FACTORS AFFECTING PRODUCT QUALITY DURING FRESH STORAGE OF JUJUBE (ZIZIPHUS JUJUBA MILL.)

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Abstract: In this study, to determine the optimal conditions for storing jujube (*Ziziphus jujuba Mill.*) fruits fresh, work was carried out to assess various storage temperatures and periods. Three levels of storage temperature were studied - low (5°C), medium (15°C), and room temperature (22°C), as well as at 3, 6, 9, and 12-week storage periods. Also, work was carried out to determine the quality indicators of the product, the amount of vitamin C, soluble sugars, the amount of shriveled and natural loss of fruits, and necessary recommendations were given for production enterprises.

Keywords: Jujube, fresh fruit, storage conditions, shelf life, shriveled fruit, vitamin C and sugars

Introduction. The high content of minerals and vitamins in jujube fruits helps consumers maintains a healthy lifestyle. Usually, fruits are consumed in various ways: fresh, dried, as a natural infusion, juice, or in the form of various confectionery products. In the conditions of Uzbekistan, jujube fruits are consumed almost in a dried and sugared state, however, according to the analysis of the studied literature, in many developed countries, the consumption of fresh fruits is becoming fashionable, which is explained by the high content of natural components such as carbohydrates and vitamins in the composition of these fresh fruits.

Fresh fruits of celery spoil quickly and cannot be stored at home for more than 10 days without serious spoilage [1]. However, in India, some improved varieties have been reported to last up to 15 days without losing their organoleptic quality [3]. It has been found that high temperatures increase water loss from fruits, resulting in fruit shrinkage and loss of fresh appearance [4]. Temperature control is one of the most important means of extending the shelf life of fruits. Storing fresh fruits at 4-10 °C extends their shelf life to 33 days [5].

The use of a refrigerator for storing fresh and dried fruits can ensure its availability throughout the year [6]. It has been noted that vitamin C in fruits and vegetables is affected by temperature and shelf life [2]. While wild jujube fruits contain 26-27% carbohydrates, fruits of cultivated varieties contain up to 33% carbohydrates. Vitamin C is found in small-fruited jujube varieties up to 880 mg%, and in cultivated varieties up to 680 mg%. In terms of vitamin C content (200-1725 mg%), the fruits of jujube are superior to lemons, apricots, and black currants. Another important aspect is the preservation of vitamin C content up to 80% during processing [8].

In our republic, insufficient scientific research has been conducted on the development of technologies for storing jujube fruits in fresh form, analyzing the biochemical composition, physical properties, and edible value of jujube fruits after storage [7]. Therefore, it is important to conduct scientific and practical work on the development of technological elements for preserving jujube fruits.

Experimental materials and methods. The research was conducted in 2024 in the laboratory "Storage and Processing of Agricultural Products" of the Tashkent State Agrarian University and the refrigerated warehouses of "OLMOS-LLC" in the Parkent district. Selected fruits of jujube varieties grown in the educational and scientific experimental farm of the university were used.

In the experiment, fruits were weighed before and after each storage period, and the natural loss of fruits was determined by the arithmetic mean. Also, at the end of each storage period, it was noted that the fruits had a poor-quality appearance (wrinkled), darkened, and were infested with insects. The experiments were conducted at three storage temperatures - room temperature (22°C), medium temperature (15°C), and low temperature (5°C) in refrigeration chambers with four storage periods (3, 6, 9, and 12 weeks). Samples were selected from each batch of fruits collected from trees of the same vegetation by random sampling of 100 fruits in three repeated cases. All experiments were carried out within 24 hours after harvesting and before placing the fruits in storage.

In the experiment, vitamin C was determined by the titrimetric method with 2,6-dichlorophenolindophenol, recommended by Egan et al. (1987); titratable acidity - by the titrimetric method using sodium hydroxide; carbohydrate content - by the Fehling method (Egan et al., 1987) and the "Agilent 1100" liquid chromatograph (USA).

Results and discussion of the experiment. The high-water content in the incompletely ripened (fresh) fruits of jujube leads to an accelerated water loss process. Therefore, it is impossible to store them for a long time under normal conditions. In the experiment, a noticeable difference was observed between the temperature and storage periods of fruits. Storage at low temperatures in a cold storage significantly reduced the weight loss of fresh jujube fruits by 27% during the 12-week storage period (Fig. 1).

In the first 3 weeks of storage, the highest natural losses in all variants compared to other periods were recorded at 5,10 and 12 percent respectively, and partial changes in the quality indicators of fruits were observed, which is explained by the fact that fruits breathe rapidly at the time of fresh harvest due to the high sensitivity of environmental factors.

