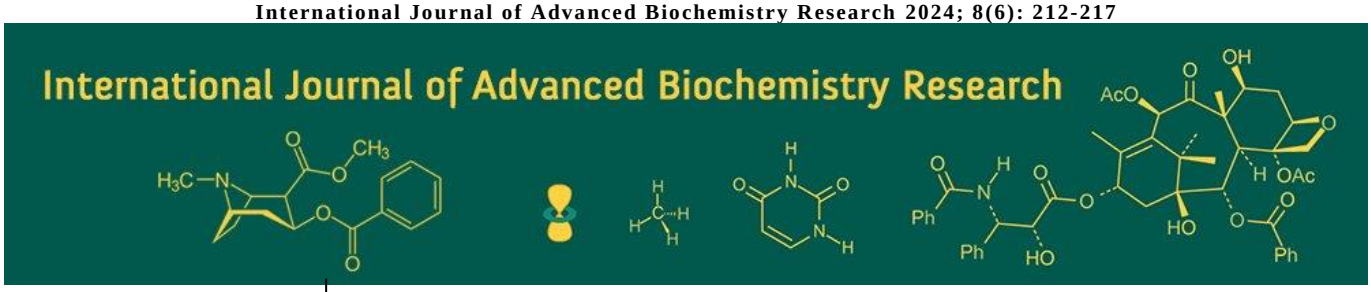

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Impact of leave extract and alternate sweeteners on Physio-chemical properties of dragon fruit jam

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Abstract
The exotic and visually appealing dragon fruit is native to India and is rich in nutrients and phytochemicals. It contains soluble fibre in water, vitamin C, antioxidants that guard against heart disease, and bacteria and fungi that support the body's overall health. Its flavour, however, is poor and extremely ephemeral. In the current research, we evaluated the physiochemical properties of dragon fruit jam which is prepared with leaves extract as natural preservatives and alternate sweetener sources under ambient condition. Three distinct leaf extracts (tulsi, lemongrass, and mint) and alternative sources of sweetness (honey, stevia, and coconut sugar) were combined to create ten distinct treatments. Ten treatments comprise the control, which is composed of lemon juice and sugar. The taste revealed that chewiness decreased while gumminess, elasticity, and adhesiveness increased when leave extract and other sugar sources were combined. The data was analysed in different storage intervals (14, 21 and 28 days). According to the storage period we evaluated the final results where the combination of mint leave extract and stevia as alternate sugar source gave the best result having 65-66^{0}B total soluble solids, 0.25-0.26% titratable acidity, 9.0-9.4 mg/100g ascorbic acid, 4-4.2 pH, 8.2-9.2% total sugar, 4.5-3.5% reducing sugar and 4.2-4.1% non-reducing sugar.

Keywords: Physio-chemical, TSS, titratable acidity, combinations, ambient condition

1. Introduction
There is a finite shelf life to many fruits due to their extremely perishable nature. The various handling and marketing procedures cause a considerable amount of agricultural produce to be lost. Between harvest and consumption, agricultural products experience both qualitative and quantitative losses (Roy *et al*., 2020) [1].

Hylocereus undatus, commonly known as the dragon fruit, is a delightful exotic fruit native to India. It is also known as the Queen of Night due to its large flowers, which bloom exclusively at night (Mori *et al*., 2023) [2]. This species of vine cactus is diploid (2n = 2X = 22) and is a member of the Cactaceae family. It was introduced to Vietnam by the French over a century ago. It has become the most profitable crop for Vitnamese farmers. Vietnam is the main supplier of dragon fruit because of the tremendous demand for the fruit around the world (Luu *et al*., 2021) [3].

The dietary content of dragon fruit varies depending on the species, origin, and harvesting period. Compared to mangosteen and pineapple, it has higher concentrations of several minerals, such as phosphorus, potassium, sodium, and magnesium (Hossian *et al*., 2021) [4]. Because of the conditions under which it grows, red dragon fruit's nutritional makeup and phytochemical characteristics differ significantly (Dembitsky *et al.*, 2011) [5]. Red-fleshed Dragon fruits produced the colours that provided them their colour as they developed older. The fruit tastes crisp and delicious and is high in sugars and antioxidants (Rao and Asanka, 2015) [6]. Dragon fruit is an enjoyable fruit that is high in vitamin C, water-soluble fibre, and antioxidants such as betalains, hydroxycinnamates, and flavonoids. Its capacity to strengthen the immune system, reduce LDL cholesterol, promote weight loss, and enhance digestion are just a few of its many health advantages. By influencing blood vessels and brain cells, hydroxycinnamates assist in avoiding cancer and flavonoids lower the chance of heart disease. Moreover, it protects the body from bacteria and fungi and enhances overall bodily function (Verma *et al*., 2017) [7].

