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Effect of stevia substitution on physical, chemical and sensory properties of low-calorie apricot jam

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Annotation. A standard sample of apricot jam was prepared and sucrose was replaced with Stevia sweetener (Rebaudioside A), one of the glycoside stevia compounds, with replacement percentages of 25, 50 and 75%. The physical, chemical and sensory properties of all treatments were studied while they were stored for 60 days. It was found from the results that the highest significant value was obtained at the end of the storage period in the values of each indicators of the total acidity percentage of treatment T3 amounted to 0.893% and the percentage of total soluble solids for standard treatment T0, which amounted to 66.270%. while the least significant value was at the end of the storage period in The values of each indicators of pH for treatment T2 which reached 3.190 and T3 which reached to 3.187 and the concentration of vitamin C in treatment T0 amounted to 7.477 mg/100 g and the percentage of moisture in the standard treatment T0 amounted to 28.413% in the same period. The type of treatments and the storage period affected the sensory properties (taste, odor, color and general appearance) of apricot jam, and the degrees of acceptance of all treatments were high at the beginning of storage, but decreased at the end. Replacing the sucrose in them with rebaudioside A by 25 and 50%, respectively, as the use of these two percentages hid the bitter taste left by the sweetener after tasting, and the taste was somewhat similar to the taste of standard treatment T0 at the beginning and end of storage, as well as improving the color, flavor and general appearance in them. T3 was not accepted by the assessors despite the high color and general appearance due to the bitter taste left by the sweetener after tasting with the increase in the proportion of substitution.

Keywords: Apricot jam, Sweetener, Stevia, Rebaudioside A Replacing, sweetener

Introduction

Apricots are among the fruits that have a very low shelf life due to their high respiration rate and rapid ripening process. In order to reduce post-harvest losses, many techniques and processes have been developed to preserve the apricot fruits and consume them in the off-season, such as turning them into jam (Touati, 2014; Lateef et al.2021). Which it is a medium-moisture food, it is prepared by boiling fruit pulp with sugar, pectin and acid to obtain a reasonably thick consistency. In general, storing fruit jam at high temperatures leads to a decrease in the nutritional value and sensory properties (Vidhya & Narain, 2011). Usually, jam is prepared with a high amount of sugars, especially sucrose whose consumption has been linked to many diseases such as obesity, diabetes, cardiovascular disease, hypertension and other diseases (Sutwal et al., 2019). These growing health problems have led to the creation of low-calorie sweeteners as an alternative to sucrose to keep away from them while providing a sweet taste. Food makers have had to develop new formulations by reducing sugar content during food production (Jribi, 2021). Natural sweeteners are getting more attention as an alternative to sugar, and stevia has recently gained importance as a natural sweetener that does not contain calories because of its health benefits, as it does not affect sugar levels, insulin and pressure in the blood, in addition to its work as a heart tonic (Anton, 2010 and Sutwal et al., 2019). And a source of bioactive ingredients due to its antioxidant properties, as well as being non-toxic, non-mutagenic and completely safe unlike artificial sweeteners, the demand for natural stevia sweetener has increased (Singh, 2019). The process of reducing the amount of sucrose in food and beverages is a difficult

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task, because these sweeteners have a unique sweetness that is difficult to replace, as well as the difficulty in maintaining the texture, viscosity and appearance of processed food products, so food manufacturers faced a great challenge to reduce the amount of sucrose without affecting its sensory properties (Hutchings, et al. 2019).

The aim of the research is to reduce the loss of apricot fruits after harvesting and produce a functional jam sweetened with one of the glycoside stevia compounds called Rebaudioside A free of calories for people who suffer from obesity and diabetes who are prohibited from using nutritious sweeteners because of the health problems they cause, so that the accepted by consumers and provides them with a sweetening pleasure. studying the effect of partial replacement with the sweetener on the physical, chemical and sensory properties of low-calorie apricot jam during storage, as well as finding the best substitution ratio that can replace sucrose so that it has properties that are somewhat similar to jam sweetened with sucrose

Materials and methods

The study used fine white sucrose powder that was purchased from the local market of Mosul/Iraq. A Rebaudioside A is a fine white powder of stevia glycosides with a purity of 98%. High methoxyl pectin (HMP), low methoxyl pectin LM, citric acid, calcium chloride and locust bean gum imported from Jiangxi Congcongle Food Industry Co., Ltd. Medium ripe apricot fruits, *Prunus armeniaca*, from the local mark -et of Mosul, Iraq.

