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Role of date seed powder in maintaining the quality and nutritional value of the jujube fruits during storage

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ABSTRACT

This study was conducted on jujube fruits at the maturity stage of the Tuffahi and Malasi cultivars, obtained from a private farmer in the Hamdan region, Abu Al-Khaseeb district, South of Basra, on October 5, 2024. The fruits were transferred to the Laboratory of Food Sciences Department, where they were washed with distilled water to remove dirt and dust. Small, damaged fruits were discarded. Then treated with three concentrations of date seed powder (0, 10, and 20) %, after that fruits were packed in 250 g containers, and stored in a refrigerated incubator at 4°C for eight weeks. The results showed that the 20% date seed powder treatment was superior to the other treatments in reducing decay and weight loss, improving flavor, appearance, and increasing the active substances in the fruits. In comparison, the 10% concentration exceeded the other treatments in increasing the percentage of acidity and total soluble solids. Tuffahi CV. outperformed the Malasi one in most of the studied characteristics. Results also showed an increase in the percentages of decay, weight loss, and total soluble solids, with a decrease in the total acidity, as increasing the storage period.

1-Introduction

Ziziphus mauritiana is one of the first edible fruits described in the holy Quran and other holy texts. It is an evergreen fruit tree and a paradise plant in the family Rhamnaceae. It is one of the most well-known genera. The Rhamnaceae is a huge plant family with 55 genera and over 950 species. The genus Ziziphus belongs to the family Rhamnaceae. It has 170 species found in mild temperate, tropical, and subtropical climates worldwide. Cultivated cultivars include Bambawi and Malasi (Z. spina-christi), as well as Zaitoni and Tuffahi (Z. mauritiana). It is a wide variety in Iraq, with cultivation concentrated in the country's center and southern areas [1, 2]. The Sidr tree has recently gained significant attention for its ability to adapt to a wide range of soil types. Sidr agriculture is common in southern and central Iraq, and there are several cost-effective cultivars with high yield and quality, such as the Armouti, Tuffahi, and Red Malasi [3].

Sidr trees are utilized for their therapeutic properties. Previous research has indicated that various Ziziphus species may help regulate liver and intestinal issues, as well as treat skin illnesses. They are also used as antiseptics Sidr fruits also contain many active ingredients such as flavones, fibers, proteins, starches, organic acids, iron, calcium, phosphorus, and vitamins, antiseptic and bactericidal substances. They also contain varying amounts of oil, which is sometimes extracted from the pulp alone, the seeds alone, or the entire fruit. [4, 5]. Fixed oil is a fatty liquid at room temperature and is insoluble in water. Vegetable oils are found in nature from plants, especially fruits, including jujube fruits. Methods for extracting oil from plants have been adopted, and these methods have varied and developed in order to improve yield and extract the largest amount of oil at the lowest cost [6].

Date seeds have a high nutritional value, and an important role in the fields of health and food systems due to their possession of many properties that may lead to improving the functional and sensory qualities and extending the shelf life of foods, given that a large amount of date seeds is produced as waste [7]. Remarkably, date seeds contain relatively high amounts of protein and fat compared to the fruit itself. Protein and fat levels in the seeds were 1.5- 3.0%, while the fruit contained only 0.1-1.4%. Since the seed contains fatty substances in proportions between 8.5-10%, it was found that it is possible to produce distinguished medicinal soap from it by simple chemical treatment, adding some alkali, and then adding some germicides and fungicides, thus making it a good medicinal soap for general use and for treating some skin and scalp diseases [8, 9].

Sidr fruits are often displayed in the markets during the fully ripe stage and their period of staying. The shelf life of fruits in markets is quite short since they have a high respiration rate after harvesting and enter the aging stage quickly, causing them to lose their distinguishing features. The uneven form and tiny size of the fruit have a significant influence on its qualitative qualities, which reduces the producer's profitability [3]. Fruits in refrigerated markets contain live organs that conduct critical tasks such as breathing and others. This is followed by changes in nutritional components and their proportions, which impact the fruits' chemical, physical, and physiological qualities. Fruits inside refrigerated shops undergo a variety of alterations, some of which are pathological, while others are not. Microorganisms such as bacteria, fungi, and yeasts attack fresh fruits via wounds, fissures, and natural holes in the fruit walls, producing different damage and eventually spoiling the stored fruits [10, 11]. The aim of this study the effect of date seed powder treatment on the chemical, physical, and sensory properties of the Tuffahi and Malasi fruits, and to extract some active ingredients from them.

