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A weedy species in agricultural areas and an attractive wildflower in nature: Common poppy (*Papaver rhoeas* L.) – Can it be used for fruit preservation in the future?

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ABSTRACT: Weeds are the plants growing where they are bot desired and are notorious yield reducers that are responsible for significant crop yield and quality losses in agricultural areas. Common poppy is one of these plants**.** As can be understood from the title, the purpose of this study was to test the possibility of using fruit extracts of common poppy (*Papaver rhoeas* L.) for the preservation of fruit quality. The experiments were conducted with apricot fruits cv. 'Şalak'. Two different concentrations (0.5% and 2.5%) of *P. rhoeas* fruit extracts together with an un-treated control treatment were tested in the current work. Studies were carried out with three replications for each treatment, where each replication consisted of six individual fruits. Studies were continued for 42 days and the fruits were stored at 0.0±0.5 °C with 90-95% relative humidity. Different quality parameters of apricot fruits were measured and noted with 7-days interval. It was found that the hypothesis of current research was acceptable, where the fruit extracts of *P. rhoeas* were found to reduce weight loss at the apricot fruits, help to reduce disease severity, maintain visual quality of the fruits, reduce the chilling injury and fruit firmness and significantly influence the ascorbic acid content by delaying its reduction. Overall, findings of current work suggest that the *P. rhoeas* fruit extracts have ability to maintain postharvest quality of apricot fruits and further studies are required to determine the exact mechanism and the responsible constituents.

Keywords: apricot fruits, chilling injury, common poppy and its fruit extracts, extension of storability, visual quality, weight loss preservation

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INTRODUCTION

Common poppy (*Papaver rhoeas* L.) is an attractive wildflower when it grows in nature, but is also an important dicot weed causing reductions in the crop yield when it founds in agricultural areas (Clapham et al., 1962; Scarabel et al., 2015). It is native to Asia and Europe and is an important weed in different agricultural croplands, especially winter cereals. Studies suggested that it has high ability to reduce cereal yield in southern Europe (Wilson et al. 1995; Holm et al. 1997). One of the main characteristics that makes it troublesome in cereals is its ability to form a persistent seed bank in soil. This extends the germination period of the weed and so persist, grow and invade in the croplands (Torra and Recasens 2008). Its seeds are mainly used for flavouring cakes, bread and salads and known to not contain any alkaloids (Duke and Ayensu, 1985). On the other hand, its leaves are known to include alkaloids, which may cause toxicity and is strongly recommended to make a moderate use (Mabberley 2017; Oh et al., 2018). Different plant parts have been traditionally used to treat inflamation, nervousness, cough, diarrhea, insomnia and respiratory disorders (Pourmotabbed et al., 2004; Grauso et al., 2020). Besides to alkaloids, *Papaver* plants had been reported to include various phytochemical components such as anthocyanins (Matysik and Benesz, 1991), flavonoids (Hillenbrand et al., 2004) and essential oils (Dogan and Bagci, 2004).

Any parts of plants have been used for different purposes including food, medicine, cloth, animal feed, fuel and medicine since the ancient times (Dellavalle et al., 2011). Additional to these well-known usage of the plants, different plant extracts have been studied and reported to have beneficial effects on the preservation of different fresh fruits and vegetables (Chen et al., 2019; Moosa et al., 2019; Riva et al., 2020; Poveda, 2020). Plant extracts, including proteins, polysaccharides and essential oils are generally used for the production of edible films or edible coatings and coverage of fruits and vegetables with those materials provide semi-permeable barrier against water vapour and atmospheric gaseous. These in general reduce the transpiration and respiration rates of the crops and helps to delay physical, bio-chemical, physiological and enzymatic degradation (Kahramanoğlu 2017). Such materials have also been reported to enhance the activity of defensive enzymes, such as polyphenol oxidase (PPO) and improves products' resistance to fungal pathogens (Ncama et al., 2019).