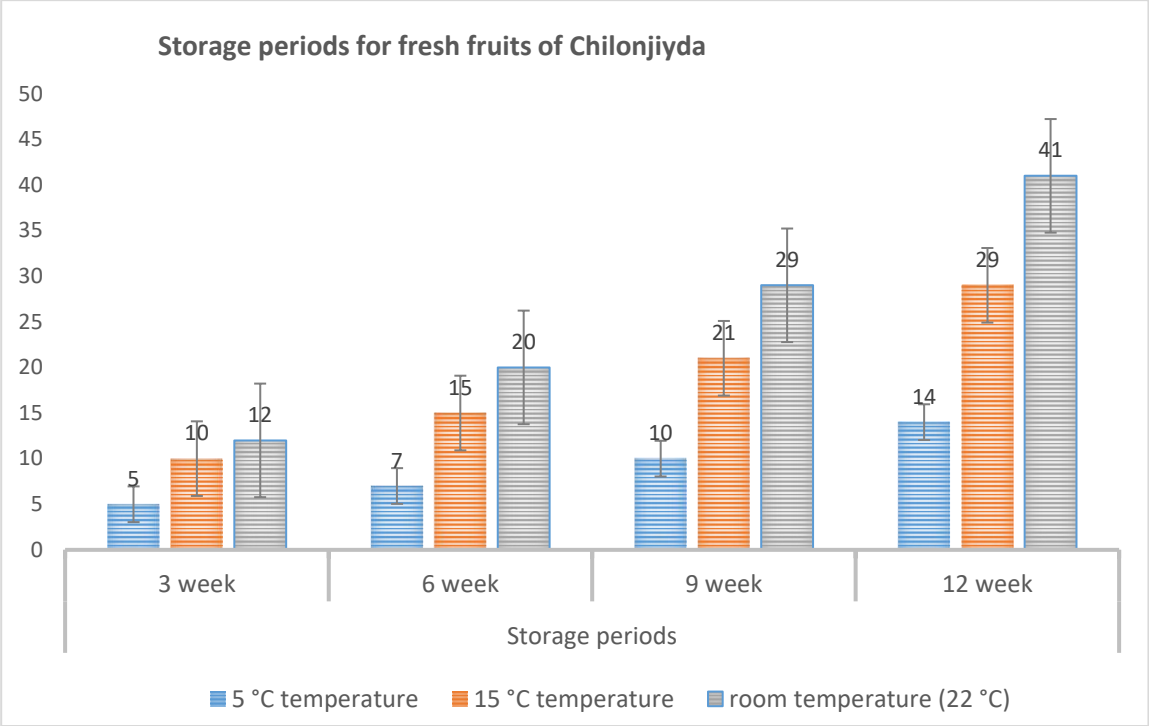

Figure 1. *Influence of storage temperature and duration on the amount of natural loss of jujube fruits.*

In the subsequent 6 weeks of storage, the amount of natural loss in the fruits gradually decreased and showed the smallest amount of natural loss compared to all variants, which is explained by the increased adaptability of the fruits to external stresses. Compared to the initial 3-week storage period, a natural decrease of 2% was observed at a temperature of 5°C, 5% at a temperature of 15°C, and at a room temperature of 22°C, a natural decrease of 8% was observed, which amounted to 7.15 and 20%, respectively.

During the 9th week of storage, a gradual increase in natural weight loss was observed across all variants: 7-10% at a low temperature of 5°C, 15-21% at a moderate temperature of 15°C, and 20-29% at room temperature of 22°C. As a result of the accelerated metabolic processes in the fruits, their tissues progressively softened.

At the 12th week of storage, signs of quality deterioration became evident in the external appearance of the fruits. Notably, fruit shriveling, darkening of color to a deep brown, and changes in fruit shape were observed. Therefore, the amount of natural loss of chilonjiyda fruits stored in a refrigerator at a temperature below 5°C was 14%, which can be designated as a critical point of natural loss. During this period, a natural decrease of 29% is observed when stored in refrigerated conditions at an average temperature of 15°C, and 41% when kept at room temperature (22°C). This indicates that the fruits are no longer suitable for consumption in their prime condition. However, these fruits can still be used as second-grade raw materials for processing enterprises.