Prepare apricot jam

Apricot jam was prepared and tests were carried out in Food Research Laboratory/ University of Mosul/ Iraq. The apricot fruits were sorted, washed, the stone core was removed, and the pulp was chopped into small cubes with ordinary knives. To prepare the standard sample, the cut fruits were placed in an open stainless steel bowl, a sufficient amount of water was added to it for the purpose of boiling. The boiled fruits were separated from the boiling water, and the weight was 45 g. The amount of sucrose was calculated based on the weight of the boiled pulp, according to the standard modified in Codex Stan. (2020). As every 45% of the pulp, 55% of sucrose is added which calculated on the basis of weight. Return the pulp again to the bowl and add the boiling water and sucrose until the mixture boils , thickens with stirring, 0.3% of citric acid calculated on the basis of the amount of pulp was added. When the total soluble solids that measured by manual Refractometer reached 60%, high methoxyl pectin was added 0.7%. When the TSS reached %63%, which was also calculated on the basis of the amount of sucrose, continued boiling until the temperature reached 105°C or %TSS reached 65%, removed from the heat, slightly warmed and packed into clean, dry, sterilized glass containers, closed tightly and left to cool. The amount of sweetener was calculated on the basis of the amount of sucrose, since its amount is 55 gm and the sweetness of Rebaudioside A is 250 times sweeter than sucrose, the amount of sucrose was divided by the sweetness of the sweetener and the amount was 0.22 g. sucrose was replaced by 25, 50, and 75% rebaudioside A, and the jam was prepared in the same way as the standard method, with the amount of apricot pulp, LM low-methoxyl pectin (2.0%), calcium chloride 2.0%) and locust bean gum (0.1%).Those were fixed in all the replacement samples after conducting preliminary experiments, all samples were stored in a refrigerator at 4°C ±1.

Physical, chemical and sensory analyses

The pH was estimated using a manual pH2- Singapore Eco Tester, No. 374, % TA as citric acid, %TSS using a Digital-L.002-R.2-Germaney Refractometer, Manual at 20°C. Moisture was measured in a laboratory vacuum oven, German origin, according to AOAC (2012). Vitamin C was estimated according to the method reported by Satpathy et al. (2021) and samples were sensually evaluated using 9 degrees of acceptance (taste, odor, color and general appearance) according to the method mentioned by Meilgaard et

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al. (1999). Finally, statistical analysis of the data was conducted according to the factorial system using the Completely Randomized Design C.R.D. Significantly different coefficients were marked with different alphabets using Duncan's Multiple Range Test under 5% probability level (Antar,2010).

Results and discussion

Effect of treatment type and storage period on the pH of apricot jam

It is noted from the results of Table (1) that there were significant differences ($p \leq 0.05$) in the pH values of the apricot jam that was sweetened with sucrose in the standard treatment T0 and the jam samples treated with rebaudioside A, which is one of the stevia glycoside compounds with replacement rates of 25, 50 and 75% at the beginning of storage. (zero day), as it was found that the value increased significantly in the standard treatment, which amounted to 3.503 compared to treatments T_1, T_2 and T_3, in which the same value reached 3.433, 3.403 and 3.383, respectively. Close to neutrality, (Abu-Arab et al., 2010) mentioned that the pH value of stevioside sweetening powder, which is one of the stevia glycoside compounds, was 5.72, while sucrose was close to neutral.

Table (1): Effect of treatment type and storage period on the pH of apricot jam

storage period/day / *Treatments	pH				
	zero beginning of (storage)	15	30	45	60
T_0	3.503 a	3.453 b	3.377 e	3.271 g	3.219 i
T_1	3.433 c	3.407 d	3.320 f	3.243 h	3.217 i
T_2	3.403 d	3.377 e	3.319 f	3.242 h	3.190 j
T_3	3.383 e	3.323 f	3.245 h	3.193 j	3.187 j

*T_0=Standard(sucrose), T_1= 25% Rebaudioside A +75% Sucrose,T_2= 50% Rebaudioside A + 50% sucrose, T_3= 75% Rebaudioside A +25% Sucrose. *The coefficients that took the same letter are not significantly different from each other under the 0.05 probability level.