One product that is used extensively is jam. The world's largest producer and consumer of jam is France. In 2016, 3.36 billion were used and about 4000 tonnes were produced. Fruits such as strawberries, blueberries, mangoes, pineapples, grapes, apricots, oranges, and pomegranates are used to make jam. Jams are easy to carry around, logistics, and store, and they are inexpensive to make. They also have a longer shelf life and encourage the use of fruit during the off-season (Teixeria *et al*., 2020) [8].

Sugars that are found naturally in whole foods are essential to a diet that is both balanced and healthful. While added sugars boost calorie intake, meal satisfaction, and sensory aspects of the meal, they are not essential for good nutrition and health (Fidler Mis *et al.*, 2017) [9]. When they take the place of nutrient-dense foods, they may supply calories without important elements like vitamins, minerals, or other critical nutrients, which can have a negative impact on health (Slavin, 2012) [10]. Conversely, patients with diabetes benefit from using other sugar substitutes, such as stevia leaf extract, honey, or coconut sugar. It is not able to lower blood sugar levels. It has the ability to maintain normal blood sugar levels. It may reduce the likelihood of dental decay and cavities. Furthermore, blood sugar levels do not increase when using sugar substitutes. In the short term, managing weight can also be aided by substituting sugar sources for both adults and kids who are overweight or obese (Curi *et al.*, 2017) [11]. Therefore, the objective of the study was to assess how the physiochemical qualities of dragon fruit jam were affected by the addition of various sugar sources and leaf extract.

2. Materials and Methods

The current study was carried out from August 2023 to February 2024 at Lovely Professional University's Horticulture Laboratory, Department of Horticulture, Phagwara, Punjab. For each treatment, 100g of pulp were used. The nutritious fruits were gathered from the Phagwara, Punjab. Furthermore, from there were brought some other significant materials needed to carry out the experiments, including dragon fruit, sugar, citric acid, pectin, honey, coconut sugar, stevia, mint, tulsi, and lemongrass leaves. The fruit's variety is determined by what the market has to offer. The fruits, whose flesh is pink and whose pulp is white, were picked from the local market. Ten dragon fruit jam formulations (including control) were prepared: T_1 (Tulsi @3ml + Honey @ 45ml), T_2 (Tulsi @3ml + Stevia @ 15g), T_3 (Tulsi @3ml + Coconut Sugar @ 40g), T_4 (Lemongrass @ 2.5ml + Honey @ 45ml), T_5 (Lemongrass @ 2.5ml + Stevia @ 15g), T_6 (Lemongrass @ 2.5ml + Coconut Sugar @ 40g), T_7 (Mint @2.5 ml + Honey @ 45ml), T_8 (Mint @2.5 ml + Stevia @ 15g), T_9 (Mint @2.5 ml + Coconut Sugar @ 40g), T_{10} (Sugar @45g + Citric Acid @6ml). Based on the product's initial sensory testing, the number of ingredients was determined.

2.1 Determination of Total Soluble Solids (^{0}Brix)

TSS can determined the percentage of soluble solids which is present in the sample. To determined it digital or hand refractometer was used. In that experiment we have used digital refractometer. A little amount of dragon fruit jam was put on the plate of the refractometer and the reflected reading was recorded (Umer *et al.*, 2022) [12].

2.2 Determination of Titratable Acidity (%)

The titratable acidity of the dragon fruit jam was measured by dilution of five grams of jam with 10ml of distilled water and titrated with 0.1N NaOH followed by addition of 1-2 drops of phenolphthalein as indicator to the aliquot taken of sample by using AOAC method. When the color of the sample turned changed into pink then took the reading and calculated titratable acidity percentage through the following formula (Kanwal *et al.*, 2017; Parveen and Khatkar, 2015) [14, 13].

$$\text{Calculation } \frac{\text{Titre value X Normality of alkali X Vol.made up X 64.04 X 100}}{\text{Weight of sample X Vol.of aliquot taken X 1000}}$$

2.3 Determination of Ascorbic Acid (mg/100g)

A two-gram sample was homogenised in 100ml of 3% metaphosphoric acid with distilled water. After that, the sample was filtered through 2,6-dichlorophenol-indophenol dye until a 15-second pink hue emerged. The observations were noted and expressed as milligrammes per 100 grammes (Nurani and Sulistyoningsih, 2021; Porto *et al*., 2019) [15, 16].

