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This book covers key areas of agricultural sciences. The contributions by the authors include preservation methods, quality of rhizome, sensory quality, danshen, sunflower genotypes, sulphur nutrition, edible oil, intensive cropping with high yielding varieties, mechanization, oil seed production, precision farming, yellow revolution, extension agrometeorology, agro-advisory, climate change, sustainable agricultural productivity, crop growth stages, management practices, soil and water conservation, cropping system, monocropping, artificial intelligence, machine learning, improve soil performance, AI-driven approach management-oriented modelling, digital elevation model, spotted pod borer, webbed flowers, Indian bean, larval population, pomegranate peel extract, postharvest treatments, storage behavior, broad beans, climate-smart agriculture, farmer perceptions, climatic variability. This book contains various materials suitable for students, researchers, and academicians in the fields of agricultural sciences.

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ABSTRACT

Vicia faba L is considered the fourth most important leguminous crop in the world, as it occupies an important place among food security crops in a number of countries. Calcium salts are used to increase the hardness of fruits and to treat many physiological disorders in fruits and resistance to damage. The present study aims to improve the storage ability of beans after treating them before storage with pomegranate peel extract and calcium. After harvesting the crop of broad beans grown in one of the orchards in Al-Hartha region, Basrah, Iraq for the agricultural season 2023-2024, the pods were separated to obtain the seeds by removing the pod, then the seeds were divided into three parts. The first was treated by dipping seeds in pomegranate peel extract at a concentration of 3 ml l⁻¹ for 5 minutes. The second part of the seeds was dipped in calcium at a concentration of 2 ml l⁻¹ for 5 minutes. The last part was dipped in distilled water only for 5 minutes. After drying, seeds were packed in perforated polyethylene bags (8 holes of 5 mm diameter) with an amount of 1 kg per bag and stored at a temperature of 4°C for two weeks. The mean differences were compared using the least significant difference (L.S.D) test at the probability level of 0.05. The experiment was carried out as a factorial experiment using a Complete Randomized Design (CRD) with 3 replicates. The results showed that 2 ml l⁻¹ calcium treatment was the best in reducing the weight loss of seeds and recording the highest percentage of total soluble solids and protein, while the treatment of pomegranate peel extract was superior to the rest of the treatments recorded the highest vitamin C. The results also showed that stored seeds treated by the two mentioned treatments did not record any significant decay

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after two weeks of storage compared to the control treatment. The weight loss of seeds, the percentage of decay, and the total soluble solids increased, while the protein percentage and vitamin C decreased with increasing storage period. The treatment of pomegranate peel extract was superior to the rest treatments in recording the highest vitamin C and the stored seeds dipped in pomegranate peel extract and calcium solution did not record any significant decay after two weeks of storage compared to the control treatment.

Keywords: *Bean seeds; pomegranate peel extract; calcium; weight loss; vitamin C.*

1. INTRODUCTION

Legume crops, a sustainable source of high-protein food, are grown widely throughout the world. Among legumes, faba bean (*Vicia faba* L.), also known as fava bean, broad bean, and horse bean, is one of the oldest crops cultivated worldwide [1]. *Vicia faba* L. is one of the important winter vegetable crops belonging to the *Fabaceae* family, which is grown for its pods or fresh or dry seeds. This ancient world plant may be found across Africa, Europe, and Western Asia. Bean is a rainfed cold season crop that thrives in locations with sufficient rainfall, allowing it to thrive in various nations [1]. It is considered the fourth most important leguminous crop in the world, as it occupies an important place among food security crops in a number of countries. This importance comes as a result of the high protein content of seeds, estimated at 8.4 gm per 100 gm of seeds [2,3]. In addition to being a source of energy and containing a good percentage of crude fiber ranging between 5-8.5%, this has made the crop one of the most important low-cost food sources, especially in poor people, as an alternative to expensive animal proteins. Mainly due to the existence of polyphenolic compounds which provide an antioxidant effect, thus reducing oxidative stress. It is an excellent source of dietary fiber, choline, lecithin, folate, and secondary metabolites such as polyphenols which are described in the below section [4]. The importance of beans is also due to their ability to improve soil properties through their contribution to fixing atmospheric nitrogen through the root nodule bacteria *Rhizobium leguminosarum* [5]. The storage conditions have a significant influence on the sustainability of seed viability [6].