It is noted from Table (1) that the highest significant value of pH was in the standard jam treatment T_0, which amounted to 3.503 in zero days of storage, and the lowest significant value was in the treatment T3 which reached 3.187 in 60 days of storage. The same value decrease is also observed with the progression of storage periods, the reason may be attributed to the high acidity due to the hydrolysis of polysaccharides or the pectin (Shah et al., 2015). The same results and Kamal et al. (2015) reached the same results when storing apricot jam that replaced sucrose with a sweeteners of aspartame and saccharin And Sutwal et al. (2019) who observed a decrease in pH when apple jam was stored at 5°C for 28 days for the aforementioned reason.

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Effect of treatment type and storage duration on the percentage of total acidity TA% of apricot jam

The results of Table (2) showed that there were significant differences ($p \leq 0.05$) in the percentage of total acidity TA% of the apricot jam sweetened with sucrose in the standard treatment T0 and the rest of the jam samples treated with the sweetener Rebaudioside A in zero storage days. Whereas, TA decreased significantly ($p \leq 0.05$) in the standard treatment T0 and amounted to 0.811% compared to the treatments T_1, T_2 and T_3, which increased significantly in this percentage and amounted to 0.824%, 0.843% and 0.855%, respectively, for the same reason mentioned in the pH. It was found that the highest significant value of the total acidity percentage was in the two treatments T_2 and T_3, which amounted to 0.892 and 0.893%, respectively, in 60 days of storage, and the lowest significant value was for the standard sample T_0, which amounted to 0.811% in zero days of storage. It is noted from the same table that TA% increased significantly($p \leq 0.05$) with the progression of the storage period, for the reason mentioned in the pH

Table (2): Effect of treatment type and storage period on the percentage of total acidity TA% of apricot jam

storage period/day / *Treastment	TA٪				
	zero beginning of) (storage	15	30	45	60
T_0	0.811 r	0.844 o	0.852 l	0.877 g	0.884 d
T_1	0.824 q	0.849 n	0.868 i	0.882 e	0.889 b
T_2	0.843 p	0.851 m	0.873 h	0.885 c	0.892 a
T_3	0.855 k	0.864 j	0.878 f	0.889 b	0.893 a

*T_0=Standard(sucrose), T_1= 25% Rebaudioside A +75% Sucrose,T_2= 50% Rebaudioside A + 50% sucrose, T_3= 75% Rebaudioside A +25% Sucrose. *The coefficients that took the same letter are not significantly different from each other under the 0.05 probability level

Effect of treatment type and storage period on the percentage of soluble solids of apricot jam

The results of Table (3) show that there are significant differences ($p \leq 0.05$) in the percentage of total soluble solids for apricot jam between the standard treatment T0 at the beginning of storage, which amounted to 65.12, and the rest of the treatments T_1, T_2 and T3, which amounted to 57.23, 55.47 and 53.32%, respectively. The increase in TSS% in the standard treatment compared to the rest of the treatments due to the difference of sucrose amounts that added according to the study plan, in addition to the contribution of reducing sugars (glucose and fructose) resulting from the degradation of sucrose by acid and heat treatment, in increasing this percentage. Whereas, Rebaudioside A, which is one of the stevia glycoside compounds, stable to the heat treatment used, does not contribute to the increase TSS% (Kovacevic et al.,

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2018). It is noted from the table that the highest of TSS% for treatment T_0 that reached 66.26% at the end of the storage period and the lowest percentage for treatment T3 reached 53.32% at the beginning of the storage period (0 days), and it is noted from the same table that TSS% increased significantly ($p \leq 0.05$) in Standard treatment T0 and the replacement of T_1, T_2, and T_3 With the progression of storage periods. The reason may be attributed to the degradation of sucrose added or present in the apricot pulp to two sugars, glucose and fructose, as well as the degradation of pectin into simple sugars that contributed to the increase in TSS%. Khan et al. (2012) reached the same results when strawberry jam was storage in refrigerated at 5°C for 60 days and Touati et al. (2014) when storing apricot jam at 5°C for 60 days also.