2- Materials and methods

2-1 Sample collection

This study was conducted on ripe jujube fruits of the Tuffahi and Malasi cultivars, which were collected from a private farmer in the Hamdan area, Abu Al-Khaseeb District, south of Basra, on October 5, 2024. The fruits went to the Food Science Department's laboratory, where they were rinsed using distilled water to eliminate dirt and dust. Fruits that were small, ill, and mechanically damaged were removed and treated with three different concentrations of date seed powder (0, 10, and 20%). The fruits were put in 250 g containers and stored in a refrigerated incubator at 4°C for eight weeks.

2-2 Weight loss percent

Measure the weight loss of the fruits as a percentage. Every two weeks for eight weeks, use an electronic scale to calculate the percentage of drop in weight following the equation here:

$$\text{Weight loss} = \frac{\text{Sample weight before storage} - \text{Sample weight after storage}}{\text{Sample weight before storage}} \times 100$$

2-3 Percentage of neutralizable acidity.

The total acidity of jujube fruits was determined using the technique of [12], by mashing 5 gm of fresh fruits for each replicate with 20 ml of distilled water, then mixing them with an electric blender for five minutes, filtering with a piece of gauze, 10 ml of the filtrate was taken, and phenolphthalein was used as an indicator, then neutralized with 0.1 N sodium hydroxide. Until the equilibrium point was attained and the pink color appeared, which remained solid without shaking. The share of total acidity is calculated using citric acid in the fruit juice. The following equation [13]:

$$\text{Total acidity (\%)} = \frac{NaOH \times 0.1 \times 0.064}{\text{weight sample}} \times 100$$

2-4 Total Soluble Solids (TSS) %

The (TSS) of the fruit was calculated according to the method of [14]. This was achieved by clearing the fruit juice (after filtration) on the surface of a table-top refractometer (2WAJ, China-made) by choking 5 g of soft fruit puree per replicate with 5 ml of distilled water, pulling the juice, and applying one or two drops of it. The refractometer's lens was carefully washed and dried after each reading. The tables described in [15] served to alter the readings at 23°C.

2-5 Percentage of damaged fruits (%)

The percentage of damaged fruits infected with pathogens or that have not achieved full maturity is calculated as follows:

$$\text{Damage fruits (\%)} = \frac{\text{weight of damaged fruits per package}}{\text{Total fruit weight per package}} \times 100$$

2-6 Fixed oil extraction

Fixed oil extraction from the fruit flesh was carried out according to the method described by [16]. 100 g of dried and ground jujube fruit was taken and placed in a Soxhlet extraction flask connected to a half-liter receiving flask. 300 ml of petroleum spirit solvent was used. (Distillation range 40.60 ˚C) to separate the oil for a cumulative period of 48 hours, then the solvent was evaporated from the oil using a rotary evaporator at a temperature of 60˚C until the solvent was completely evaporated. The percentage of oil in the fruit flesh was estimated according to what [17] mentioned by applying the following equation:

$$\text{Oil \%} = \frac{\text{Weight of the resulting oil (g)}}{\text{Sample weight (g)}} \times 100$$

2-7 Identification of fixed oil compounds using gas chromatography (GC-MS)

2-7-1 Oil sample preparation for analysis in the GC-MS

The separation and identification of a Sidr fruit oil sample was carried out using the external standard method. This was achieved by comparing the retention time (RT) of the separated compounds on the chromatography

column with the retention time (RT) of the standard compounds for Sidr fruit oil. The fixed oil sample was prepared by adding 1 ml of hexane as a solvent to dilute 1 ml of the resulting oil. 0.1 µl of the sample was then withdrawn after drying and injected using a micropipette into the gas chromatography-mass spectrometry (GC-MS) device under the separation conditions described in Table 1. The active compounds in the fixed oil were identified based on peak heights and compared to the compounds in the separated oil under the same conditions, and based on the retention time (RT).

The active compounds of extracted Sidr fruit flesh oil were identified using gas chromatography coupled with mass spectrometry type GC-MS-QP2010 Ultra, in the laboratories of the College of Agriculture - University of Basra.