According to the analysis results, the highest vitamin C content in premium chilonjiyda fruits was observed in the "Shi-yang-zao" and "Ta-yan-zao" varieties, both containing 498 mg. The "Ji-shin-zao," "Jun-zao," and "Tang-zao" varieties contained 488, 430, and 403 mg/% respectively. The remaining varieties, "Zanhuang-da-zao," "Dong-zao," "Linyu-li-zao," "Dabai-

ling-zao," and "Maya-bayi-zao," showed lower levels, recording 325, 293, 292, 280, and 259 mg/% respectively (Figure 2).

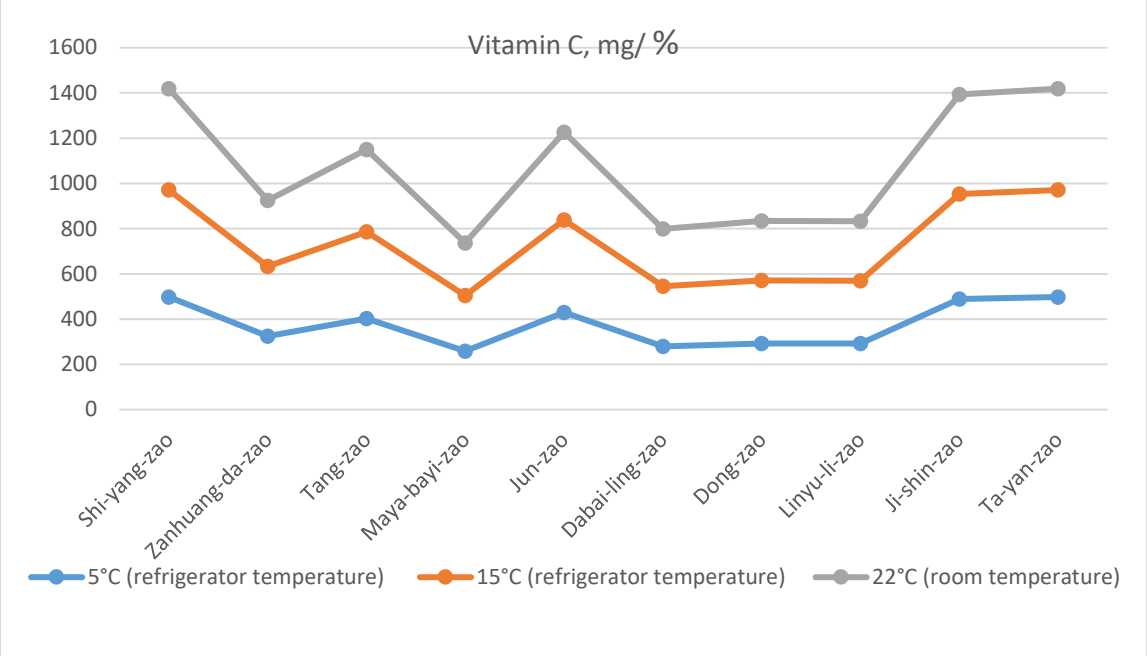

Figure 2. *Content of vitamin C in the fruits of jujube, by variety*

It was determined that all varieties grown in the conditions of Tashkent region contain vitamin C in the range of 259-498 mg/%. These experiments were conducted under artificially cooled refrigeration conditions at 5,15 and 22°C (room temperature). As the overall storage temperatures increased and storage duration extended, the vitamin C content in the fruit gradually decreased.

One of the main quality indicators of fruits is the amount of regenerated sugars. According to it, at a temperature of 5°C in refrigerated conditions, the varieties "Linyu-li-zao" showed high sugar content with 19%, "Shi-yang-zao" and "Jun-zao" - 18%, "Zanxuang-da-zao," "Tang-zao," "Dong-zao" and "Ji-shin-zao" - 16%. The varieties "Maya-bayi-zao" - 14%, "Ta-yan-szao" - 13%, and "Dabay-ling-zao" have a lower sugar content compared to other varieties. These indicators were determined for varieties of fruits suitable for storage, i.e., underripe fruits (Fig. 3). During the ripening period, when the fruits were harvested for drying, the sugar content was somewhat higher.

In jujube fruits stored in cold storage at a temperature of 15°C, the sugar content in the varieties "Ta-yan-tsao" and "Linyu-li-zao" was recorded at 13.7-19.9%. An increase in sugar content within the range of 1-2% was observed compared to fruits stored in an average cold storage at a temperature of 5°C.

In fruits stored at 22°C (room temperature), the lowest indicator was 14.9% in the "Ta-yan-szao" variety, and the highest in the "Linyu-li-zao" variety averaged 21.9%. As the storage temperature increased, the sugar content in the fruits also increased. The main reason for this is the breakdown of substances such as starch, pectin, and acids in fruits and their conversion into other compounds.

