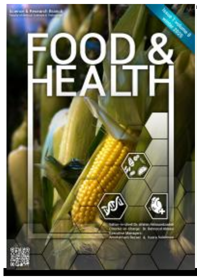
Food & Health 2025, 8(1): 32-44



Food & Health Journal

Journal homepage: sanad.iau.ir/journal/fh

Investigating the physicochemical and sensory properties of the Functional jelly powder formulation based on whey protein concentrate and licorice extract

Mohamad Javad Shakouri *[1], Melika Usefi [1], Alireza Shahab Lavasani [2]

[1] Department of Food Science and Technology, Faculty of Biological Sciences, North Tehran Branch, Islamic Azad University, P.O. Box 16511-53311, Tehran, Iran.

[2] Department of Food Science and Technology, College of Agriculture, Varamin-Pishva Branch, Islamic Azad University, Varamin, Iran.

A R T I C L E I N F O

Original Article

Article history:
Received 12 January 2025
Revised 8 February 2025
Accepted 22 March 2025
Available online 25 March 2025

Keywords:
Licorice extract
Whey powder
Jelly powder

A B S T R A C T

Today, functional foods have opened a special place in food formulation, and the confectionery industry is no exception. In this research, licorice extract and whey powder in jelly formulation with percentages of 21.25, 42.56, 63.75 and 85% of licorice extract and amounts of zero, 3.5, 10.5 and 14% of whey powder. The combined form was used. Free radical inhibition percentage tests for extracts and moisture percentage tests, colorimetry, gel formation strength, syneresis percentage, water activity level and sensory properties were investigated for the product. The brightness index, redness significantly decreased and the yellowness index, moisture percentage, water activity increased significantly. There was a significant difference between the overall acceptance desirability scores of the treatments at the 95% confidence level ($p \geq 0.05$). In general, the sensory score of overall acceptance in the treatment (T1) showed no significant differences with the control treatment ($p > 0.05$). Among the investigated features, the closest treatment to the control treatment was the treatment (T1).

1. Introduction

Nowadays, due to the increase in nutritional awareness and the change in people's attitudes in different societies, foods that improve health and reduce the risk of disease are of great interest. In addition, consumers usually prefer low-calorie foods and drinks for this reason, so that they can experience the sweet taste without receiving calories or the risk of tooth decay. It should be mentioned that these foods are very suitable for diabetics and obese people. Now, various sugar substitutes have been proposed for use in various foods, including artificial sweeteners, sugar alcohols, sugar alcohols, and new sugars (neosugars) (1). Addiction to sugar in children along with unhealthy diets increases the risk of various chronic diseases such as obesity, heart disease, tooth decay and type 2 diabetes. Excessive consumption of sugar, especially in children, can be completely harmful to a person's health. This is despite the fact that nowadays sugar can be found in all kinds of foods with different names on food labels.Another reason for high sugar consumption in children may be insufficient sleep. In children, sleep is also especially important to support growth. In general, lack of sleep interferes with the function of appetite-regulating hormones. In this brain function is disturbed and consequently the person eats foods with high calories in order to provide the energy needed by the body. In this situation, consuming sweet foods can provide this energy. Accordingly, the desire of people to eat sweet foods increases (1). Jelly is a semi-solid and transparent product that is prepared during a special process by using sugar or fruit juice or other permitted sugary substances as a sweetener and pectin or gelatin as a gel forming agent, and it may be a flavoring and coloring agent. also be added to it. In normal jellies, the presence of ester-rich materials, high amounts of sugar (65-60%, gelling agents such as pectin) and pH less than 3.5 are necessary to form a gel. At present, jelly is mostly found in the form of jelly powder, which It should be mixed with hot and cold water and coagulated in the refrigerator. Jelly powder is a salty or sweet jelly-like food that is usually prepared by adding gelatin or pectin (vegetable gelatin). Sweet gel-like foods include gelatin desserts, such as jelly powder, blanc mange, or jam. Salty gel-like foods include: aspic or plain gelatin (2).Licorice contains approximately 100 calories per ounce (28.35 grams). By boiling the root of the plant and evaporating most of its water, a black (brownish) substance is obtained.

*Corresponding author: Department of Food Science and Technology, Faculty of Biological Sciences, North Tehran Branch, Islamic Azad University, P.O. Box 16511-53311, Tehran, Iran.

E-mail address: mj.shakouri@gmail.com (Mohamad Javad Shakouri).

This substance is offered in two solid forms (extract and juice) (dressing-sauce). The main use of this substance is (in Western countries) to sweeten food products; Because it is 50 times sweeter than sucrose and has medicinal properties. The dried licorice root can be used as a seasoning. (In Western countries) Licorice extract flavor is found in a wide variety of sweet snacks (such as candy). The most popular of these sweets in England is Liqourice allsorts (3).Proteins can be widely extracted and used in the food industry. Enzymatic hydrolysis is one of the methods used to improve the functional and nutritional properties of food proteins. Hydrolysis of proteins is one of the latest technologies to produce products with high added value, and chemical and biological methods are used for this purpose. The process of using commercial enzymes instead of chemical processes or internal enzymes has many advantages, because the entire hydrolysis process is completely under control and as a result, products with specific properties are produced. Enzymatic hydrolysis of food proteins is an effective method in recovering strong bioactive peptides. Compared to enzymes of plant and animal origin, microbial enzymes have more advantages, among which the diversity of proteolytic properties and greater stability in pH and different temperatures can be mentioned. In general, Alcalase 2.4L enzyme is an enzyme that is secreted from the main cells of the stomach and helps digest proteins due to its function in alkaline pH, the production of hydrolyzed protein with a higher degree of hydrolysis and the length of pepsin. The shorter peptide chain has received the most attention (4). In this research, low-calorie protein jelly was prepared and formulated using natural antioxidants. Fruit jelly is one of the types of desserts and suitable snacks that have been researched in different countries for its low-calorie types. Francisca et al. In these products, ingredients such as gelatin, modified starch, pectin, carrageenan and gum arabic are used to achieve the desired texture.The nutritional trend of the food industry in recent years has created new challenges in the field of designing and formulating new food products with medicinal, beneficial, low-fat, low-calorie, probiotic, prebiotic and synbiotic properties. In other words, nowadays consumers prefer foods that have nutritional benefits in addition to being safe for them. The diversity of food industry products and the competitiveness of food manufacturing companies and the movement in the direction of consumers' desire and taste justify the need for research and the creation of new formulations. One of the important and influential issues in the taste of consumers is the nutritional culture of that country, which has a significant impact on the formulation and variety of products. The beverage industry is not exempt from this trend (5). Due to the limitation of food materials, especially protein materials, many researchers have turned their attention to the optimal use of available food materials and the use of food waste. Whey is a by-product of whey production, which has a higher nutritional value due to the presence of valuable nutrients, especially serum proteins. Due to the relatively large amount of whey produced in the country, which is more than 6,723,000 tons per year, finding a logical and suitable solution for using whey has always been of interest (6). The dairy industry is one of the most important and major sectors of the food industry and has a significant share of liquid waste. Therefore, large costs are needed to dispose of this waste. The wastes from the dairy industries play an essential role in the surface pollution of water and soil. These wastes have characteristics such as a high amount of organic matter (fatty acids and lactose), a significant pH range (4.2-4.9) and relatively Above the suspended solids are 0.4-0.2 grams per liter (6). Therefore, the purpose of this study is to investigate the physicochemical and sensory properties of the ultra-beneficial jelly powder formulation based on whey protein concentrate and sweet extract. It is an expression.

