plant soluble and thus preserving these compounds in storage fruits (Ding *et al*., 1998).

Conclusion

One of the main causes of damage to fruits and other gardening products is the inappropriate conditions of keeping them after harvesting. Because with poor

maintenance, the quality of the fruit is low and even up to 90 percent of the product can be lost and destroyed. Eventually, among the damages that come to the fruits can be reduced the weight of fruits, the brown of the fruit tissue and its decay, which results in a reduction of apparent quality and flavor of fruits. Besides, with increasing period of fruit storage, biochemical changes such as changes in sugar content, soluble solids and acidity are also caused. In this study, the fresh fruit of the treated white species was stored in three times of 7, 14 and 21 days in storage under temperature of 2 to 5 °C, and during this period it was determined that with increasing the storage time of fruits weight decreased and also suffered decay, their texture went towards getting brown and their sensory assessment was also reduced as a measure of apparent quality and flavor of fruits.

The treatments used in this research are greatly effective in maintaining the quality of fruits in postharvest. The results showed that the treatment of calcium chloride 4% and ultraviolet irradiation for 15 minutes had the greatest positive impact on fruit weight and greatly reduced the weight of fruits during the 21st day period of storage, which prevented most of the damage. The results also showed that this level of treatments had the highest role in reducing brownness and fruit tissue decay. With increasing the duration of fruit storage, the amount of sugars and solids and acidity of fruits were also decreased. However, the lowest of them were observed in the treatment of 21st days of storage and without application of calcium chloride and irradiation of UV-radiation, and the application of calcium chloride and irradiation 15-minute of UV-radiation had the greatest impact on the fruit traits. Therefore, for increasing shelf life after harvesting of fresh fig fruit, calcium chloride 4% and UV-radiation, especially for 15 minutes, are highly suggested and recommended.

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