Because of these abilities and increasing awareness of consumers about the problems caused by fungicides, the use of different plant extracts in postharvest handling practices had been increased since the 21st century. Postharvest studies with plant extracts are very important especially for the sensitive crops. Apricot (*Prunus armeniaca* L.) fruits are among these sensitive crops. They have been reported to be very beneficial for human health, due to their high phytochemical compounds (Zhou et al., 2020). The main postharvest problems of apricots are rapid rate of softening and sensitivity to mechanical and microbial damages (Siddiq 2006). The optimum temperature for apricot storage is 0±0.5 °C, which on the other hand increase the susceptibility to chilling injury (Liu et al. 2019). In recent years, there have been some studies carried with plant extracts (i.e. *Nigella sativa* oil and *Ailanthus altissima* (Mill.) Swingle) and found to be effective in improving storability of apricot fruits (Kahramanoğlu, 2021; Gürbüz and Kahramanoğlu, 2021). In line with this general information, authors have thought that common poppy might have some advantages in improving the postharvest storability of fruits, but requires scientific verification with experimental studies. It was thought that a success in the usage of its fruits for postharvest handling practices would help to reduce its seed bank in soil by recommending its collection at fruiting period. After a quick search in the published media, authors could not find any information about this topic and have agreed to perform this study with an aim of testing the possibility of using fruit extracts of common poppy (*Papaver rhoeas* L.) for the preservation of apricot fruit quality.

MATERIALS AND METHODS

Materials

Apricot (*P. armeniaca* L.) cv. 'Şalak' fruits were used in present study. This is the most abundant and popular cultivar in Iğdır region. These fruits have low dry content, which makes it unsuitable for drying and very suitable for fresh consumption (Güleryüz et al., 1999). If not stored, the fruits of 'Şalak' cultivar had to be consumed in 3-5 days, due to their rapid loss of visual and nutritional quality (Taze and Unluturk, 2018). The fruits, at horticultural maturity, were collected from an orchard located in Iğdır, Turkey and transferred to laboratory in 2 hours at 1 °C temperature. At the same day, about 1 kg of common poppy (*P. rhoeas* L.) fruits were hand collected from an edge of agricultural land. It was paid attention that no pesticide application was made in the area where the samples were collected.

Experimental Studies

Current studies were conducted with three different treatments. Two of these treatments were the different doses (0.5% and 2.5%) of *P. rhoeas* fruit extracts, while the third one was the control group treated with pure water. Therefore, before the experiments, fruits were grouped into three (# of treatments) and each group was composed of 108 fruits. The fruit extracts of *P. rhoeas* had been prepared by following the formula reported by Gürbüz and Kahramanoğlu (2021). To do so, 25 g of *P. rhoeas* fruit was mixed with 5 L of water and heated until 100 ºC (This is for dose 0.5%; for the other dose 125 g of fruit was used and concentration was equalled to 2.5%) (Figure 1A). To obtain extracts, the temperature was kept for 30 min at that temperature, then filtered through metal strainer (mesh size 35) and cooled to 25 ºC. Thus, the application of the *P. rhoeas* fruit extracts were performed by dipping the fruits into the prepared solutions for 2 min and the fruits were then air dried for 30 min. For the control treatment, the fruits were immersed in a pure water at same temperature with the *P. rhoeas* fruit extracts (25 ºC) for 2 min and same procedure was followed for drying. Hereafter, the 108 fruit of each treatment were randomly divided into 18 groups. These 18 groups were defined as 3 replications * 6 measurement point. The studies were planned to continue for 42 days and the quality measurements were performed with 7-day intervals. The six fruits of each 18 groups were packed in an egg-container. The fruits were stored in storage chambers adjusted at 0.0±0.5 °C with 90-95% relative humidity (Figure 1B).

Figure 1. (A) Preparation of common poppy fruit extracts, (B) storage of fruit samples in chambers and (C) measuring of fruit weight with digital scale.

Physical and Bio-chemical Quality Analysis

Different physical and bio-chemical quality parameters were measured with a 7-day interval. For this reason, 3 replications (an egg-container with 6 fruits) from each treatment were taken out from the storage rooms at the mentioned storage points. First of all, the weight of each fruit was measured with a digital scale (Figure 1C) and compared with the initial weight to calculate the weight loss. Standard ratio method was used for that. Afterwards, decay incidence of the fruits was described by following the method of Cao et al. (2011) and indicated as percentage (%). The visual quality of the fruits was then measured by following the 0-5 scale reported by Kahramanoğlu and Wan (2020). The other important quality parameter, chilling injury, was then determined according to the method of Xue et al. (2012) and the fruits with a score of more than 0.4 was classified as unacceptable for consumption as reported by (Ghasemnezhad et al. (2011). A hand penetrometer was used to measure fruit firmness (kg cm^{-2}). The probe diameter was selected as 5 mm and the penetration speed was 1 mm s^{-1} for the measurements. Then, a hand refractometer was used to measure the soluble solids concentration (SSC) of each fruit (as %). Ascorbic acid (AsA: vitamin C) content of each fruits was then determined by following the standard titrating method with 2,6-dichlorophenol indophenols as mg 100 g^{-1}, and finally the titratable acidity (TA: g 100 g^{-1} malic acid) was determined according to the NaOH titration method.