$$\text{Calculation } \frac{\text{Titre value x dye factor x volume made x 100}}{\text{Volume of filtrate taken x weight of sample}}$$

2.4 Determination of TSS-Acid Ratio

It was computed by dividing of TSS and percentage of titratable acidity that present in the jam. It was calculated through below mentioned formula:

$$\text{TSS-Acid ratio} = \frac{\textbf{Total soluble solids}}{\textbf{Titratable acidity}}$$

2.5 Determination of pH

An electronic pH meter can be used to measure the pH in fruit jam (Nurani and Sulistyoningsih, 2021) [15].

2.6 Determination of Total Sugar (%)

The method provided by Kanwal *et al*. (2017) [14] was followed to estimate total sugar using the anthrone reagent. A solution of 0.05% anthrone in concentrated sulfuric acid was used to create an anthrone reagent. 100ml of distilled water was macerated with 2g of jam sample in order to prepare the sample. Next, a test tube containing 1 millilitre of jam sample was filled with 1 millilitre of distilled water, 3 millilitres of anthrone reagent, and sealed. Following that, the test tube spent fifteen minutes at 100 °C in a water bath. Then it is calculated through the formula:

$$\text{Total sugar (\%)} = \frac{\text{Factor for fehling solution} \times \text{Dilution} \times 100}{\text{Titre} \times \text{Weight or volume of sample for estimation}}$$

2.7 Determination of Reducing Sugar (%)

The AOAC (2000) method was used to estimate the reduction of sugar. In one conical flask, 5ml of Fehling solution A and 5ml of Fehling solution B has taken and then titrate this mixed solution with the sample solution by adding methylene blue which act as an indicator. A sufficient volume of the extract was heated to a boil for two minutes after being treated with Fehling solution. The indicator's discoloration to lessen Fehling solution was the end point, which was determined after two minutes of treatment and boiling (Lakho *et al.*, 2017) [18].

Calculation

$$\text{Reducing sugar} = \frac{\textbf{Dilution X Factor of fehling (gm)}}{\textbf{Weight of sample X Titre value}} \text{ X100}$$

2.8 Determination of Non-Reducing Sugar (%)

The percentage of non-reducing sugar was calculated through that formula which has given below (Lakho *et al*., 2017) [18].

Non-reducing Sugar (%) = Percentage of total Sugar – Percentage of reducing Sugar

3. Results

3.1 Total Soluble Solids

According to the data of table 1 TSS were decreased gradually during 14 to 28 days of storage of jam under room condition and highest value showed in treatment T_8- Mint @ 2.5 ml + Stevia @ 15g because stevia is the best substitute of sugar.

3.2 Titratable acidity

The data in relation to titratable acidity in various treatments of sugar sources and leave extract is demonstrated in the table no. 1. It shows increased of titratable acidity percentage within 14 to 28 days of storage of dragon fruit jam under ambient condition. In treatment T_6- Lemongrass @ 2.5ml + Coconut Sugar @ 40g showed the highest acidity percentage and treatment T_3- Tulsi @3ml + Coconut Sugar @ 40g showed lowest acidity.

3.3 Ascorbic Acid

It is cleared from table no. 1 that treatment T_4- Lemongrass @ 2.5ml + Honey @ 45ml shows the best result because of highest ascorbic acid content and it was gradually increased between 14 to 28 days of storage under ambient condition.

3.4 TSS-Acid Ratio

The result demonstrated significant variations in TSS-acid ratio among all the treatments applied on dragon fruit jam. Table 1 shows decreased of that ratio gradually between 14 to 21 days storage and again 28 days it was increased.

3.5 pH

It is apparent from the table 1 that all the treatments increased pH value up to 21 days and after that at 28 days of storage it was decreased in some treatments. Treatment T_6- Lemongrass @ 2.5ml + Coconut Sugar @ 40g reveals the best result with 4.2 pH.