2. Materials & methods

2.1. Preparation of licorice plant

Each of the plants was prepared from the Medicinal Plants Research Institute located on the Karaj-Tehran highway, and after washing with distilled water at a temperature of 25 degrees Celsius and in dry shade conditions, and to prepare the extract, the roots of the plant were ground into powder by a mechanical mill. It was prepared uniformly with particles less than 30 microns.

2.1.1. Extracting the extract using the soaking method

5 grams of powdered plant sample was mixed with 175 ml of 80% methanol (volume/weight ratio: 35:1) during 24 hours using a magnetic stirrer at room temperature. The obtained mixture was filtered with Whatman number one paper and the filtered extract was kept at 2-5 degrees Celsius (refrigerator) to preserve the compounds. In the next step, the licorice extract extracted in the first step was weighed and mixed with a fresh solvent (80% methanol) at a ratio of 35:1 by volume and mixed at room temperature for 24 hours. The mixture obtained from the second step was filtered with Whatman number one paper as in the first step and the extract from this step was added to the previous extract and concentrated at 38 degrees Celsius with a rotary device and then in an oven under vacuum and at the same temperature until Reaching a constant dry weight (7).

2.2. Evaluation of DPPH free radical inhibition rate

The antioxidant capacity of the extract was determined through free radical neutralization (2 and 2-diphenyl-1-pecryl-hydrazyl (DPPH). For this purpose, 50 microliters of diluted sample extract was added along with 950 microliters of normal DPPH solution 0.1. The resulting solution was well It was shaken for 30 minutes in a dark place at room temperature, then the standard absorbance of the sample was determined using a spectrophotometer at 517 nm, and finally the inhibition of DPPH free radicals was calculated using formula 1.

$$\text{DPPH} = (\text{Ablank} - \text{Asample}/\text{Ablank}) \times 100$$

In this formula, Ablank shows the optical absorbance of the negative control that does not contain the extract, and Asample expresses the optical absorbance of different concentrations of the extract.

2.3. Evaluation of Moisture

About 5 grams of the sample was carefully weighed in a weighing container, which has already reached a constant weight, and the sample was spread at the bottom of the container with gentle movements. The container containing the sample, Germany) was placed in an oven at a temperature of 100 ± 5 °C for 3 hours. After that, the container was removed from the oven and placed in a desiccator to cool and then weighed. The difference in the weight of the sample Before and after baking, it determines the moisture content of the sample.

2.4. Evaluation of colorimetric indices

The color analysis was done with the help of Hunter Lab (England, -CAM * and b * a * 500 system (and by determining three indices L representing the lightness of the sample *. The index L is white and its range is from zero (absolute black) to 100) absolute) the degree of closeness of the color of the sample to the * colors is variable. Index a shows green and red and its range is variable from 120) -absolute green) to 120) +absolute red). The b index shows the color of the sample in blue and yellow colors and its range is variable from 120 (absolute blue) to 120 (absolute yellow) (8).

2.5. Evaluation of the ability to form a gel and the rheological characteristics of the resulting jelly

The preparation of mixed gel samples was boiled according to the coding table until the total solid material was reached. Finally, the samples were packed and cooled at 90 degrees Celsius in sterile containers with labels to form the gel network. The strength of the gel was determined using the CNS Farnell, Borehamwood, Farnell QTS (UK, Herts) histometer. The ratio of the diameter of the container to the diameter of the probe should be at least 3 to 1 in order to prevent the effect of the walls of the container on the texture properties, for this purpose. The samples were prepared in containers with a diameter of 12.5 mm. The strength of the gel is the maximum force used in this test 1 mm/s and 15 mm penetrated the samples. The maximum force required for penetration was recorded in Newtons (9).

2.6. Measurement of syneresis

The syneresis of jelly samples, as one of the important physical facts in jelly production, was measured 2 hours after closing the jelly using a centrifuge at 5000 g at ambient temperature (Hosseini Nejad et al., 2014). The amount of liquid separated from the jelly tissue was calculated in measuring containers and the percentage of syneresis was calculated based on formula 2.

Synersis percentage = total weight of separated liquid / total weight of jelly × 100

2.7. Evaluation of water activity

The water activity of jelly powder samples was determined by Sprint Novasina model 500TH device, made in Switzerland (10).

2.8. Sensory evaluation

After the preliminary training about the sensory test, 11 people (male and female, aged 24-26) were selected as evaluators. For sensory evaluation of jelly samples, 5-point hedonic method was used and influencing factors including texture, flavor, appearance color, chewability and overall acceptability were evaluated (9).

2.9. Statistical analysis

The experiment is factorial in the form of a completely random design. One-way analysis of variance was used to detect the significance of $P<0.05$ or non-significance of $P>0.05$. The comparison of means was done with Duncan's test at the 5% level. The treatments formulated in this research are presented in Table 1.

Table.1. Formulation of research treatments (%).