Table (3): Effect of treatment type and storage period on the percentage of total soluble solids of apricot jam

storage period/day / *Treastment	TSS٪				
	zero beginning of) (storage	15	30	45	60
T_0	65.117 e	65.437 d	65.963 c	66.113 b	66.270 a
T_1	57.233 j	57.523 i	57.873 h	58.137 g	58.180 f
T_2	55.470 n	55.563 m	55.787 l	56.237 k	56.233 K
T_3	53.323 s	53.687 r	53.820 q	53.940 p	54.023 o

*T_0=Standard (sucrose),T_1=25%RebaudiosideA+75%Sucrose,T_2=50% Rebaudioside A +50% sucrose,T_3=75% Rebaudioside A +25% Sucrose. * The treatments that took the same letter are not significantly different from each Other under the 0.05 probability level.

Effect of treatment type and storage period of vitamin C concentration in apricot jam

Vitamin C is less stable towards heat and storage conditions of products containing it during storage, as it was found from the results of Table (4) that there were significant differences ($p \leq 0.05$) in the concentration of vitamin C between the standard treatment T_0 and the rest of the treatments, as its concentration decreased significantly in the standard treatment T_0, It reached 7.822 mg/100 gm in zero days of storage, while its concentration increased significantly in all replacement treatmentses T_1, T_2 and T_3 in the same period and reached 7.835, 7.841 and 7.847 mg/100 gm, respectively. The reason is due to the containing of Rebaudioside A on Flavanones and flavanols that preserved vitamin C. The results agreed with what Salar et al. (2020) reported that antioxidants in stevia-containing beverages and foods preserved vitamin C, especially in refrigerated conditions. The effect of the interaction of treatments type and storage period ($p \leq 0.05$) on vitamin concentration was also observed, as the highest significant value of it in T3 reached 7.847 mg/100 gm in zero days of storage and the lowest significant value for treatment T_0 that reached 7.447 mg/100 gm in 60 days of storage. In addition to a significant decrease in its concentration with the progression of storage periods, the reason may be due to the oxidation of ascorbic acid to dehydroascorbic acid in the presence of the enzyme ascorbic acid oxidase (ascorbinase) resulting from

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residual oxygen in cans (Kamal et al., 2015) who they reached these results when storage apricot jam that sweetened with aspartame and saccharin at room temperature and Rahman et al. (2018) when storing apricot jam for 90 days at room temperature.

Table (4): The effect of treatment type and storage period on the vitamin c concentration of apricot jam

storage period/day / *Treatments	vitamin C mg/100 gm				
	zero beginning) (of storage	15	30	45	60
T_0	7.822 b	7.550 d e f	7.523 g h i	7.497 j	7.447 k
T_1	7.835 a b	7.562 c d e	7.537 f g h	7.517 h i j	7.482 j
T_2	7.841 a b	7.574 c d	7.551 d e f	7.538 e-h	7.511 i j
T_3	7.847 a	7.580 c	7.562 c d e	7.544 e f g	7.532 f-i

*T_0=Standard(sucrose),T_1=25%RebaudiosideA+75%Sucrose,T_2=50% Rebaudioside A +50% sucrose,T_3=75% Rebaudioside A +25% Sucrose. * The treatments that took the same letter are not significantly different from each other under the 0.05 probability level

Effect of type of treatment and storage period on the moisture percentage of apricot jam

The results of Table (5) indicate that there are significant differences ($p \leq 0.05$) in the moisture percentage of apricot jam sweetened with sucrose, represented by standard treatment T_0, and the rest of the treatments in which sucrose was replaced by rebaudioside A, which is one of the stevia glycoside compounds, as its percentage decreased significantly in standard treatment T_0 in the beginning of storage, reached 28.435%, while its concentration increased significantly in all the replacement treatments T_1, T_2 and T_3 in the same period. they were amounted to 28.683, 28.867 and 29.139%, respectively. the reason may be due to the decrease in the total soluble solids in those treatments as a result of the difference in the added amounts of sucrose and rebaudioside A sweetener according to the study plan, as well as the ability of low methoxyl pectin to retain water through its association with hydrogen bonds with it (Broomes and Badrie (2010).