Statistical Analysis and Figure Preparation

The raw data was firstly cured with Microsoft excel. Means and standard deviations were calculated for each treatment at each measurement point and the suitable figures were then prepared. Besides to that, statistical comparison of the means was performed with the SPSS 22.0 software by conducting analysis of variance and Tukey's HSD test (at $p = 0.05$) consecutively (IBM, 2013).

RESULTS AND DISCUSSION

Effects on Physical Quality Parameters

The first results about the physical quality of apricot fruits suggested that the *P. rhoeas* fruit extracts would be used in postharvest studies. It was found that both doses of the *P. rhoeas* fruit extracts significantly preserved fruit weight (See Figure 2A). During storage, weight loss at the apricot fruits increased continuously, while the weight of the fruits treated with *P. rhoeas* fruit extracts had lower weight loss. The weight losses of the Pr (0.5%) and Pr (2.5%) treated fruits were about 10.00% and 10.01% at the 28th day, where the control fruits had 14.76% weight loss at the same time. At the 42th day of storage, the weight loss of the control fruits was 27.44%, while the fruits treated with two different doses of *P. rhoeas* fruit extracts had a weight loss of 21.66% and 22.00%. The observed findings supported, and *vice versa*, the results of several research (Ncama et al., 2018; Kahramanoğlu 2019; Moosa et al., 2019; Riva et al., 2020) which reported that the plant extracts have high ability to preserve storage quality of different fruits (oranges, strawberry, avocado and apples). Results were also found to be in agreement with the positive effects of plant extracts and to have better performance in preserving the apricot fruits weight. In one of these studies Kahramanoğlu (2021) suggested that the use of *N. sativa* oil and *Glycyrrhiza glabra* syrup help to keep weight loss between 18.37% and 20.82% in 35 days of storage. Results of current study provided better performance than those studies in preventing weight loss, where the weight loss was only around 21.66%-22.00% at the 42th day of storage.

In other recent studies, Nourozi and Sayyari (2020) reported success for basil seed mucilage and Gürbüz and Kahramanoğlu (2021) noted good performance for *A. altissima*. While the current results are better than the results of Kahramanoğlu (2021) with *N. sativa* oil and *Glycyrrhiza glabra*, the results of Gürbüz and Kahramanoğlu (2021) with *A. altissima* are better than current results. Therefore, it can be concluded that the performance of *P. rhoeas* fruit extracts is less than *A. altissima* leaf extract but better than *N. sativa* oil and *Glycyrrhiza glabra*. In a recent study, Gull et al. (2021) reported that nanochitosan emulsion coatings enriched with pomegranate peel extract provided good performance in preventing weight loss, where the weight loss was kept around 18% in 30 days of storage. In our study, the fruit extracts of *P. rhoeas* provided better performance than nanochitosan emulsion coatings and maintained the weight loss around 10% in 30 days of storage. Moreover, Bahadırlı et al. (2020) suggested that the essential oils of myrtle (*Myrtus communis* L.) provide similar performance in preventing weight loss of loquat fruits. Although the test materials are different, overall results and discussion with the existing available information suggests that fruit extracts of *P. rhoeas* have significant impact on the prevention of weight loss at apricot fruits.

Similar to weight loss results, *P. rhoeas* fruit extracts had been observed to prevent decay incidence (See Figure 2B). In this study, no detail research was conducted for the mechanism behind this success, but it was clearly observed that the *P. rhoeas* fruit extracts significantly prevent the decay incidence as compared with control apricots. Although the mechanism was not tested, Poveda (2020) noted that the efficacy of plant extracts in preventing pathogen development can be due to the phytochemicals of plant extracts. Similarly, Gürbüz and Kahramanoğlu (2021) found that *A. altissima* helps to preserve apricots fruits from pathogens. The performance of *P. rhoeas* fruit extracts was found to be better than *A. altissima* leaf extracts in terms of the prevention of the decay incidence.