2-8 Sensory Evaluation

The fruits were sensory evaluated by a panel of judges to determine the extent of changes in color and flavor, as shown in Table 1. They were divided into:

	80-90% : Very Good	60-70 % :Good	50-60 % : Acceptable	10-40% : Unacceptable
Colour				
Taste				

2-9 Experimental design and analysis

The experiment was done as a factorial experiment using a full randomized design (CRD) and three replicates of each treatment. The first factor was the date seed powder treatment at three concentrations (0, 10, and 20%), the second was two types of jujube fruit (Tuffahi and Malassi), and the third was the storage period, which was divided into four periods (after two weeks, four weeks, six weeks, and eight weeks). Mean differences were determined by the least significant difference (LSD) test with a 5% probability limit [18]. The data was assessed using the Genstate program.

3-Result and Discussion

3-1 Percentage of weight loss

Table 2 shows the effect of date seed powder treatment, variety, storage time, and their interaction on the percentage of weight loss in Sidr fruits of the Tuffahi and Malasi forms kept at 4°C. Treatment with date seed powder has a significant effect on reducing the percentage of weight loss, with the lowest percentage of weight loss being 3.78% for fruits treated with date seed powder at a 20% concentration, and the highest percentage of weight loss being 6.70% for fruits treated with date seed powder at 0% concentration. The low percentage of weight loss might be caused by the fact that putting date seed powder on the peel of fresh fruits reduces weight loss via reduced transpiration, and fruit weight loss is caused by water loss through evaporation and transpiration. Date seed powder serves as a barrier, limiting water flow and keeping the fruit's exterior from impact. It also heals minor wounds, which slows dehydration [19].

In terms of the variety effect, the Malasi variety had the highest percentage of balloon loss, 5.75%, while the Tuffahi variety had the lowest, 4.56%. This might be because of the Tuffahi's thicker peel than the Malasi. The fruit's water content is a significant storage property. Water loss from the fruit happens due to a decrease in turgor pressure, causing the fruit to lose weight and luster, resulting in wilting and shrinking symptoms. It must be maintained throughout the storage facility. According to the chart above, the percentage of weight loss grew as the storage duration increased, with the maximum percentage of weight loss reaching 8.42% after 8 weeks of storage, while the percentage of weight loss was 2.20% after the first and second weeks. Weight loss can occur with extended storage periods

due to biological activity inside the fruit, such as breathing, as well as the loss of water from the fruit's surface via transpiration [20, 21]. This finding is consistent with [22] found that weight loss increases with increasing storage time while storing Sidr fruits at 5°C for 12 weeks, which is consistent with the study findings [23] found that when Sidr fruits were kept at 4°C for 25 days, weight loss increased with the storage period.

In terms of the interaction impact between date seed powder treatment and variety, the fruits of the Tuffahi variety lost the least amount of weight (3.03%) when treated with date seed powder at a 20% concentration, while the fruits of the Malasi variety lost the maximum weight.

The results also revealed a significant interaction effect between date seed powder treatment and storage period, with fruits treated with 20% date seed powder with the lowest weight loss percentage at the end of the 8-week storage period, and fruits treated with 0% date seed powder with the highest weight loss percentage at 11.37%. The Tuffahi variety's fruits lost the least weight (7.81%) at the close of the 8-week storage period, but the Malasi variety lost the most. (9.04%). The fruits of the Tuffahi variety lost a small percentage of weight (5.35%) when treated with date seed powder at a 20% concentration at the end of the 8-week storage period, while the fruits of the Malasi variety lost the most weight (12.44%).