Table (5): The effect of treatment type and storage period on moisture percentage of apricot jam

storage	moisture ٪

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period/day *Treastment	zero beginning of) (storage	15	30	45	60
T_0	28.435 m	28.422 n	28.420 n	28.413 o	28.411 o
T_1	28.683 i	28.665 j	28.659 j k	28.653 k l	28.649 l
T_2	28.867 e	28.859 f	28.847 g	28.841 g h	28.837 h
T_3	29.139 a	29.104 b	29.006 c	28.988 d	28.984 d

*T_0=Standard(sucrose),T_1=25%RebaudiosideA+75%Sucrose,T_2=50% Rebaudioside A +50% sucrose,T_3=75% Rebaudioside A +25% Sucrose.

* The treatments that took the same letter are not significantly different from each other under the 0.05 probability level

It was also shown from the same table the effect of the interaction ($p \leq 0.05$) of the treatments type and storage period on the moisture percentage of jam, as the highest significant percentage of it in T3 was 29.139% in zero days of storage, and the lowest significant moisture percentage in T0, it reached 28.411% in 60 days of storage. In addition to its significant decrease with the progression of storage periods. The same results were reached by Sutwal et al., 2019). The reason may be due to the continued increase of total soluble solids resulting from the decradation of sucrose, whether added or present in the pulp of apricots, to the reducing sugars (glucose and fructose) with the progression of storage periods. The same results were reached by Wani et al. (2017).

Effect of type of treatment and storage period on sensory evaluation character-istics (taste, odor, color and appearance) of apricot jam

It is noticeable from the results of Table (6) that there are significant differences ($p \leq 0.05$) between the apricot jam samples for the degree of taste acceptance at the beginning of storage. Apricots made from it contain compounds (taste and odor) such as hexanal, 2-hexenal and β-linalool and 1- hexanol (Ayour et al., 2020), as well as the contribution of citric acid and the natural acidity found in apricot fruits to improve the taste of jam. (Wani et al., 2017), while treatments T1, T2 and T3 had the lowest acceptance score of 9.77, 9.50 and 8.93 respectively for the same storage period. The reason for the decrease in the degree of taste acceptance may be attributed to the feeling of a light bitter taste left by the sweetener after tasting, which is associated with an increase in the proportion of substitution due to its containing some phenolic compounds such as flavanoids and tannins (Samuel et al., 2018). At the end of the storage period, a significant decrease ($p \leq 0.05$) in the degree of acceptance of the taste of all treatments is observed from those degrees at the beginning , they reached 9.40, 9.29, 8.96 and 8.82 in treatments T0, T1, T2, and T3, respectively. The reason

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for the decrease in taste during storage may be due to the loss of compounds The volatile flavor (taste and odor) mentioned above, as well as the degradation of sucrose and some compounds with advanced storage times. The results are consistent with Sutwal et al. (2019) when stevia-sweetened apple jam was stored at room temperature for 28 days.

As for the degree of odor acceptance, it is noted from the results of the same table that the two standard treatments T0 and T1 obtained the highest significant value ($p \leq 0.05$) in the degree of odor acceptance, which reached 9.77 and 9.74, respectively compared to the rest of the treatments in which the degree of acceptance mentioned at the beginning of storage decreased. They are treatments of T2 and T3 which reached 88.8 and 8.75, respectively. The reason for the high degree of odor acceptance in treatments containing a high amount of sucrose may be attributed, to the presence of residual amounts of volatile flavor compounds (taste and smell) present in the apricot fruits at the beginning of storage, as well as the formation of carboxylic acids that play an important role in flavor enhancement (Cheng et al. , 2012), The reason for the decrease in flavor compounds with an increase in the proportion of replacement with rebaudioside A is due to the small amounts of aromatic odors remaining in the mentioned sweetener (Kumari et al., 2017). While the degree of odor acceptance of apricot jam decreased at the end of storage period in all treatments, possibly due to the loss of volatile flavor compounds at the end of storage (Ishaq et al., 2009). It was noted that the highest significant decrease at the end of the storage period was in treatment T0, which amounted to 8.60, and the least significant decrease in the same period was in treatment T3, which amounted to 9.47.