Treatment code	Sugars	Licorice extract	Whey powder	Gelatin
T	85	0	0	14
T1	63.75	21.25	3.5	10.5
T2	41.5	42.56	3.5	10.5
T3	21.25	63.75	3.5	10.5
T4	0	85	3.5	10.5
T5	63.75	21.25	10.5	3.5
T6	42.5	42.56	10.5	3.5
T7	21.25	63.75	10.5	3.5
T8	0	85	10.5	3.5
T9	63.75	21.25	14	0
T10	42.5	42.56	14	0
T11	21.25	63.75	14	0
T12	0	85	14	0

3. Results and discussion

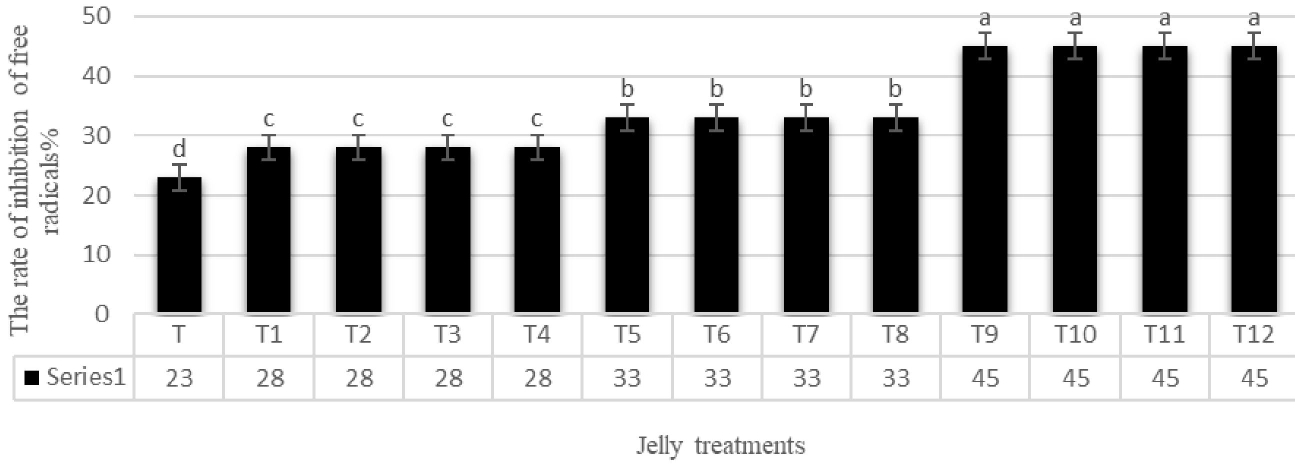
3.1. Evaluation of free radicals inhibitory rate

According to the table 2, the analysis of variance showed that the effect of the treatment on the degree of inhibition of free radicals of jelly was significant at the 99% confidence level ($p\geq0.05$).

Table.2. The analysis of variance jelly free radical inhibitory index.

Source of Variation	df	SS	MS	F	P
Treatment	10	0.05676	0.30568**	94.27	0.000
Error	22	0.07133	0.00324		
Total	32	3.12809			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.1. Comparison of the free radical inhibitory effect of jelly treatments.

According to Figure 1, it was observed that there were significant differences between the jelly treatments at different levels of licorice extract ($p \geq 0.05$). By increasing the percentage of replacing sucrose instead of licorice extract, the free radical inhibitory power increases significantly, but the use of whey powder did not show significant effects on the free radical inhibitory percentage ($p \geq 0.05$). Finally, the jelly treatment with 85% licorice extract has the highest rate of free radical inhibition and the control treatment has the lowest rate of free radical inhibitory power. By increasing the concentration of licorice extract in the formulation, the inhibition rate of free radicals increased. One of the important reasons related to this is related to the inhibitory power of plant extracts. In general, phenols and polyphenols are widely found in many foods of plant origin and can have very high antioxidant effects. The mechanism of action of flavonoids for their antioxidant effect is to collect free radicals such as superoxide, anions, lipid peroxide radicals and hydroxyl radicals. In addition, they have the ability to trap single oxygen and chelate metals. The stable DPPH radical scavenging model is used to evaluate the free radical scavenging ability of different samples. The DPPH radical is a stable free radical with a central nitrogen atom that changes color from purple to yellow upon reduction and production of the stable H-DPPH molecule.DPPH radical has absorbance at 115 nm, but upon reduction by an antioxidant, absorbance decreases. The antioxidant activity of the samples is expressed as the disappearance of the purple color. According to the reduction percentage of the studied extract, it has good antioxidant properties and can be a good substitute for synthetic antioxidants. The DPPH method is a simple, fast and inexpensive method to measure the antioxidant capacity of foods. DPPH is a stable radical and is inactive as a hydrogen acceptor and is widely used to study the antioxidant properties of bioactive compounds isolated from plant extracts. The reducing power shows the electron donating ability of the antioxidant. If a compound has this characteristic, it can reduce the amount of oxidized intermediate compounds made during lipid peroxidation stages. In this way, it breaks the reaction chain and can act as a primary and secondary antioxidant (11). There are various studies to investigate the antioxidant effects of plant extracts. It is obvious that in this research, with the increase in the percentage of licorice extract, the amount of bioactive compounds as well as antioxidants in it increases significantly. According to this mechanism, antioxidants prevent further chain reactions by giving a hydrogen atom to the free radical formed at the beginning of the oxidation process. From this point of view, the efficiency and degree of effect of an antioxidant depends on the ease of separation of this hydrogen atom from it. Of course, the free radical produced from the antioxidant after giving hydrogen, should not cause the creation of fatty acid free radical and begin its oxidation, and also it should not be quickly oxidized by oxygen. In general, in the strengthening phenomenon or the occurrence of antagonism in the presence of a mixture of two antioxidants, these three characteristics must be affected in a positive or negative way. The presence of licorice extract increased the free radical inhibitory activity due to its triterpene compounds, and in the treatments that used both algae, especially with the increase in the percentage of these compounds, the free radical inhibitory percentage index significantly increased. You have increased. Among them, Akbari Lalai et al. (2014) investigated the antioxidant effects of the ethanolic extract of kara green algae collected from the wetlands of Sari city and confirmed the inhibitory level of free radicals in high concentrations of the extract, which is in agree with the findings of the current research (12).