Table 1: Physio-chemical properties of dragon fruit jam in different storage stages

Treatments	TSS			Titratable acidity			Ascorbic acid			TSS-acid ratio			Ph		
	14 days	21 days	28 days	14 days	21 days	28 days	14 days	21 days	28 days	14 days	21 days	28 days	14 days	21 days	28 days
T_1	66.400 ± 0.289	65.800 ± 0.351	65.367 ± 0.438	0.217 ±0.003	0.253 ± 0.003	0.273 ± 0.003	8.600 ± 0.058	10.167 ± 0.033	8.867 ± 0.033	308.123 ± 4.034	236.770 ± 2.499	257.193 ± 3.409	2.082 ± 0.008	4.167 ± 0.033	4.133 ± 0.033
T_2	67.033 ± 0.120	66.567 ± 0.091	65.433 ± 0.202	0.237 ± 0.003	0.277 ± 0.003	0.293 ± 0.003	8.833 ± 0.067	9.067 ± 0.088	9.367 ± 0.088	280.527 ± 3.748	219.700 ± 1.875	237.063 ± 3.140	2.000 ± 0.014	4.500 ± 0.058	3.700 ± 0.058
T_3	65.633 ± 0.329	65.900 ± 0.058	65.767 ± 0.234	0.263 ± 0.003	0.243 ± 0.003	0.250 ± 0.006	8.067 ± 0.088	8.600 ± 0.058	8.733 ± 0.033	251.830 ± 2.213	258.033 ± 6.545	269.953 ± 3.453	1.807 ± 0.018	4.200 ± 0.058	4.167 ± 0.033
T_4	66.567 ± 0.296	65.933 ± 0.273	65.000 ± 0.557	0.230 ± 0.006	0.277 ± 0.003	0.313 ± 0.003	9.033 ± 0.088	11.033 ± 0.088	9.467 ± 0.088	288.637 ± 7.510	206.427 ± 2.168	235.973 ± 2.954	2.168 ± 0.000	4.100 ± 0.058	4.000 ± 0.058
T_5	66.967 ± 0.088	63.300 ± 1.450	61.367 ± 0.121	0.267 ± 0.003	0.253 ± 0.003	0.347 ± 0.003	7.233 ± 0.088	8.233 ± 0.088	8.767 ± 0.033	249.470 ± 3.726	185.707 ± 1.738	259.190 ± 4.211	2.258 ± 0.000	4.200 ± 0.058	4.133 ± 0.033
T_6	66.800 ± 0.061	65.567 ± 0.121	62.700 ± 0.153	0.277 ± 0.003	0.227 ± 0.003	0.370 ± 0.006	7.933 ± 0.088	7.700 ± 0.115	8.400 ± 0.058	241.513 ± 2.766	174.960 ± 3.048	289.380 ± 3.963	2.057 ± 0.008	4.267 ± 0.033	4.233 ± 0.033
T_7	66.267 ± 0.290	65.700 ± 0.305	65.133 ± 0.260	0.257 ± 0.003	0.287 ± 0.003	0.317 ± 0.003	9.567 ± 0.120	10.233 ± 0.088	8.800 ± 0.058	258.780 ± 3.082	203.613 ± 1.581	228.107 ± 3.626	2.236 ± 0.013	4.367 ± 0.033	4.133 ± 0.033
T_8	66.967 ± 0.088	66.700 ± 0.152	66.333 ± 0.119	0.230 ± 0.006	0.257 ± 0.003	0.270 ± 0.006	8.767 ± 0.088	8.800 ± 0.058	9.067 ± 0.088	289.670 ± 7.801	238.503 ± 5.419	256.067 ± 3.609	2.113 ± 0.016	4.233 ± 0.067	3.733 ± 0.033
T_9	65.667 ± 0.561	65.300 ± 0.666	66.067 ± 0.144	0.257 ± 0.003	0.270 ± 0.006	0.300 ± 0.006	8.733 ± 0.088	8.767 ± 0.088	8.800 ± 0.058	259.827 ± 3.317	214.847 ± 4.665	242.073 ± 5.210	2.191 ± 0.013	4.267 ± 0.033	4.133 ± 0.033
T_{10}	66.367 ± 0.348	65.900 ± 0.289	64.867 ± 0.463	0.227 ± 0.003	0.263 ± 0.003	0.347 ± 0.003	9.300 ± 0.153	9.700 ± 0.058	8.800 ± 0.058	293.930 ± 3.717	186.197 ± 2.253	249.050 ± 2.491	2.236 ± 0.022	4.367 ± 0.033	4.000 ± 0.058
C.D.	0.857	1.619	0.917	0.012	0.011	0.013	0.285	0.236	0.188	13.559	10.641	10.919	0.039	0.144	0.125
SE (m)	0.289	0.545	0.309	0.004	0.004	0.004	0.096	0.080	0.063	4.564	3.582	3.676	0.013	0.048	0.042
SE (d)	0.408	0.771	0.436	0.006	0.005	0.006	0.136	0.113	0.089	6.455	5.066	5.198	0.019	0.068	0.060
C.V.	0.752	1.438	0.825	2.777	2.426	2.515	1.933	1.493	1.230	2.904	2.920	2.522	1.089	1.961	1.809