Table 2: The effect of treatment with date seed powder, variety, and storage period on the percentage of weight loss of jujube fruits of the Tuffahi and Malasi varieties and the interaction between them.

concentrations of date seed powder	Variety	storage period(week)					Effect of concentrations of date seed powder and variety
		storage after	2	4	6	8	
0%	Tuffahi	0.00	2.72	4.34	7.43	10.54	6.26
	Malasi	0.00	3.21	5.66	8.95	12.44	7.56
10%	Tuffahi	0.00	1.48	3.39	5.18	7.54	4.40
	Malasi	0.00	2.75	4.29	6.43	8.26	5.43
20%	Tuffahi	0.00	1.04	2.51	3.20	5.35	3.03
	Malasi	0.00	2.23	3.74	4.62	6.43	4.25
							Effect of concentrations of date seed powder
Effect of concentrations of date seed powder and storage period	0%	0.00	2.75	4.80	7.89	11.37	6.70
	10%	0.00	1.99	3.84	5.82	7.84	4.87
	20%	0.00	1.64	3.25	4.21	6.02	3.78
							effect of variety
effect of variety and storage period	Tuffahi	0.00	1.75	3.41	5.27	5.27	4.56
	Malasi	0.00	2.73	4.56	6.66	6.66	5.75
effect of storage period			2.20	3.98	5.97	8.42	

Least significant difference at level 5%						
date seed powder	Variety	storage period	date seed powder and variety	date seed powder and storage period	of variety and storage period	Triple overlap
0.06	0.06	0.07	0.12	0.14	0.14	0.24

3-2 Percentage of total neutralizable acidity

The findings of Table 3 show how date seed powder treatment, cultivar, storage period, and their interaction affect the total soluble acidity % of Tuffahi and Malasi jujube fruit kept at 4°C. The date seed powder treatment had a substantial impact on maintaining the total soluble acidity percentage, as the highest TSO percentage was at a concentration of 20% (1.24%), while the lowest TSO percentage was 0.90% in the control treatment. As for the cultivar effect, the highest TSO value was 1.07% for Malasi jujube fruit, while Tuffahi jujube fruit yielded the lowest TSO percentage, reaching 0.92%. The higher TSO value for Malasi jujube fruit may be due to its sour flavor compared to the sweet flavor of Tuffahi jujube fruit.

The table additionally shows the value of storage time for calculating total neutralizable acidity. The percentage of total neutralizable acidity fell with storage time at 4°C, reaching a low of 0.52% after 8 weeks, as opposed to the greatest amount of total acidity at the start of storage (1.46%). A drop in the general acidity content of the fruit due to longer storage might be explained by the fact that it can be absorbed via respiration or converted into sugars [24]. The reason could also be attributed to the decrease in total neutralizing acidity percentage with continuous storage as a result of physiological and chemical changes that occur within the fruits, or to the fruits' advanced ripening until they reach the stage of maturity and transformation into sugars, where they become suitable for consumption, or to their consumption by the respiration process [25, 24]. It is in line with those of [22]. Tembo et al. (2008) discovered that after 12 weeks of storage at 5°C, the acidity percentage of Sidr fruits fell. It is consistent with what was found in [26]. According to Sahalah (2015), the total neutralizing acidity percentage of Sidr fruits reduced as their storage time grew when stored at 5°C for 5 weeks, which is in line with findings by [27]. Zeraatgar et al. (2018) found that the acidity percentage of Sidr fruits decreased with storage time, with the fruits kept for 30 days.

The interplay of date seed powder treatment and cultivar had a substantial impact on total neutralizable acidity. The Malasi cultivar treated with 20% date seed powder surpassed the Tuffahi cultivar, with a total acidity of 1.41%, whereas the Tuffahi cultivar treated with 0% date seed powder had the lowest total acidity at 0.80%. The study also found a significant relationship between date seed powder treatment and storage length. After eight weeks of storage, the fruits treated with 20% date seed powder had the greatest total neutralizable acidity of 0.75%. After 8 weeks of storage, the control-treated fruit had the lowest total acidity (0.48%).

The Malasi variety has a strong interaction with the duration of storage at a 5% level. After the eighth week of storage, its greatest percentage of total acidity was 0.63%, while the Taffahi variety had the lowest percentage of total acidity at the end of storage. The table shows how the three variables (date seed powder treatment, variety, and storage time) interact to affect the total neutralizable acidity %. The highest acidity percentage. After 8 weeks of storage, the Malasi variety fruits treated with date seed powder at a 20% concentration have a high acidity percentage (0.76%), but the apple type fruits treated with date seed powder at a concentration of 0%.