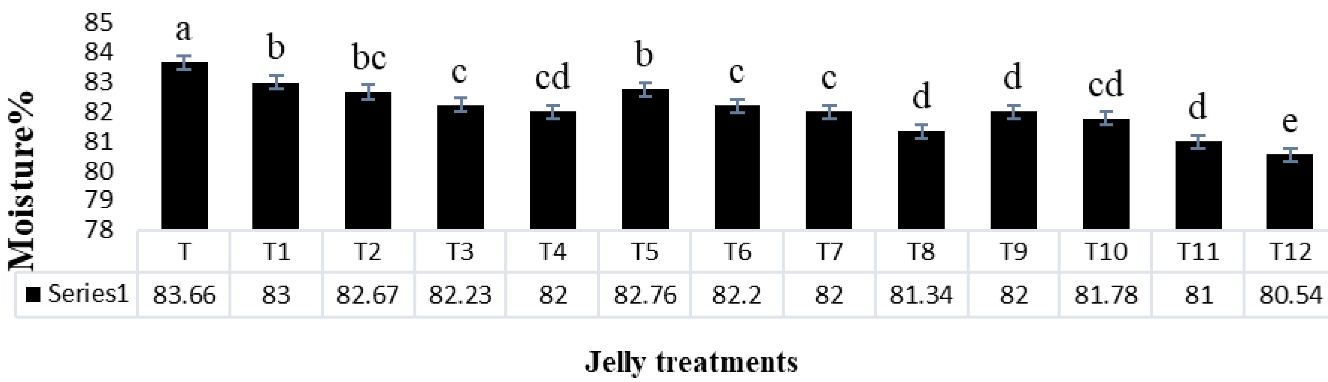
3.2. Evaluation of moisture (%)

According to the analysis of variance table 3, it was observed that the effect of the treatment on the moisture percentage of the jelly treatments was significant at the 95% confidence level (p≥0.05). According to Figure 2, it was observed that the effect of using licorice extract is significant on the moisture content of the whole jelly treatments (p≥0.05). By increasing the percentage of using licorice extract instead of sucrose, the moisture percentage of the jelly treatments decreased significantly (p≥0.05). According to the reduction of sucrose in the jelly formulation, with the reduction of the amount of polyol groups, the percentage of total moisture is significantly reduced (p≥0.05). Therefore, the moisture percentage of the total jelly treatments decreased significantly (p≥0.05). In this regard, there were also similar researches (p≥0.05).

Table.3. The analysis of variance jelly free radical inhibitory index.

Source of Variation	df	SS	MS	F	P
Treatment	10	0.05579	0.30667**	92.21	0.000
Error	22	0.07256	0.00321		
Total	32	3.12200			
Coefficient of Variation	0.05593			Correlation coefficient	97.61

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.2. Comparison of moisture percentage of jelly treatments.

Also, based on the results of using whey powder, the percentage of total moisture was significantly reduced due to the ability of whey proteins to absorb moisture and the hydrophilic properties of casein molecules. Jelly treatment with 14% whey powder was significantly higher than other jelly treatments (p≥0.05). In this regard, there were also similar researches. Yazdani et al. Jelly treatments are significantly reduced, which is in line with the results of the present research (13).

3.3. Evaluation of colorimetric indices

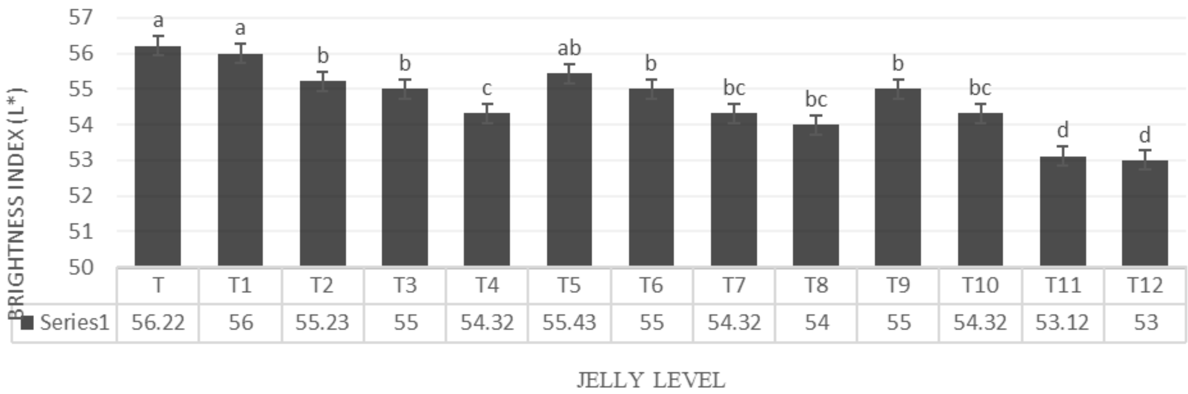
3.3.1. Brightness index (L)*

According to the analysis of variance table 4, it was observed that the effect of the treatment on the level of brightness index (L*) of the jelly treatments was significant at the 95% confidence level (p≥0.05). According to Figure 3, it was observed that the brightness index (L*) of the jelly treatments decreases significantly with the increase in the concentration of extract and whey powder (p≥0.05). The highest brightness index (L*) was observed in the control jelly treatment and the lowest in the jelly treatment with 14% whey powder and 100% licorice extract (p≥0.05). There was a significant decreasing trend with increasing percentage of whey powder and licorice extract (p≥0.05).

Table.4. Analysis of Variance brightness index (L*) of jelly.

Source of Variation	df	SS	MS	F	P
Treatment	10	249872.9	62468.2**	34704.57	0.000
Error	22	18.0	1.8		
Total	32	249890.9			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.3. Comparison of moisture percentage of jelly treatments.

Considering that licorice extract contains xanthophyll and carotenoid compounds, increasing its use can significantly increase the brightness index (L*) of jelly treatments ($p \geq 0.05$). One of the other reasons for the decrease in the lightness index (L*) of jelly treatments is due to the color of whey powder composition, which increases the amount of lightness index (L*) of jelly treatments.