Table (5): Effect of treatment type and storage period on sensory evaluation properties (taste, odor, color and appearance) of apricot jam

*Treatments	sensory evaluation properties							
	The degree of taste acceptance		The degree of odor acceptance		The degree of color acceptance		The degree of general appearance acceptance	
	start of storage	end of storage	start of storage	end of storage	start of storage	end of storage	start of storage	end of storage
T_0	9.80 a	9.40 c b	9.77 a	8.60 g	9.72 b	8.42 f	9.82 a	8.67 b
T_1	9.77 a	9.29 c	9.74 a	8.69 f	9.76 a	8.53 e	9.82 a	8.73 b
T_2	9.50 b	8.96 d	8.88 d	9.31 c	9.79 a	8.81 d	9.85 a	8.80 b
T_3	8.75 e	7.82 f	8.75 e	9.47 b	9.79 a	8.85 c	9.85 a	8.82 b

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*T_0=Standard (sucrose),T_1=25%RebaudiosideA+75%Sucrose,T_2=50% Rebaudioside A +50% sucrose,T_3=75% Rebaudioside A +25% Sucrose. * The treatments that took the same letter are not significantly different from each other under the 0.05 probability level

As for the degree of color acceptance, the type of treatment and storage period had a significant effect ($p \leq 0.05$) on the color of apricot jam, whether in the standard or replacement treatments. The results showed that the least significant degree of color acceptance at the beginning of storage was in the standard treatment T0 which amounted to 9.72 and this degree increased significantly with the increase in the proportion of sucrose replaced by rebaudioside A. The highest significant value ($p \leq 0.05$) was reached in the treatment T2 and T3 which amounted to 9.79 for both. The reason for the high degree of color in the substituted treatments may be due to the fact that the sweetener Rebaudioside A is rich in antioxidants such as flavonoids, which play an important role in maintaining color by reducing the oxidative reactions that occur for vitamin C (Hossain et al., 2017). As well as the inability of the sweetener to participate in Maillard reactions because it does not contain a free carbonyl group (Kovacevic et al., 2018). It is also noted that the degree of color acceptance decreased significantly at the end of the storage period for all treatments compared at the beginning of storage. It was observed that the highest significant decrease ($p \leq 0.05$) in the degree of acceptance, was in treatment T0 which amounted to 8.42, and the least significant decrease in that degree of acceptance was in treatment T3, which amounted to 8.85. In addition to the occurrence of Maillard and vitamin oxidation reactions by heat treatment. The same results were reached by Sutwal et al. (2019) when they stored low-energy apple jam at room temperature for 28 days.

It is noted from the same table that the type of treatment and storage period had a significant effect ($p \leq 0.05$) in the values of the degree of acceptance of appearance, which is one of the main sensory characteristics that determine the extent to which the consumer accepts the food correctly (Mahony, 2011). The highest significant value ($p \leq 0.05$) was for the degree of appearance acceptance at the beginning of storage for all treatments, but from a practical point of view a slight increase in the degree of appearance acceptance with an increase in the percentage of replacement, thus it can be said that all treatments were accepted at the beginning of storage, but at the end of it the degree of the appearance acceptability in all the treatments, standard and in which sucrose was replaced by rebaudioside A decreased by 25, 50 and 75% due to the occurrence of changes in color for the mentioned reason in the degree of color. It can be concluded from the results of all sensory properties, that the two treatments T1 and T2, in which sucrose was replaced by rebaudioside A by 25% and 50%, respectively, were acceptable by the assessors at the beginning and end of storage, due to the improvement of the taste in them, in addition to the acceptability of the rest of the traits in these two treatments. (odor, color and appearance) by assessors.

Conclusions

Replacing sucrose with the sweetener Rebaudioside A to result a functional jam that is low in calories and rich in antioxidants, which gave acceptance in terms of sensory properties in treatments that partially replaced sucrose with the sweetener and in the replacement ratios of 25 and 50% until the end of storage, and the sweetener reduced the loss of vitamin C and color loss during cryopreservation.

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