The modern trend in agriculture is to move away from the use of chemical fertilizers, chemical growth regulators, and pesticides due to their toxic effects on human and animal life. Therefore, researchers in agriculture have turned to finding safer materials, such as the use of plant and herbal extracts [7,8,3]. Polyphenols constitute most part of the components of pomegranate peels, which include flavonoids (flavonols, flavanols, and anthocyanins), condensed tannins, proanthocyanidins, and biodegradable tannins, ellagitannins, and gallotannins [9,10]. Calcium salts are used to increase the hardness of fruits and to treat many physiological disorders in fruits and resistance to damage because calcium is involved in the construction of the middle lamina of the cell wall and plays an important role in activating many enzymes, and therefore treatment with

calcium salts plays a major role, especially in the postharvest physiology of fruits [11]. The present study aims to improve the storage ability of beans after treating them before storage with pomegranate peel extract and calcium.

2. MATERIALS AND METHODS

After harvesting the crop of broad beans grown in one of the orchards in Al-Hartha region, Basrah, Iraq for the agricultural season 2023-2024, the pods were separated to obtain the seeds by removing the pod, then the seeds were divided into three parts [3]. The first was treated by dipping seeds in pomegranate peel extract at a concentration of 3 ml l⁻¹ for 5 minutes. The second part of the seeds was dipped in calcium at a concentration of 2 ml l⁻¹ for 5 minutes. The last part was dipped in distilled water only for 5 minutes. After drying, seeds were packed in perforated polyethylene bags (8 holes of 5 mm diameter) with an amount of 1 kg per bag and stored at a temperature of 4°C for two weeks. Tests were conducted on the seeds during the storage periods as the decay and weight loss of seeds were calculated as percentages, Vitamin C (mg / 100 g), and protein were determined according to A.O.A.C. [12]. Total soluble solids were estimated by using a hand refractometer and the results were corrected to 20°C.

The experiment was carried out as a factorial experiment consisting of two factors (treatments× storage periods), using a Complete Randomize Design (CRD) with 3 replicates. The mean differences were compared using the least significant difference (L.S.D) test at the probability level of 0.05 [13,3].

3. RESULTS AND DISCUSSION

3.1 Weight Loss (%)

Table 1 shows the effect of treatment with pomegranate peel extract, calcium, storage period, and their interaction on the weight loss (%) of broad bean seeds stored at 4°C [3]. It is noted from Table 1, that the treatment with 2 ml l⁻¹ calcium is superior to the rest treatments in reducing the weight loss of seeds stored at 4 °C recorded at 0.68%, followed by the treatment with pomegranate peel extract at the concentration of 3 ml l⁻¹, which recorded 0.89%. The highest percentage of weight loss was in the control treatment (distilled water only), which gave 2.23% after two weeks of storage.

The water content of fruits is one of the most important factors affecting the fruit quality during storage because the loss of water leads to reduced turgor pressure of fruit tissues and wilting of fruits [3]. Weight loss of fruits takes place as a result of the loss of stored food caused by vital processes, especially respiration rate, or as a result of the loss of water content due to evaporation of water or both [14]. Results are in constant with Taain et al. [7] as reported that the loss of weight of tomato fruits hybrid Wegdan increased with the increment of storage period and the percentage of weight loss decreased in fruits treated with calcium chloride as compared to untreated fruits.