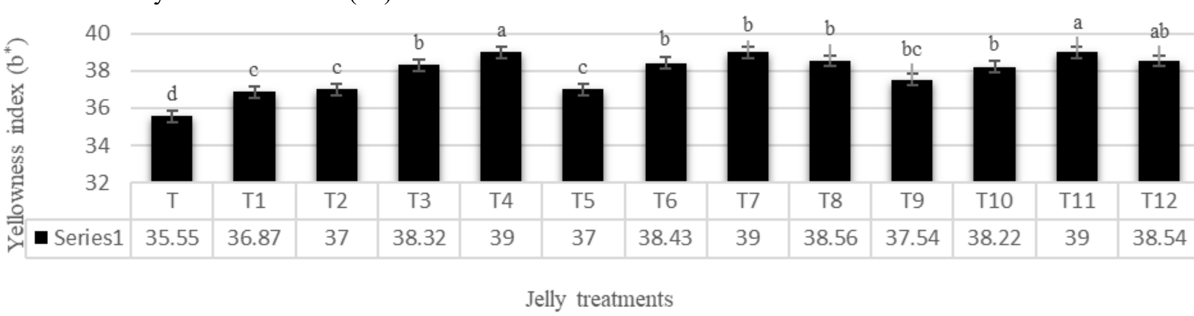
3.3.2. Yellowness index (b)*

According to the analysis of variance table 5, it was observed that the effect of the treatment on the amount of yellowness index (b*) of the jelly treatments was significant at the 95% confidence level ($p \geq 0.05$). According to Figure 4, it was observed that the yellowness index (b*) of the jelly treatments increases significantly with the increase in the concentration of extract and whey powder ($p \geq 0.05$). The lowest amount of yellowness index (b*) was observed in the control jelly treatment and the highest in the jelly treatment with 14% whey powder and 100% licorice extract ($p \geq 0.05$). There was a significant decrease in the yellowness index (b*) with the increase in the percentage of whey powder and licorice extract ($p \geq 0.05$).

Table.5. Analysis of variance jelly yellowness index (b*).

Source of Variation	df	SS	MS	F	P
Treatment	10	5677.21	141.80**	20.77	0.000
Error	22	68.28	6.63		
Total	32	635.49			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.4. Comparison of yellowness index (b*) of jelly treatments.

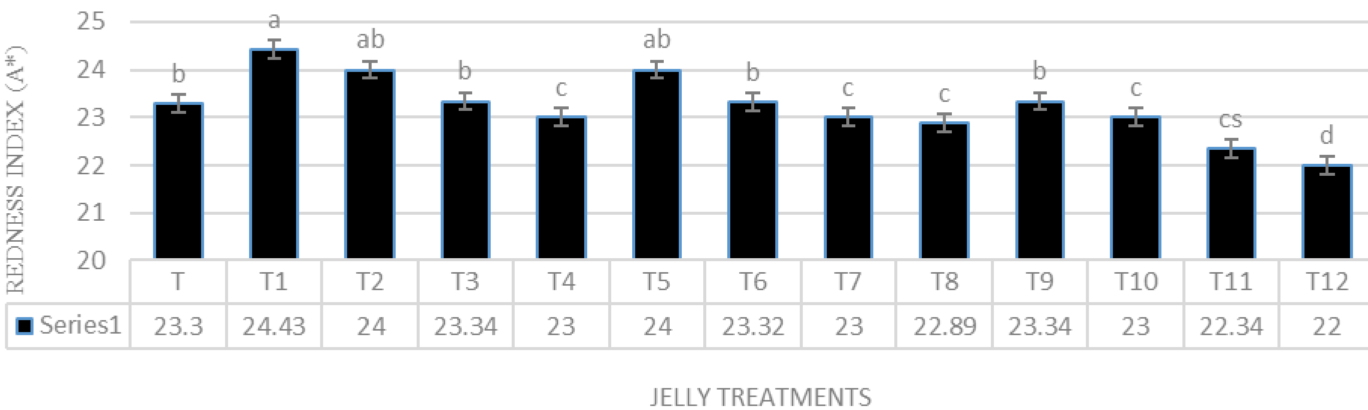
3.3.3. Redness index (a)*

According to the analysis of variance table 6, showed that the effect of the treatment on the amount of redness index (a*) of the jelly treatments was significant at the 95% confidence level ($p \geq 0.05$). According to figure 5, it was observed that the redness index (a*) of the jelly treatments increases significantly with the increase in the concentration of extract and whey powder ($p \geq 0.05$). The lowest amount of redness index (a*) was observed in the control jelly treatment and the highest in the jelly treatment with 14% whey powder and licorice extract percentage ($p \geq 0.05$). There was a significant decrease in the redness index (a*) with an increase of 85% in the use of whey powder and licorice extract ($p \geq 0.05$).

Table.6. Analysis of Variance of the redness index (a*).

Source of Variation	df	SS	MS	F	P
Treatment	10	23.85906	5.96479	1139.77	0.000
Error	22	0.05244	0.00523		
Total	32	23.91149			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.5. Comparison of yellowness index (b*) of jelly treatments.

3.4. Evaluation of the ability to form a gel and the rheological characteristics of the resulting jelly

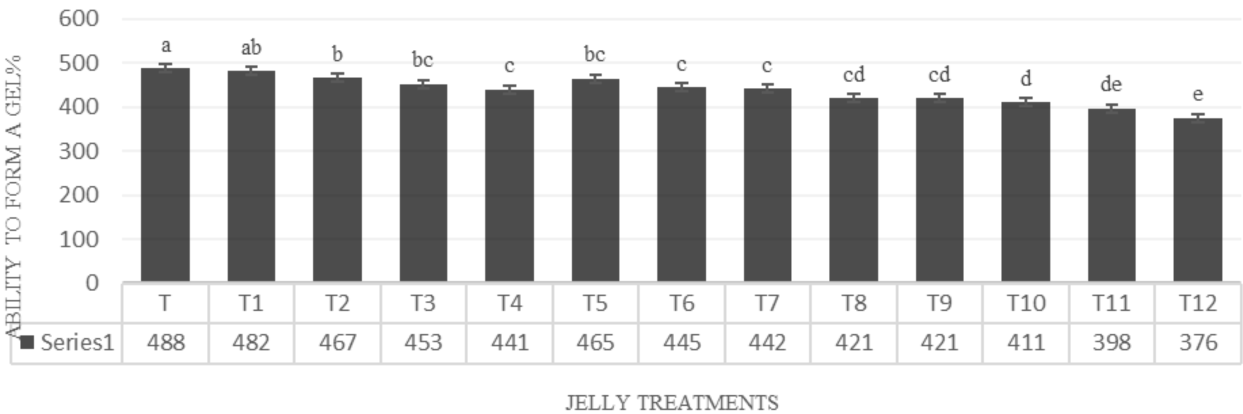
According to the analysis of variance table 7, it was observed that the effect of the treatment on the gel formation index of the jelly treatments was significant at the 95% confidence level ($p \geq 0.05$). By increasing the percentage of sweet extract and whey powder to 100% and 14%, the strength of gel formation decreases significantly, which is due to the disturbance of acidity and balance between water and sucrose molecules in gel formation. It was conclude that with the increase in the percentage of each licorice extract, the acidity increased significantly, and this increase also affected the gel forming power, also, due to the high absorption of jelly moisture, whey powder can reduce the percentage of jelly moisture and significantly reduce the strength of gel formation. However, in T1 treatment, with total amounts of 3% of sweet extract and whey powder, the amount of gel formation strength decreases by 3% (Figure 6).