Table 2: Sugar content of dragon fruit jam in different storage stages

Treatments	Total sugar			Reducing sugar			Non-reducing sugar		
	14 Days	21 Days	28 Days	14 Days	21 Days	28 Days	14 Days	21 Days	28 Days
T_1	8.233 ± 0.088	7.667 ± 0.033	7.400 ± 0.058	4.233 ± 0.033	4.033 ± 0.067	4.067 ± 0.033	4.000 ± 0.100	3.633 ± 0.033	3.333 ±0.033
T_2	8.767 ± 0.088	8.367 ± 0.088	7.833 ± 0.033	3.800 ± 0.058	4.500 ± 0.058	4.833 ± 0.033	4.967 ± 0.133	3.867 ± 0.145	3.000 ± 0.058
T_3	7.067 ± 0.033	7.033 ± 0.067	6.667 ± 0.033	4.500 ± 0.058	4.800 ± 0.058	4.400 ± 0.058	2.567 ± 0.088	2.233 ± 0.120	2.267 ± 0.067
T_4	8.300 ± 0.058	8.167 ± 0.120	8.000 ± 0.058	4.133 ± 0.033	4.200 ± 0.058	4.300 ± 0.058	4.167 ± 0.067	3.967 ± 0.145	3.700 ± 0.000
T_5	9.267 ± 0.088	8.667 ± 0.088	8.233 ± 0.033	4.333 ± 0.033	3.833 ± 0.033	4.133 ± 0.033	4.933 ± 0.088	4.833 ± 0.088	4.100 ± 0.000
T_6	8.567 ± 0.088	8.567 ± 0.088	8.000 ± 0.058	3.933 ± 0.033	4.200 ± 0.058	4.767 ± 0.033	4.633 ± 0.067	4.367 ± 0.033	3.233 ± 0.033
T_7	8.767 ± 0.088	8.333 ± 0.088	8.067 ± 0.033	4.300 ± 0.058	4.367 ± 0.033	4.067 ± 0.033	4.467 ± 0.133	3.967 ± 0.120	4.000 ± 0.058
T_8	7.733 ± 0.088	7.733 ± 0.088	7.533 ± 0.033	4.567 ± 0.088	4.200 ± 0.058	4.067 ± 0.088	3.167 ± 0.088	3.533 ± 0.088	3.467 ± 0.067
T_9	8.267 ± 0.120	8.067 ± 0.088	7.300 ± 0.058	4.367 ± 0.033	3.800 ± 0.058	3.500 ± 0.058	3.900 ± 0.115	4.267 ± 0.033	3.800 ± 0.058
T_{10}	8.367 ± 0.088	8.033 ± 0.088	7.700 ± 0.058	4.000 ± 0.058	3.900 ± 0.058	3.700 ± 0.058	4.367 ± 0.120	4.133 ± 0.008	4.000 ± 0.100
C.D.	0.254	0.256	0.140	0.153	0.163	0.153	0.305	0.294	0.166
SE (m)	0.086	0.086	0.047	0.052	0.055	0.052	0.103	0.099	0.056
SE (d)	0.121	0.122	0.067	0.073	0.077	0.073	0.145	0.140	0.079
C.V.	1.780	1.853	1.064	2.121	2.268	2.138	4.323	4.414	2.768

3.6 Total Sugar Content

The table no. 2 shows total sugar content of different treatments in dragon fruit jam at three different storage stage (14-28 days) under ambient condition where the best outcome is not attributed to treatment, but rather to the presence of stevia treatment T_5- Lemongrass @ 2.5ml + Stevia @ 15g. T_3- 40g of coconut sugar + 3ml of tulsi. Since stevia is a better source of sugar than coconut sugar, as the TSS table demonstrates, the total sugar content is also reliant on it.

3.7 Reducing Sugar

The content of reducing sugar of jam at different treatments varied significantly which was given above table no. 2. During three different storage stages (14, 21 and 28 days) there was gradually increase reducing sugar value of jam. It is cleared from 4.2 table, treatment T_2- Tulsi @3ml + Stevia @ 15g shows best result with less reducing sugar than treatment T_9- Mint @2.5 ml + Coconut Sugar @ 40g with more reducing sugar.