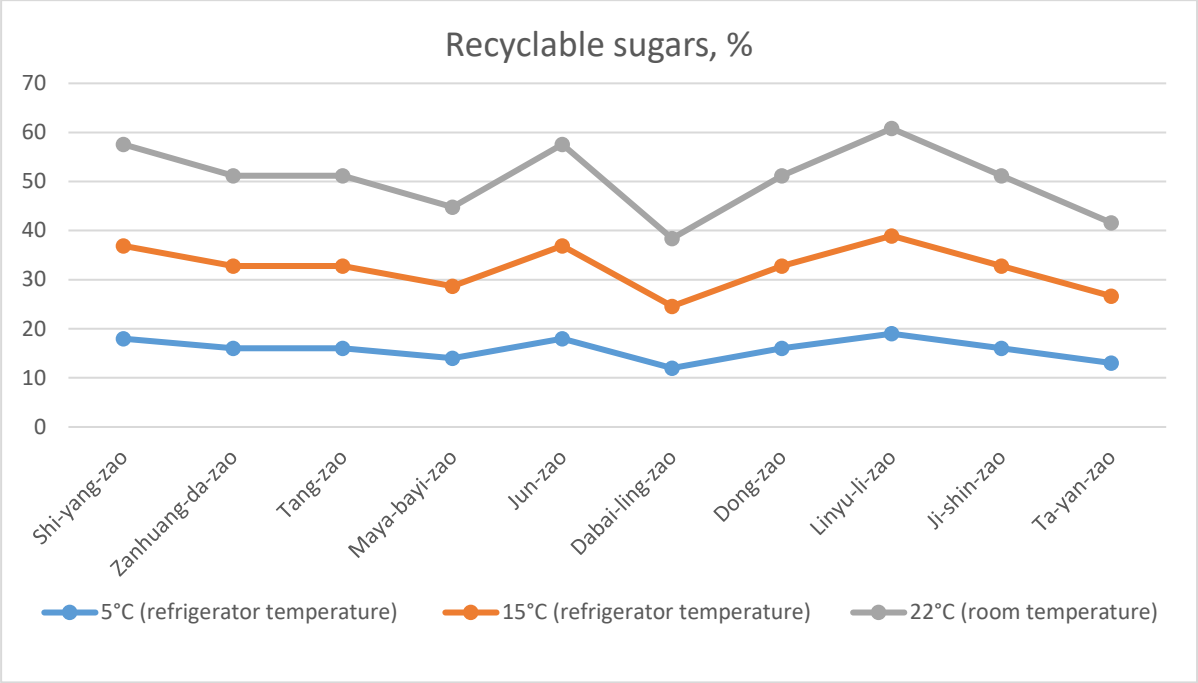

Figure 3. *The amount of renewable sugars in the fruits of jujube, by variety*

In the first variant of the experiment on determining the proportion of poor-quality (wrinkled) fruits, the following indicators were noted in jujube fruits stored in refrigerated conditions at a temperature of 5°C until the end of storage (12 weeks): 35% in the "Dong-zao" and "Ji-shin-zao" varieties, the same 32% in the "Ta-yan-szao" and "Tang-zao" varieties, and the "Jun-zao" variety showed the highest degree of wrinkling with 28%, which proved that these fruits are completely unsuitable for storage (Table 1).