Similarly Gull et al. (2021) suggested that the nanochitosan emulsion coatings enriched with pomegranate peel extract is effective in reducing the decay percentage of the apricot fruits. The reported success for the coating materials was found to be closely similar with the effects of fruit extracts of *P. rhoeas*. Both fruit weight and decay incidence are important indicators for visual quality. Because, these two are the easiest quality parameters to be observed by the consumers. Therefore, improvement of these two characteristics could attract the consumers and may help to improve the marketability of the stored products. In this regard, the results of current study give a possibility to the *P. rhoeas* fruit extracts to be used in postharvest handling practices.

Therefore, according to the results obtained, the fruits treated with *P. rhoeas* fruit extracts had better visual quality (See Figure 2C). According to the results, the first notable reduction in the visual quality was observed after 21 days of storage. The visual appearance of the fruits 42 days after storage are presented in Figure 3. Hereafter, the quality of control fruits had rapidly decreased while both doses of *P. rhoeas* fruit extracts had prevented this reduction. In a different study, it was also reported that essential oils of myrtle improve visual quality and reduce browning of the loquat fruits (Bahadırlı et al., 2020).

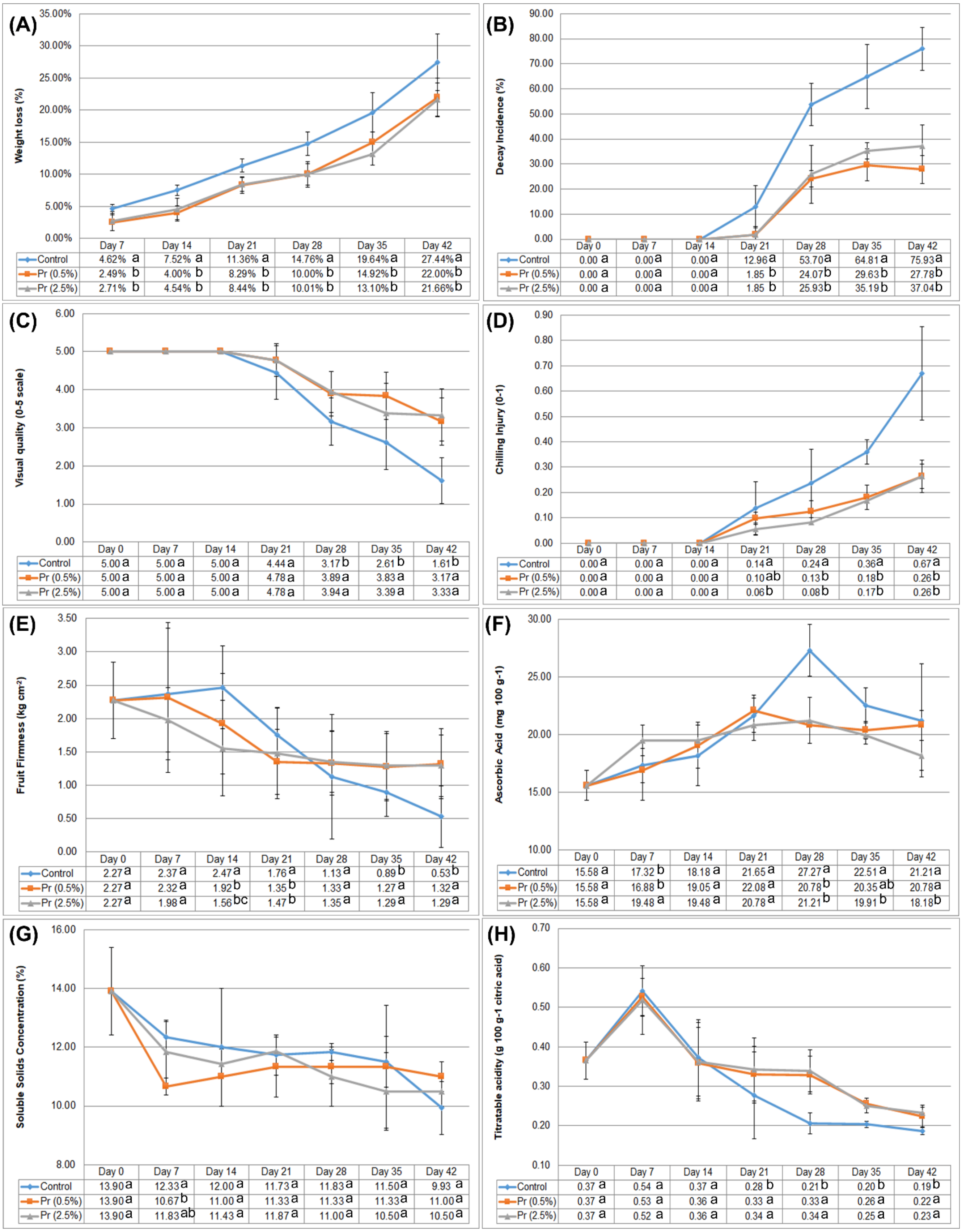

Figure 2. Effects of *P. rhoeas* fruit extracts on the (A) weight loss, (B) decay incidence, (C) visual quality, (D) chilling injury, (E) fruit firmness, (F) ascorbic acid, (G) soluble solids concentration and (H) titratable acidity apricot fruits. Different letters next to the mean values below each figure, at each column, represent significant differences.

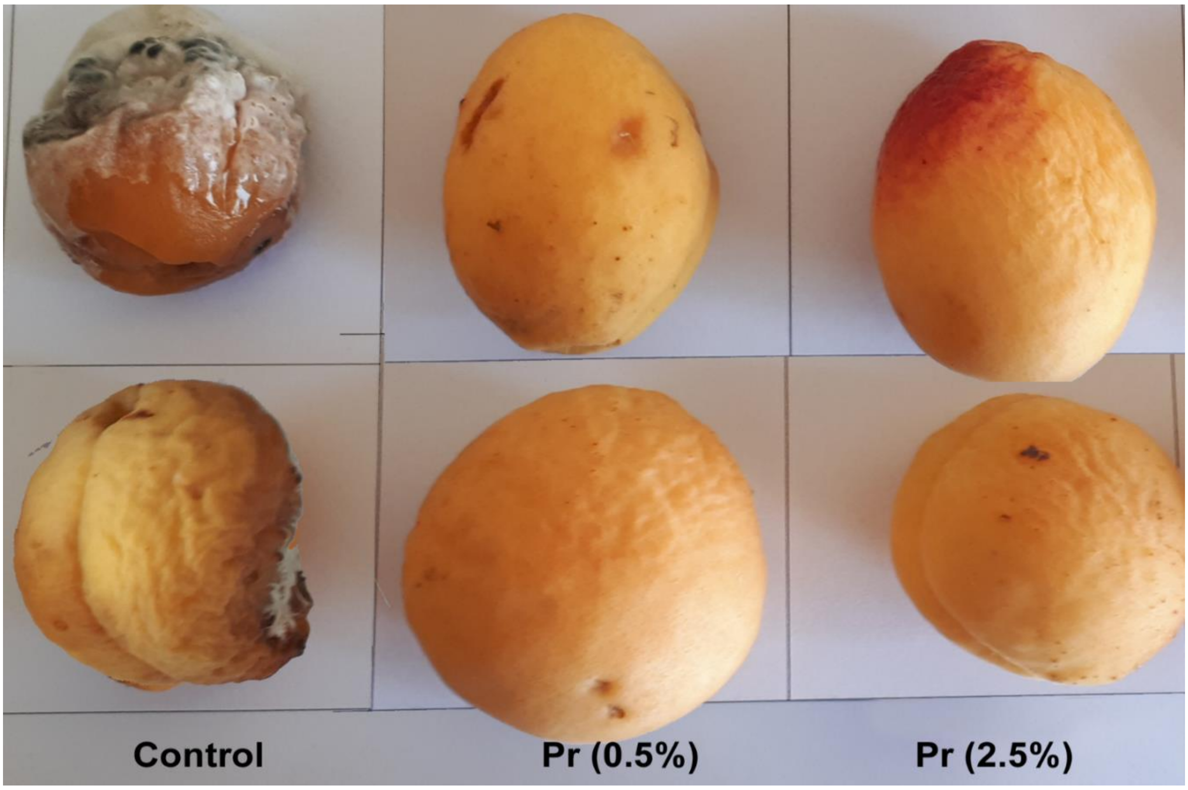

Figure 3. Visual appearance of apricot fruits treated with control, Pr (0.5%) & Pr (2.5%) and stored at 0.0±0.5 °C & 90-95% relative humidity for 42 days.