3.2 Decay (%)

Table 2 shows the effect of treatment with pomegranate peel extract and calcium, the storage period, and the interaction between them on the decay (%) of broad bean seeds stored at 4°C [3]. It is noted from the table that the treatment with pomegranate peel extract 3 ml l⁻¹ and the treatment with calcium 2 ml l⁻¹ were superior to the control treatment due to the two treatments did not record any significant decay after two weeks of storage compared to the control treatment, which recorded 1.21% at the end of the storage period. It is also noted from the same table, the significance of the interaction between the treatments and the storage period in affecting the decay percentage, as it is noted that the highest percentage of decay was in fruits of the control treatment after two weeks of storage, which was 1.63%. During handling and storage, fruits are exposed to damage that can take some forms depending on the reason [3]. It may be the result of mechanical injuries resulting from the pressure of fruits each other inside the package or the damage caused by pathogens infections like bacteria, fungi, and yeasts [14]. Results are in agreement with Fadala *et al.* (2023) who reported that the decay percentage decreased when pepper fruits were treated with calcium salts and stored for two weeks at 10°C.

Table 1. Effect of treatment with pomegranate peel extract, calcium, storage period, and their interaction on weight loss (%) of bean seeds stored at 4°C

Treatments	Storage period (week)		Average treatments
	1	2	
Pomegranate peel extract (3 ml l ⁻¹)	0.56	1.22	0.89
Calcium (2 ml/l ⁻¹)	0.23	1.12	0.68
Control	1.33	3.12	2.23
Average storage period	0.71	1.82	
RLSD 0.05			
Treatment	Storage period	Treatment × Storage period	
0.22	0.78	1.03	

Table 2. Effect of treatment with pomegranate peel extract, calcium, storage period, and their interaction on decay (%) of bean seeds stored at 4°C

Treatments	Storage period (week)		Average treatments
	1	2	
Pomegranate peel extract (3 ml l ⁻¹)	0	0	0
Calcium (2 ml/l ⁻¹)	0	0	0
Control	0.78	1.63	1.21
Average storage period	0.78	1.3	
RLSD 0.05			
Treatment	Storage period	Treatment × Storage period	
0.76	0.22	0.88	

3.3 Total Soluble Solids

It is clear from Table 3 that treatment of broad bean seeds with calcium at a concentration of 2 ml l⁻¹ achieved the highest percentage of total soluble solids, reaching 8.75%, with a significant difference from the rest of treatments, followed by treatment with 3 ml l⁻¹ pomegranate peel extract, while the lowest percentage of total soluble solids was in the control treatment, which recorded 7.1%. It is noted from the table that total soluble solids increased as the storage period continued, reaching 8.3% after two weeks of storage [3].

Regarding the effect of the interaction between treatments and the storage period, the highest percentage of total soluble solids was in the calcium treatment after two weeks of storage, while the lowest percentage of total soluble solids was in the control treatment after a week of storage.

The accumulation of total soluble solids with the increment of storage periods may be due to the decrease of the water content of seeds with the increment of storage periods, leading to an increment of the total soluble solids [11].

The application of post-harvest calcium preserved the dry matter content, as well as the role of calcium in reducing the breakdown of pectic soluble materials, which are a part of the total soluble solids and increases the firmness of cell walls because it is included in the synthesis of calcium pectate [15,16,3].

Table 3. Effect of treatment with pomegranate peel extract, calcium, storage period, and their interaction on total soluble solids of bean seeds stored at 4°C

Treatments	Storage period (week)		Average treatments
	1	2	
Pomegranate peel extract (3 ml l ⁻¹)	7.8	8.2	8
Calcium (2 ml/l ⁻¹)	8.5	9	8.75
Control	6.5	7.7	7.1
Average storage period	7.6	8.3	
RLSD 0.05			
Treatment	Storage period	Treatment × Storage period	
0.22	0.72	1.07	

3.4 Protein (%)

The results of Table 4 indicated that the treatments differed significantly in affecting the percentage of protein in the seeds. The 2 ml l⁻¹ calcium treatment excelled in recording the highest percentage of protein, amounting to 26.19%, followed by the treatment with pomegranate peel extract, while the lowest percentage of protein was in the control treatment, which was recorded. 21.78%.