Table 3: The effect of treatment with date seed powder, variety, and storage period on the fruits of the Tuffahi and Malasi varieties of Sidr in terms of the total neutralizable acidity and the interaction between them.

concentrations of date seed powder	Variety	storage period(week)					effect of concentrations of date seed powder and variety
		storage after	2	4	6	8	
0%	Tuffahi	1.80	1.17	0.89	0.68	0.46	0.80
	Malasi	1.80	1.28	1.03	0.71	0.50	0.88
10%	Tuffahi	1.80	1.33	1.06	0.73	0.46	0.89
	Malasi	1.80	1.57	1.18	0.97	0.64	1.09
20%	Tuffahi	1.80	1.46	1.28	0.90	0.60	1.06
	Malasi	1.80	1.78	1.36	1.13	0.76	1.26
							effect of concentrations of date seed powder
effect of concentrations of date seed powder and storage period	0%	1.80	1.32	1.05	0.75	0.48	0.90
	10%	1.80	1.56	1.21	0.91	0.61	1.07
	20%	1.80	1.73	1.40	1.09	0.75	1.24
							effect of variety
effect of variety and storage period	Tuffahi	1.80	1.32	1.07	0.77	0.51	0.92
	Malasi	1.80	1.54	1.19	0.93	0.63	1.07
effect of storage period		1.80	1.46	1.15	0.87	0.52	

Least significant difference at level 5%						
date seed powder	Variety	storage period	date seed powder and variety	date seed powder and storage period	of variety and storage period	Triple overlap
0.01	0.01	0.01	0.02	0.02	0.02	0.04

3-3 Total Soluble Solids % (TSS)

Table 4 shows the influence of date seed powder treatment, variety, storage duration, and their interaction on the percentage of total dissolved solids in Sidr fruits of the Tuffahi and Malasi kinds when kept at 4°C. It should be noted that treatment with date seed the lowest percentage of total dissolved solids, which was 15.19% for fruits treated with date seed powder at a 20% concentration, while the highest percentage was 16.86% for fruits treated with date seed powder at a 0% concentration.

The cultivar had a substantial influence on lowering total soluble solids, with the Tuffahi cultivar having the lowest percentage at 14.19% and the Malasi cultivar having the greatest at 16.83%. This might be because the Tuffahi cultivar loses less water content in its fruits than the Malasi variety. It might also be related to the decreased proportion of fruit juice and fruit with a low moisture content [24].

The storage duration had a beneficial effect. According to the findings above, the percentage of solids rose with storage time, peaking at 18.33% after 8 weeks and dropping to 12.87% following the first and second weeks. This may be because total soluble solids increase as fruit water content falls. This might be because the solids in ripening fruits increase as they hit the final stages of maturity [28]. Sidr fruits are also known as chlamydial fruits, which acquire total soluble solids as they grow. The ripening process is followed by a series of swift chemical changes, mainly enzyme-controlled activities that result in a rise in the sugar content of the fruits, defined by their soluble solid content. It lies in line with [29, 30]. These results are similar to those of [26]Sahalah (2015), who found that when Sidr fruits were left at 5°C for 5 weeks, the ratio of total soluble solids in the fruits grew with time. They also support the findings of [23]. When sidr fruits were kept at 4°C for 25 days, the percentage of total dissolved solids in the fruits grew with the length of storage, similar to what Zeraatgar et al. (2018) saw when sidr fruits were held for 30 days. For the interaction with the date seed powder treatment and variety, the fruits of the Tuffahi variety treated with 10% date seed powder had the lowest percentage of solids (14.14%), which did not vary significantly from the fruits of the Tuffahi variety treated with 20% date seed powder (14.18%), the Sidr fruits of the Tuffahi variety treated with 0% date seed powder had the highest percentage of solids (18.50%).

The table also shows the effect of interaction between date seed powder treatment and storage period, with the lowest percentage of total soluble solids attracting 17.69% for Sidr fruits treated with 20% date seed powder after 8 weeks of storage and the highest percent of solids reaching 18.91% for Sidr fruits treated with 0% date seed powder at the end of the storage period, which did not differ significantly from fruits treated with 10% date.

After eight weeks of storage, the Tuffahi variety of sidr fruits had the lowest proportion of solids, reaching 16.34%. At the conclusion of the storage time, the Malasi variety had the highest solids percentage, at 20.20%. The findings also showed the impact of the interaction of three variables: date, seed powder treatment, cultivar, and storage length. At the conclusion of the 8-week storage period, seed Tuffahi variety of sidr fruits treated with 20% date seed powder had the lowest percentage of solids at 16.13%, which did not vary substantially from the Tuffahi variety of sidr fruits treated with 10%. Meanwhile, at the conclusion of the storage period, the Malasi

variety of sidr fruits treated with 20% date seed powder had the greatest percentage of solids (20.32%), which was not substantially different from the Malasi variety of sidr fruits treated with 10%.