3.8 Non-reducing Sugar

The non-reducing sugar content of jam at different treatments has given above table no.2. During storage of 14, 21 and 28 days interval, there was gradually decreased non-reducing sugar value of jam in most of the treatments and some treatments showed decreased value at a point of storage where treatment T_5- Lemongrass @ 2.5ml + Stevia @ 15g shows best result rather than others.

4. Discussion

According to the table 1, the result shows that decrease of TSS during storage which was similar with dragon fruit jam which was made up with different level of pectin and sugar. The total soluble solids of processed products were significantly impacted by the dissolved solids in food material (Nurani and Sulistyoningsih, 2021) [15]. Another reason was the hydrolysis of polysaccharides, which produced mono and disaccharides (Rana *et al.*, 2021) [19] and polysaccharides hydrolyze in acid to release simple soluble sugar into products (Nafri *et al*., 2021) [20] that causes increase of TSS (Krishna *et al*., 2023) [21] on processed products during the storage under ambient condition.

The increases of titratable acidity in mixed fruit jam (Rana *et al.*, 2021) [19] and orange jam (Teixeira *et al.*, 2020) [8] that shows the same outcome as the current experiment could be caused by enzymes, especially invertase, converting acids into salts and sugars. reported by Shamsudin *et al.* (2020) [22]. On the other hand, controversy result was showed on strawberry jam presented by Matos *et al.* (2022) [23].

Increased of ascorbic acid content findings are consistent with previous research conducted by Martinsen *et al*. (2020) [24] on strawberry and raspberry jam where ascorbic acid content was not remained same. There was little decreased in vit C for a certain period and after 21 days of storage it was remain unchanged due to polyphenol oxidase, cytochrome oxidase and peroxidase activity (Khan *et al.*, 2020) [25].

TSS-acid ratio was progressively reduced while the jam was being stored (Khan *et al.*, 2012) [10]. They also suggested that the decrease in this ratio was caused by an increase in TSS and titratable acid during storage clearly showed in treatment T_6 (lemongrass, 2.5 ml + 40 g of coconut sugar).

The mixed fruit jam experiment conducted by Rana *et al*. (2021) [19] yielded the same results on blending banana, coconut, and pineapple where pH was not remain same during storage. For a period of 14 to 28 days, mixed fruit jam was stored at room temperature with its pH value gradually increased and decreased. It might be due to break down of acid compounds (Rahman *et al*., 2021) [26]. Another experiment by Nafri *et al*. (2021) [20] revealed a different outcome when the pH was gradually lowered in papaya jam.

Total sugar content of treated dragon fruit jams were decreased gradually because polysaccharide is converted into sugar during storage at room temperature for 14 to 28 days, the total sugar gradually decreases on strawberry and kiwifruit jam (Cervera-Chiner *et al*. 2021) [27]. But contrast result was reported on date jam (Lakho *et al*., 2017) [18] and guava jam (Kanwal *et al*., 2017) [14].

The results of experiments conducted at room temperature by Cervera-Chiner *et al*. (2021) [27] with strawberry and kiwi fruit jam, guava jam (Kanwal *et al.*, 2017) [14] and Rana *et al.* (2021) [19] with mixed fruit jam blended with pineapple, coconut, and banana were identical. Conversely, the refrigerated storage preserves the same percentage of reduced sugar. They came to the conclusion that the possibility of glucose and fructose forming as a result of the inversion of disaccharides like sucrose may be the cause of the rising and decreasing sugar content of the jam samples (Cervera-Chiner *et al*., 2021) [27].

In guava jam storage (Kanwal *et al*., 2017) [14], sugar-free blended papaya and guava jam by Krishna *et al*. (2023) [21] and diet apricot jam, Kamal *et al.* (2015) [28] found the decreases of non-reducing sugar during storage where

Lakho *et al*. (2017) [18] reported decreased of non-reducing sugar percentage within in a certain period and then gradually increased of it which gives support to the present study. This may result from the inversion of sweetener in the presence of citric acids from non-reducing to reducing (Hazo *et al*., 2022) [29].

5. Conclusion

The current study has determined that, when it comes to alternative sugar sources, stevia is the most effective. While tulsi and lemongrass have therapeutic qualities, mint leaf extract works best as a preservative because it contains phenolic compounds, vitamins, anti-inflammatory, anti-cancer, and anti-fungal and anti-microbial qualities. Thus, among treated and untreated combinations, the combination of mint leaf extract and stevia, an alternative sugar source, is the most effective. However, consumers claim that coconut sugar is the best due to the jam's excellent flavour and colour.

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