Yazdani et al.(1400) in the study of the preparation of low-calorie sour tea jelly with chicken skin gelatin and stevia and its qualitative properties, found that increasing the percentage of the extract significantly reduced the strength of the gel, which is in line with the findings of the present study. was in agreement (13). Hossein et al. (2009) in investigating the effects of using high amounts of fruit juice on the concentration of guava jelly found that a high concentration of fruit juice significantly reduces the strength of gel formation, which was in agreement with the findings of the present study.

Table.7. Analysis of variance of the gel forming ability index.

Source of Variation	df	SS	MS	F	P
Treatment	10	4.90667	0.22667**	230.00	0.000
Error	22	0.05333	0.005333		
Total	32	4.96000			
Coefficient of Variation	0.05694			Correlation coefficient	98.92

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.6. Comparison of gel formation index of jelly treatments.

3.5. The amount of syneresis

According to the analysis of variance table 8, it was observed that the effect of the treatment on the amount of brix of the jelly treatments was significant at the 95% confidence level ($p \geq 0.05$). According to figure 7, it was observed that there was a significant difference between the amount of watering percentage of the jelly treatments and the control jelly treatment ($p \geq 0.05$). With the increase in the use of licorice extract, the percentage of water-flooding in each of the jelly treatments decreased significantly, and this decrease had an inverse relationship with the increase in the use of licorice extract ($p \geq 0.05$). Watering means the ability to preserve the water inside the jelly tissue and this feature is effective in maintaining the appearance quality of the jelly tissue in the shelf life of the product and preventing the growth of microorganisms. Synersis of jelly samples is one of the important physical factors in jelly production. The measurement of food syneresis is mostly for foods that have a gel-like state and have formed a network containing water, such as jelly and hydrogel. Synersis results indicate the stability of all jelly samples. The lack of increase in syneresis means the ability to retain water inside the jelly tissue (14). The reason for the watering of samples containing licorice extract is due to the reduction of sucrose resources for the formation of bonds, the reduction of soluble solids, as well as the reduction of the ability to form bonds and trap water inside the network, which increases the amount of syneresis. Also, the use of licorice extract plays an effective role in reducing the amount of effective bonds and the percentage of water retention due to the changes they cause in the acidity and can significantly increase the syneresis percentage during the storage period. . The active substance of licorice, called the composition of the extract of this plant, contains the composition of glycyrrhizin, glycyrrhizic acid and potassium and calcium salts. The percentage of using this composition, the percentage of trapping water molecules decreases and finally the percentage of syneresis increases significantly. In this regard, there were also similar researches. In Mohammadi et al.'s review (2018), they investigated the bioactive compounds of Cystoseria sp. brown algae extract and evaluated the physicochemical and sensory properties of edible jelly enriched with it and found that the use of algae extract In the jelly formulation, the use of high amounts significantly increased the syneresis percentage index, which was in agreement with the findings of the present research (15).

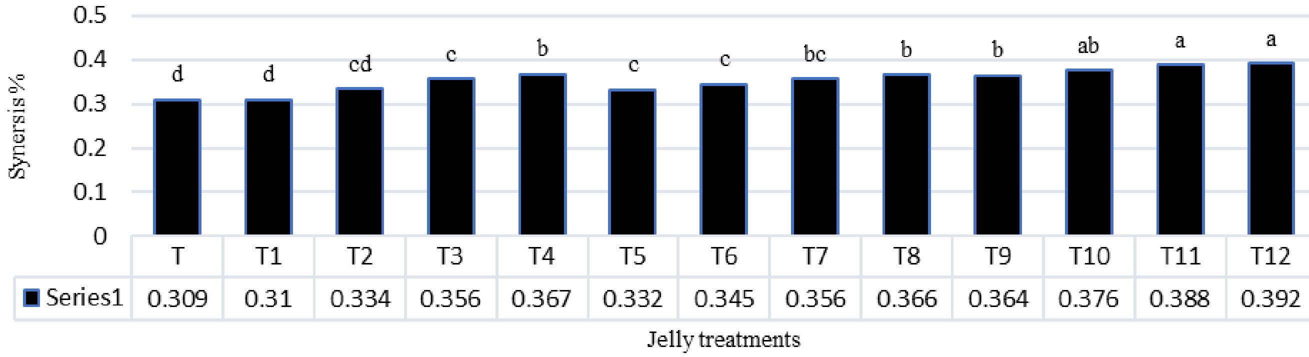
Table.8. Analysis of variance of jelly syneresis index.

Source of Variation	df	SS	MS	F	P
Treatment	10	0.0794767	0.0079477	336.25	0.000
Error	22	0.0005200	0.0000236		
Total	32	0.0799967			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.