Table 4: The effect of treatment with date seed powder, variety, and storage period on the fruits of the Taffahi and Malasi varieties of Sidr in terms of the percentage of total soluble solids and the interaction between them.

concentrations of date seed powder	Variety	storage period(week)					Effect of concentrations of date seed powder and variety
		storage after	2	4	6	8	
0%	Tuffahi		12.02	12.18	16.02	16.75	18.50
	Malasi		12.08	16.00	16.30	20.04	16.10
10%	Tuffahi		12.13	12.26	16.05	16.13	14.14
	Malasi		12.25	16.06	16.25	20.25	16.20
20%	Tuffahi		12.25	12.32	16.03	16.13	14.18
	Malasi		16.08	16.18	20.20	20.32	18.19
							effect of concentrations of date seed powder
effect of concentrations of date seed powder and storage period	0%		14.88	16.16	17.50	18.91	16.86
	10%		12.20	15.54	17.48	18.90	16.03
	20%		12.11	14.78	16.18	17.69	15.19
							effect of variety
effect of variety and storage period	Tuffahi		12.13	12.25	16.03	16.34	14.19
	Malasi		13.47	16.08	17.58	20.20	16.83
effect of storage period		12.87	14.53	16.87	18.33		

Least significant difference at level 5%						
date seed powder	Variety	storage period	date seed powder and variety	date seed powder and storage period	of variety and storage period	Triple overlap
0.09	0.09	0.10	0.15	0.18	0.18	0.31

3-4 Percentage of damaged fruits (%)

Table 5 depicts how date seed powder treatment, variety, storage length, and their interaction influence the percentage of total damage to Sidr fruits. It is worth noting that treatment with date seed powder at a 20% concentration significantly decreased the percentage of total damage, with the lowest percentage of damage being 6.33% and the greatest proportion of total damage being 24.33% for the fruits in the comparison treatment. In terms of variety impact, it was discovered that the fruits of the Tuffahi variety had the lowest percentage of overall spoilage at 8.06%, which was much lower than the Malasi variety, while the Malasi variety had the greatest percentage of total spoilage at 21.72%. The Tuffahi cultivar's fruits may have a lower rate of spoiling owing to their larger storage capacity and thicker skin than the Malasi type. Using natural components in fruit dips, such as Cordea myxa extract, may reduce gas permeability and enzyme assault, inhibiting the development of spoilage microorganisms, including bacteria and fungi [31].

The storage period had a clear impact, as shown in the table above, with the highest total damage percentage reaching 38.90% for Sidr fruits after 8 weeks of storage, and a 3.82% damage ratio at the first and second weeks. This might be tied to the fast ripening process and the existence of some fungi [32]. For the interaction between date seed powder treatment and variety, results show that the fruits of the Tuffahi variety treated with date seed powder at a concentration of 20% reduced the total damage rate by 4.08%, while the fruits of the Malasi variety treated with date seed powder at a concentration of 0% had the highest damage rate (37.25%).

The results showed a significant interaction between date seed powder treatment and storage duration, with fruits treated with 20%

date seed powder at the end of an 8-week storage period displaying the lowest percentage of damage (15.22%). After 8 weeks of storage, fruits treated with 0% date seed powder showed the highest percentage of general harm (51.22%). The mix between variety and storage length had an important impact on the overall damage percentage, with fruit having the lowest percentage of damaged fruits at the finish of the 8-week storage period, and Malasi having the highest number of damaged fruits. The interaction impact of all three factors was significant, as the fruits of the Tuffahi variety treated with 2% date seed powder at the conclusion of the 8-week storage period had the lowest percentage of overall damage. (11.67%). For an 8-week storage period, the Malasi variety's fruits treated with 0% date seed powder had the largest percentage of all damage (75.00%).