It is noted from the table that the percentage of protein decreased relatively as the storage period increased until reached 24.03% after two weeks of storage [3]. The effect of the interaction between the treatments and the storage period, was significant, as it is noted that the highest percentage of protein was in the 2 ml l⁻¹ calcium treatment after a week of storage, which amounted to 26.35%, while the lowest percentage of protein was in the control treatment after two weeks of storage, which amounted to 21.42%. The results of the present study are in the same line with Fadala [17] as reported that there was no significant difference between the fruits of pepper-sprayed with pomegranate peel extract and those treated with calcium, and both of them outperformed to control.

The reason for reducing the percentage of protein with the continuation of the storage period may be due to the biological processes that occur within the cells, which lead to the decomposition of protein [18,3].

Table 4. Effect of treatment with pomegranate peel extract, calcium, storage period, and their interaction on protein (%) of bean seeds stored at 4°C

Treatments	Storage period (week)		Average treatments
	1	2	
Pomegranate peel extract (3 ml l ⁻¹)	25.17	24.66	24.92
Calcium (2 ml/l ⁻¹)	26.35	26.02	26.19
Control	22.14	21.42	21.78
Average storage period	24.55	24.03	
RLSD 0.05			
Treatment	Storage period	Treatment × Storage period	
1.25	0.42	3.15	

3.5 Vitamin C (mg 100g⁻¹)

The results of Table 5 showed that the treatment with 3 ml l⁻¹ pomegranate peel extract was superior in recording the highest concentration of vitamin C, which reached 16.55 mg 100g⁻¹, followed by the treatment with 2 ml l⁻¹ calcium. The lowest concentration of vitamin C was in the control treatment, which recorded 11.61 mg 100g⁻¹ [3]. It is noted from the same table that the concentration of vitamin C decreased with increasing storage period until reached 12.70 mg 100g⁻¹ after two weeks of storage. As for the effect of the interaction between the treatments and the storage period, it was significant, as the highest concentration of vitamin C was in the treatment with 3 ml l⁻¹ pomegranate peel extract after a week of storage, which amounted to 17.77 mg 100g⁻¹, while the lowest concentration of vitamin C was in the control treatment after two weeks of storage, which amounted to 9.55 mg 100g⁻¹.

The reason for decreasing vitamin C with the continuation of the storage period may be due to the increment of the activity of ascorbase and oxidase with the continuation of the storage period and the exposure to light which caused the oxidation of vitamin C to dehydro ascorbic acid [18,3,19].

Table 5. Effect of treatment with pomegranate peel extract, calcium, storage period, and their interaction on Vitamin C (mg 100g⁻¹) of bean seeds stored at 4°C

Treatments	Storage period (week)		Average treatments
	1	2	
Pomegranate peel extract (3 ml l ⁻¹)	17.77	15.32	16.55
Calcium (2 ml/l ⁻¹)	15.12	13.22	14.17
Control	13.66	9.55	11.16
Average storage period	15.52	12.70	
RLSD 0.05			
Treatment	Storage period	Treatment × Storage period	
1.98	1.53	5.13	

4. CONCLUSIONS

The results of the study showed that the post-harvest treatments used in the study played a major role in improving the quality characteristics of broad beans during storage, as 2 ml l⁻¹ calcium treatment was the best in reducing the weight loss of seeds and recording the highest percentage of total soluble solids and protein, while the treatment of pomegranate peel extract was superior to the rest treatments in recorded the highest vitamin C and the stored seeds dipped in pomegranate peel extract and calcium solution did not record any significant decay after two weeks of storage compared to the control treatment.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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