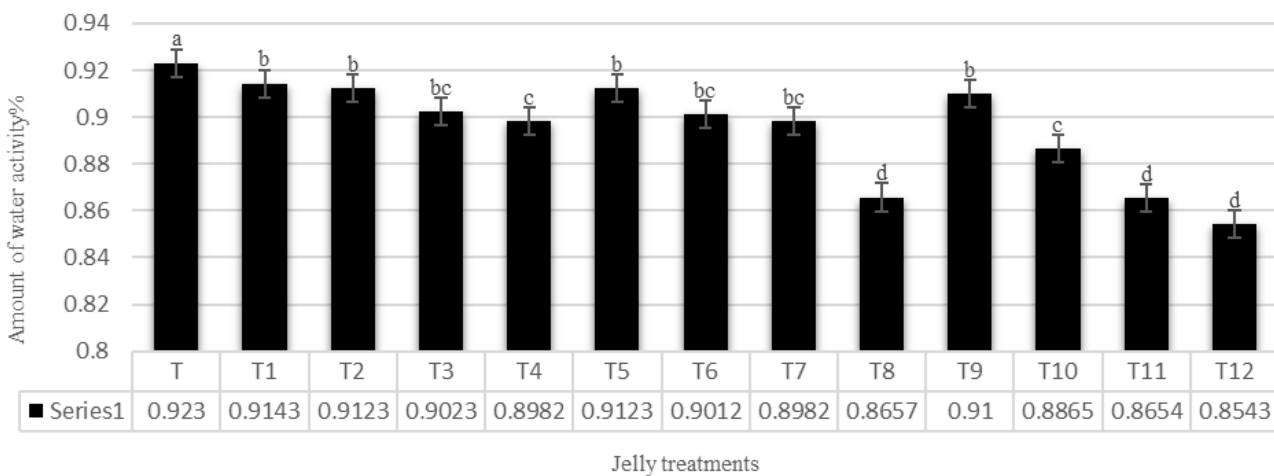
3.6. Evaluation of water activity

According to the analysis of variance table 9, it was observed that the effect of the treatment on the amount of water activity of the jelly treatments was significant at the 95% confidence level ($p \geq 0.05$). According to figure 8, it was observed that the water activity index of jelly treatments increases significantly with the decrease of sucrose in the jelly formulation and the increase of whey powder ($p \geq 0.05$). The lowest water activity index was observed in the control jelly treatment and the highest in the jelly treatment with 14% whey powder and licorice extract percentage (p≥0.05). There was a significant decreasing trend in the water activity index with an increase of 85% in the use of whey powder and licorice extract (p≥0.05).



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.7. Synersis comparison of jelly treatments.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.8. Comparison of water activity of jelly treatments.

In general, by increasing the amount of licorice extract in the formulation of the jelly treatments, the amount of water activity of the jelly treatments decreased significantly (p<0.05), and the highest amount of water activity index was observed in the control jelly treatment and the lowest amount of water activity index was in the jelly treatment with the highest amount of licorice extract. One of the reasons for these changes is due to the presence of sucrose in creating high osmotic pressure and also creating a link with accessible water in the formulation of jelly treatments, due to the lower dissolution of sugar compounds of licorice extract compared to sucrose from the amount of water activity of jelly treatments. The chemical compounds of licorice root include glycyrrhizin acid, glucuronic acid, glucoside, saponin and tannic acids, starch, glucose, sucrose, resin, mannitol, bitter substances, volatile oils, flavonoid compounds, coumarin and vitamin B, which is similar to sucrose in creating Bonding with water molecules does not work, therefore, in jelly treatments with licorice extract, the percentage of calories in jelly treatments is significantly reduced. Also, due to the absorption of high percentage of water moisture from jelly formulation, whey powder significantly reduces the amount of water activity of jelly treatments (p≥0.05). In this regard, there was also a similar research.

Syukri et al. (2023) in the study of the use of stevia powder in the formulation of low-calorie Bolu Kemojo cake, found that the use of stevia powder significantly reduces the amount of water activity of cake treatments, which is in agreement with the findings of the present research (16). Khosravi et al. (1400) also found that the use of licorice extract significantly reduced the amount of water activity in cookie treatments, which is in line with the research findings (17).

Table.9. Analysis of variance of jelly syneresis index.

Source of Variation	df	SS	MS	F	P
Treatment	10	0.05676	0.30568**	94.27	0.000
Error	22	0.07133	0.00324		
Total	32	3.12809			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.

3.7. Sensory evaluation

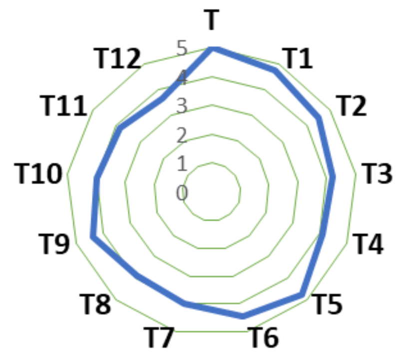
3.7.1. Texture sensory scores of Jelly Treatment

Table.10. Analysis of variance of texture sensory scores of jelly.

Source of Variation	df	SS	MS	F	P
Treatment	10	190.2307	47.5577**	557.32	0.000
Error	22	0.8533	0.0853		
Total	32	191.0940			
Coefficient of Variation	0.05694			Correlation coefficient	99.37

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.

According to the analysis of variance table 10, it was observed that the effect of the treatment on the sensory desirability of the jelly texture was significant at the 95% confidence level (p≥0.05). According to figure 9, it was observed that the effect of the treatment on the sensory scores of the jelly tissue of the jelly treatments is significant at the level of 0.05 (p≥0.05). By increasing the percentage of licorice extract and whey powder in amounts higher than T1, the sensory index scores of the jelly texture of the jelly treatments decrease significantly (p≥0.05). Among the jelly treatments, the highest degree of desirability of jelly texture sensory scores belongs to T1 treatment, which has the same desirability of texture sensory scores, and the lowest degree of desirability of jelly texture sensory scores is in the treatment of jelly with licorice extract and whey powder (p≥0.05). The texture of jelly treatments due to the reduction of sucrose and the ability to form a porous structure in amounts of 42.56% can affect the sensory desirability of the tissue and significantly reduce it. Also, due to the increase in the use of whey powder and the lumpiness of the jelly texture in high amounts and the decrease in the moisture content of the jelly texture, the desirability of the jelly texture decreased, and there were also similar articles in this regard.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.
Figure.9. Texture sensory scores of jelly treatments.