Table 5: The effect of concentrations of date seed powder, variety, and storage period on the percentage of spoilage of Sidr fruits and the interaction between them

concentrations of date seed powder	Variety	storage period(week)					effect of concentrations of date seed powder and variety
		storage after	2	4	6	8	
0%	Tuffahi	0.00	3.33	5.67	12.67	35.33	14.25
	Malasi	0.00	10.67	25.00	38.33	75.00	37.25
10%	Tuffahi	0.00	0.33	2.00	5.67	15.33	5.83
	Malasi	0.00	5.33	11.67	21.67	46.67	21.33
20%	Tuffahi	0.00	0.33	1.33	3.00	11.67	4.08
	Malasi	0.00	3.33	5.67	5.67	12.67	6.58
							effect of concentrations of date seed powder
effect of concentrations of date seed powder and storage period	0%	0.00	6.56	14.33	25.22	51.22	24.33
	10%	0.00	2.67	6.33	13.78	32.89	13.92
	20%	0.00	1.67	3.44	5.00	15.22	6.33
							effect of variety
effect of variety and storage period	Tuffahi	0.00	1.33	3.00	7.11	32.89	8.06
	Malasi	0.00	6.44	14.11	21.56	15.22	21.72
effect of storage period			3.82	8.41	14.52	38.90	
Least significant difference at level 5%							
date seed powder	Variety	storage period	date seed powder and variety		date seed powder and storage period	of variety and storage period	Triple overlap
0.79	0.79	0.90	1.43		1.65	1.65	2.86

3-5 Active Compounds in Sidr Fruit Oil

The results of Tables (٦ and ٧) for the GC-MS mass spectrometry analysis of Sidr fruit oil from the Tuffah and Malasi varieties, respectively, indicate that the compound Methyl 11,14-octadecadienoate was superior, obtaining the highest relative surface area, reaching 57.47% and 57.45% for the Tuffah and Malasi varieties, respectively, compared to the lowest relative surface area for the compounds 9-Octadecenoic acid (Z)-, 2-hydroxy-3 and Heptacosane, 1-chloro-, which obtained the same relative surface area, reaching 0.03% and 0.04% for the Tuffah and Malasi varieties, respectively. A significant increase in some of the active compounds in the oil was observed for the Tuffahi variety compared to the Malasi variety, with the number of active compounds reaching 10 for both varieties.

Table 6: The relative area of the active compounds of the oil of the jujube fruit, Tuffahi variety, identified by GC-MS mass spectrometry technique.

Peak	R-Time	Area	Area%	Names of identified vehicles
1	11.463	76071	0.19	Tetracontane-1, 40-diol.

2	11.705	129102	0.33	.beta.-D-Mannofuranose, 2,3:5,6-di-O-ethylboranediyl-1-O-(1H,1H-pentadecafluoroocty
3	11.797	169909	0.34	11-Octadecenoic acid, methyl ester
4	13.402	913343	2.29	Hexadecanoic acid, 15-methyl-, methyl ester
5	13.984	15326	0.0٥	Heptacosane, 1-chloro-
6	15.467	22571564	57.47	Methyl 11,14-octadecadienoate
7	15.308	15234384	38.81	9-Octadecenoic acid (Z)-, methyl ester
8	15.469	141642	0.28	Hexanoic acid, 3-ethyl-, methyl ester
9	15.804	20530	0.04	Octadecanoic acid, 2-[(1-oxotetradecyl)oxy]-1,3-propanediyl ester
10	18.972	16988	0.03	9-Octadecenoic acid (Z)-, 2-hydroxy-3-[(1-oxohexadecyl)oxy]propyl ester
		39288859	100.00	

Table 7: The relative area of the active compounds of the oil of the jujube fruit of the Malasi variety, identified by the GC-MS mass spectrometry technique.