№	Name of jujube varieties	5 °C temperature (cooling room)				15 °C temperature (cooling room)				22°C temperature (room conditions)			
		storage periods (weeks)											
		3	6	9	12	3	6	9	12	3	6	9	12
		Proportion of wrinkled fruits (%)											
1	Shi-yang-zao	8±0,5	14±0,5	19±0,5	23±0,5	14±0,5	25±0,5	34±0,5	40±0,5	26±0,5	38±0,5	48±0,5	57±0,5
2	Zanhuang-da-zao	7±0,5	13±0,5	17±0,5	21±0,5	13±0,5	23±0,5	31±0,5	36±0,5	23±0,5	34±0,5	43±0,5	57±0,5
3	Tang-zao	11±0,5	20±0,5	27±0,5	32±0,5	20±0,5	35±0,5	48±0,5	56±0,5	36±0,5	53±0,5	67±0,5	57±0,5
4	Maya-bayi-zao	6±0,5	13±0,5	17±0,5	21±0,5	13±0,5	23±0,5	31±0,5	36±0,5	23±0,5	34±0,5	43±0,5	57±0,5
5	Jun-zao	10±0,5	17±0,5	23±0,5	28±0,5	17±0,5	30±0,5	41±0,5	48±0,5	31±0,5	46±0,5	58±0,5	57±0,5
6	Dabay-ling-zao	7±0,5	13±0,5	17±0,5	21±0,5	13±0,5	23±0,5	31±0,5	36±0,5	23±0,5	34±0,5	43±0,5	57±0,5
7	Dong-zao	12±0,5	21±0,5	29±0,5	35±0,5	21±0,5	38±0,5	51±0,5	60±0,5	39±0,5	57±0,5	72±0,5	86±0,5
8	Linyu-li-zao	6±0,5	11±0,5	15±0,5	18±0,5	11±0,5	20±0,5	27±0,5	32±0,5	21±0,5	30±0,5	38±0,5	46±0,5
9	Ji-shin-zao	12±0,5	21±0,5	29±0,5	35±0,5	21±0,5	38±0,5	51±0,5	60±0,5	39±0,5	57±0,5	72±0,5	86±0,5
10	Ta-yan-szao	11±0,5	20±0,5	27±0,5	32±0,5	20±0,5	35±0,5	48±0,5	56±0,5	36±0,5	53±0,5	67±0,5	80±0,5

At the same temperature, the "Linyu-li-zao" variety showed the lowest degree of shrinkage at 18%, the "Maya-bayi-zao", " Zanhuang-da-zao " and "Dabay-ling-zao" varieties at 21%, and the "Shi-yang-zao" variety at 23%, which has a sharp advantage over other storage methods in terms of suitability for consumption and quality, therefore, it is recommended to store the fruits of this chilonjiyda at a temperature of 5°C for up to 12 weeks.

In the second experimental variant (cold storage conditions at 15°C), when fruits were stored for 12 weeks, the following percentages of non-shriveled fruits were observed: "Ji-shin-zao" and "Dong-zao" varieties both at 60%, "Tang-zao" and "Ta-yan-szao" varieties both at 56%, "Jun-zao" variety at 48%, "Shi-yang-zao" at 40%, "Maya-bayi-zao," "Zanxuang-da-zao" and "Dabay-ling-zao" varieties at 36%, and "Linyu-li-zao" at 32%. These results indicate that storing fruits for this duration is not advisable. However, during the first 3 weeks, the proportion of total non-shriveled fruits remained low at 13-21 percent, suggesting that it is possible to store the fruits for up to this period.

In the third experimental variant (22°C room temperature), when storing fruits for 12 weeks, all varieties accounted for 32-60% of the proportion of shriveled fruits, which indicates that during this period the fruits dry out, become of poor quality, and are even unsuitable for secondary processing. As an exception to this rule, it was proven that only the "Linyu-li-zao" variety is suitable for storage with a 21% indicator when stored for 3 weeks.

Conclusion

During the storage period, a noticeable natural decrease in the number of berries and shrinkage of the fruits was observed, which was influenced by the storage temperature and storage periods. With an increase in the shelf life, at all three storage temperatures, the natural decrease was 5-41%, and the proportion of shriveled fruits increased to 6-60%. The smallest proportion of natural shrinkage and shriveled fruits was observed when stored in cold storage conditions at a low temperature of 5°C, followed by medium-temperature cold storage conditions at 15°C, and the highest proportion was observed at room temperature (22°C).

According to the results of the analysis of the physical properties of these fruits during storage, the varieties "Ta-yan-szao," "Ji-shin-zao," "Dong-zao," "Jun-zao," and "Tang-zao" are considered unsuitable for storage due to their intolerance to storage temperature and long-term storage, while the remaining varieties "Linyu-li-zao," "Dabay-ling-zao," "Maya-bayi-zao," "Zanxuang-da-za," and "Shi-yang-zao" are suitable for storage at a temperature of 5°C in refrigerated conditions for up to 12 weeks, at an average temperature of 15°C in refrigerated conditions for up to 6 weeks, and at room temperature (22°C) for up to 3 weeks.

As the overall storage temperature rises and the storage period increases, the amount of vitamin C in the fruit decreases; on the contrary, as the storage period increases, the amount of soluble sugars in the fruit increases as a result of the breakdown of solid substances and their transformation into another form. When analyzed by variety, the sugar content in the "Linyu-li-zao," "Shi-yang-zao," and "Jun-zao" varieties increased by 3% compared to the initial composition at the end of storage.

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