Chilling injury results had been found to be similar with the visual quality results (See Figure 2D). The fruits treated with *P. rhoeas* fruit extracts were found to have a chilling injury score of less than 0.4 during the whole period of storage. On the other hand, the performance of *P. rhoeas* fruit extracts in preventing chilling injury was noted to be slightly lower than the performance of *A. altissima* leaf extracts reported by Gürbüz and Kahramanoğlu (2021). However is it acceptable, when it was compared with the control group. During storage, the fruit firmness of the apricots stayed same or slightly increased during the first 7-14 days, and then reduced (See Figure 2E). This is in agreement with the findings of Fan et al. (2018). This reduction was higher at the un-treated control fruits and the fruits treated with *P. rhoeas* fruit extracts had higher fruit firmness than the control fruits. Since the mechanism is not well known, and not tested in present study, scientific knowledge suggests that the plant extracts and other edible coatings prevents gas diffusion and reduce respiration rate, which retards the metabolic activity is fruit cells and preserve fruit hardness (Sogvar et al., 2016; Nourozi and Sayyari, 2020). Gürbüz and Kahramanoğlu (2021) also reported moderate performance for *A. altissima* leaf extracts in preventing the loss of fruit firmness. Results of current study suggested that the performance of *P. rhoseas* fruit extracts is better than *A. altissima* leaf extracts, in terms of the prevention of loss in fruit firmness. To sum up the results about physical quality parameters, the *P. rhoeas* fruit extracts are effective in keeping physical quality of apricot fruits. However, because of the fungal infections, an acceptable fruit quality can be preserved for 21-28 days of storage.

Effects on Bio-chemical Quality Parameters

Ascorbic acid values had been found to have some fluctuations during storage (See Figure 2F). It was increased during the first 28 days of storage and then decreased. Here, contrary to the physical quality parameters, fruits treated with the *P. rhoeas* fruit extracts were noted to have lower AsA content.

At the end of the storage period, there was not much difference among the initial and final AsA values and the values between the different treatments (Figure 2G). The initial AsA content was 15.58 mg 100 g^{-1} which increased to 21.21 mg 100 g^{-1} at the 0.5% dose of plant extracts and to 18.18 mg 100 g^{-1} at the 2.5% dose of the *P. rhoeas* fruit extracts. The reports of Nourozi and Sayyari (2020) were in agreement with current study, where the application of *Aloe vera* gel with basil seed mucilage was noted to have slight effect on the AsA content of the apricot fruits. Besides to the AsA, the treatments were also found to have slight/negligible effect on the soluble solids content of the apricots. The initial SSC content was 13.90% at the time of harvest and decreased to 9.93%, 10.50% and 11.00% at the groups of control, 2.5% of *P. rhoeas* fruit extracts, and 0.5% of *P. rhoeas* fruit extracts, respectively. Similarly, Gürbüz and Kahramanoğlu (2021) had noted that the plant extracts do not have significant effect on the preservation of soluble solids content. Finally, the TA content of the apricot fruits had a slight increase and then continuous decrease during storage and the *P. rhoeas* fruit extracts were found to be ineffective for the prevention of this decrease (Figure 2H). Similarly Gull et al. (2021) reported that the TA content of the apricot fruits decrease during storage. This decrease was noted to be in relation with the utilization of organic acids by respiration of the fruits (Valero and Serrano, 2010). The decrease in the SSC and TA is a well-known change in the fruit quality during storage which are associated with the weight loss (respiration) and breakdown of glycoside (Khaliq et al., 2019). So, the slight effect of the *P. rhoeas* fruit extracts can be associated with the reduction of respiration and weight loss at the fruits.

CONCLUSIONS

Overall results of current study suggested that the *P. rhoeas* fruit extracts have moderate to high efficacy in preserving fruits' physical quality; and slight to moderate efficacy in maintaining bio-chemical quality parameters of apricot fruits. Therefore, turning back to the general purpose of this study, it can be concluded that the *P. rhoeas* fruit extracts have possibility in preserving crops storability. Further studies are required mainly about the mechanism behind this success. It is of utmost importance to determine the phytochemical characteristics and may be extract these compounds and test separately. Although no toxic effect on human health was reported for the *P. rhoeas* fruits, it was also known that some plant parts include alkaloids and this might have toxic effects. This is also important to be tested. Final recommendation for this *P. rhoeas* fruit extracts is to test it on different crops.

Conflict of Interest

The article authors declare that there is no conflict of interest between them.

Author's Contributions

The authors declare that they have contributed equally to the article.

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