Peak	R-Time	Area	Area%	Names of identified vehicles
1	11.443	76061	0.17	Tetracontane-1, 40 -diol.
2	11.678	128603	0.30	.beta.-D-Mannofuranose, 2,3:5,6-di-O-ethylboranediyl-1-O-(1H,1H-pentadecafluoroocty
3	11.785	169853	0. 39	11-Octadecenoic acid, methyl ester
4	13.328	913203	2.25	Hexadecanoic acid, 15-methyl-, methyl ester
5	13.963	15206	0.04	Heptacosane, 1-chloro-
6	15.221	22571463	57.45	Methyl 11,14-octadecadienoate
7	15.223	15234384	38.78	9-Octadecenoic acid (Z)-, methyl ester
8	15.423	141642	0.36	Hexanoic acid, 3-ethyl-, methyl ester
9	15.750	20521	0.05	Octadecanoic acid, 2-[(1-oxotetradecyl)oxy]-1,3-propanediyl ester
10	18.954	17000	0.04	9-Octadecenoic acid (Z)-, 2-hydroxy-3-[(1-oxohexadecyl)oxy]propyl ester
		39288871	100.00	

3-6 Sensory qualities

Table 8 shows the effect of treatment with date seed powder, variety, and storage period on the sensory characteristics of the Taffahi and Malasi jujube fruits. Regarding the fruits of the Tuffahi variety treated with date stone powder after 8 weeks of storage, the arbitrators gave a percentage of 5% very good, 10% good, 30% acceptable, and 55% unacceptable. The arbitrators gave the Malasi variety fruits treated with date seed powder 2% very good, 3% good, 35% acceptable, and 60% unacceptable.

The arbitrators gave the comparison treatment fruits, date seed powder packed in plastic boxes, 35% very good, 2% good, 35% acceptable, and 60% unacceptable. As for the fruits of the apple variety treated with 10% date seed powder at an 8-week storage period, the arbitrators gave a 10% very high percentage., 65% good, 15% acceptable, and 10% unacceptable. The judges gave the Malasi variety fruits treated with 10% date seed powder a rating of 5% as very good, 50% as good, 25% as acceptable, and 20% as unacceptable. The judges gave the Tuffahi variety fruits treated with 10% date seed powder a rating of 7% as very good, 55% as good, 23% as acceptable, and 17% as unacceptable. While the Tuffahi variety fruits treated with 20% date seed powder at the end of the 8-week storage period were rated 15% as very good, 60% as good, 20% as acceptable, and 5% as unacceptable, the judges gave the Malasi variety fruits treated with 20% date seed powder 10% as very good, 55% as good, 25% as acceptable, and 10% as unacceptable. The

judges gave the Tuffahi variety fruits treated with 20% date seed powder 12% as very good, 58% as good, 23% as acceptable, and 7% as unacceptable. It was noted that the treatment with date seed powder gave the highest percentage in terms of sensory characteristics, because the date seed powder delayed the ripening of the fruits and thus preserved the quality characteristics in terms of color, taste, and flavor compared to the comparison treatment.

The color and flavor of the fruits change during storage as a result of an increase in biological respiration, transpiration, and enzymes such as polyphenol oxidase, which oxidizes phenolic materials and the blackening them, and chlorophyllase, which breaks down chlorophyll pigments to alter their color [33]. This reflects the findings of [23] found that Sidr fruits changed color after being stored at 5°C for 12 days. It also aligns with [34] observed that the color of Sidr fruits altered throughout the 20-day storage period. It is congruent with the findings of [35], who noticed a change in the color and taste of Sidr fruits throughout a 15-day storage period.

Table 8: The effect of treatment with date seed powder, variety, and storage period on the sensory characteristics of the Taffahi and Malasi jujube fruits

concentrations of date seed powder	Variety	End of storage period (8 weeks)				
		excellent	very good	Good	acceptable	Unacceptable
0%	Tuffahi	0%	5%	10%	30%	55%
	Malasi	0%	2%	3%	35%	60%
10%	Tuffahi	0%	10%	65%	15%	10%
	Malasi	0%	5%	50%	25%	20%
20%	Tuffahi	0%	15%	60%	20%	5%
	Malasi	0%	10%	55%	25%	10%

4- Conclusion

The treatment with 20% date seed powder was superior to other treatments in reducing spoilage and weight loss, improving flavor and appearance, and increasing the fruit's bioactive compounds. The 10% date seed powder treatment outperformed other treatments in increasing acidity and total soluble solids. The Tuffahi variety outperformed the Malasi variety in most of the studied characteristics. Increased spoilage, weight loss, and total soluble solids, along with a decrease in total acidity, were observed with increasing storage time. Additionally, it was noted that the tuffahi was more resistant to marketing processes than the amlasy due to having a firm texture and a thick outer skin.

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Conflict of interest

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Consent to participate

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