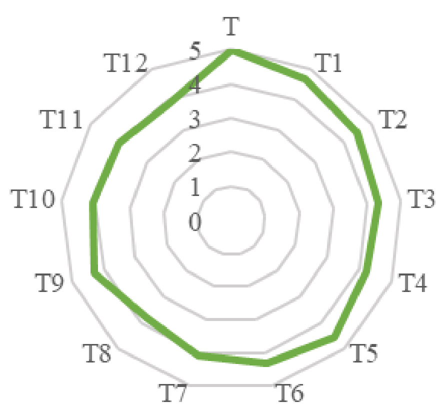
3.7.2. Evaluation of sensory scores of jelly porosity

According to the analysis of variance table 11, it was observed that the effect of the treatment on the amount of sensory scores index of porosity of the jelly treatments was significant at the 95% confidence level (p≥0.05). According to figure 10, it was observed that the effect of treatment on the amount of jelly porosity sensory scores of jelly treatments is significant at the level of 0.05 (p≥0.05). By increasing the percentage of licorice extract and whey powder in amounts higher than T1, the sensory index scores of jelly porosity of jelly treatments decrease significantly (p≥0.05). The highest level of sensory desirability of jelly porosity sensory scores among the jelly treatments belongs to T1 treatment, which has similar porosity sensory scores, and the lowest level of jelly porosity sensory scores is in the treatment of jelly with licorice extract and whey powder. In general, tissue porosity in all grain and sugar industry products is related to sucrose, and it is obvious that by reducing the percentage of sucrose in the formulation of jelly treatments, the percentage of porosity decreases significantly. Whey and the isoelectric capacity of whey molecules are high, which can disturb the air bubbles and reduce the water holding capacity, and there was also similar research in this direction. Wani et al. (2015) showed the effects of protein powder concentrate on the physicochemical properties, texture and microbial evaluation of cookies. Whey protein concentrate can be entered at different levels of zero, 2, 4 and 6%. By increasing the amount of whey concentrate used in high amounts, the sensory desirability of porosity decreased significantly, which was in line with the findings of the current research (18).

Table.11. Analysis of variance of jelly porosity index.

Source of Variation	df	SS	MS	F	P
Treatment	10	0.05676	0.30568**	94.27	0.000
Error	22	0.07133	0.00324		
Total	32	3.12809			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

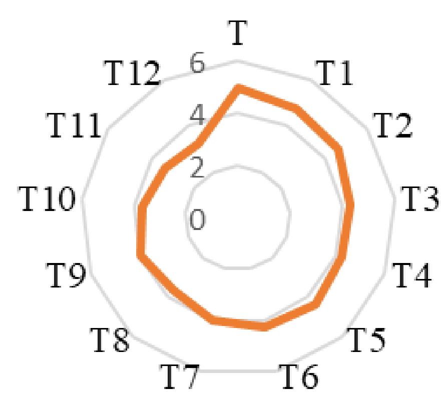
* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.
Figure.10. Porosity sensory scores of jelly treatments.

3.7.3. Sensory evaluation of chewing ability

According to the analysis of variance table 12, it was observed that the effect of the treatment on the amount of chewability sensory scores of the jelly treatments was significant at the 95% confidence level (p≥0.05). According to figure 11, it was observed that the effect of the treatment on the amount of chewability sensory scores of jelly treatments is significant at the level of 0.05 (p≥0.05). By increasing the percentage of using licorice extract and whey powder in amounts higher than T1, the sensory index scores of jelly treatments decrease significantly (p≥0.05). The highest level of chewability among the jelly treatments belongs to the T1 treatment, which has a similar overall acceptability, and the lowest level of chewability is found in the jelly with licorice extract and whey powder (p≥0.05). Also, based on the results, it was found that by reducing the percentage of sucrose in the formulation of jelly treatments, the amount of chewing ability decreases significantly (p≥0.05). One of the reasons for the decrease in the desirability of the chewability of jelly treatments is due to the characteristic of sucrose in creating the desired texture and also the crispness of the product, considering that the licorice extract has a lower percentage of sucrose than the jelly formulation, as evidenced by the increase in the percentage of using the extract. Licorice instead of sucrose significantly decreases the percentage of favorability of chewing ability (p≥0.05). Also, whey powder in high amounts of use can create a lumpy texture due to the reduction of the dissolution percentage, which can significantly reduce the sensory desirability of the chewability of jelly treatments.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.
Figure.11. Sensory scores of chewability of jelly treatments.

Table.12. Analysis of variance of chewing ability sensory index of jelly.

Source of Variation	df	SS	MS	F	P
Treatment	10	4.90667	0.22667**	230.00	0.000
Error	22	0.05333	0.005333		
Total	32	4.96000			
Coefficient of Variation	0.05694			Correlation coefficient	98.92

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.

Sabohi et al. (2019) investigated the effects of using stevia and isomalt sweeteners to produce low-calorie milk chocolate and found that increasing the percentage of stevia significantly reduces the chewability of chocolate treats (19) which was consistent with the results of the present study. Gallagher et al. (2003) investigated the effects of whey isolate and sodium caseinate on the short dough biscuit formulation and examined the properties of the dough and the final product. Dairy powders were added in amounts of 5, 10, 15% of flour weight, and with the increase in the percentage of dairy powder usage, the hardness percentage of biscuit treatments showed a significant increase, which is in agreement with the findings of the present research (20).

3.7.4. Sensory evaluation of acceptability

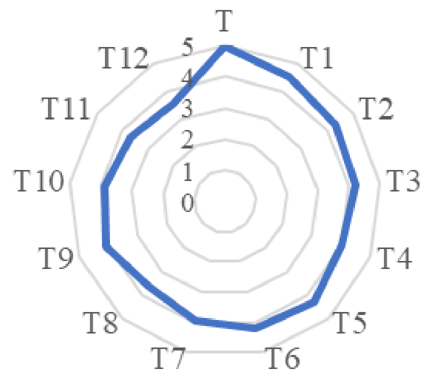
According to the variance analysis table 13, it was observed that the effect of the treatment on the overall acceptance of the jelly treatments was significant at the 95% confidence level (p≥0.05). According to figure 12, it was observed that the effect of the treatment on the amount of sensory scores of general acceptance of jelly treatments is significant at the level of 0.05 (p≥0.05). By increasing the percentage of licorice extract and whey powder in amounts higher than T1, the sensory index scores of general acceptance of jelly treatments decrease significantly (p≥0.05). Among the jelly treatments, the highest level of overall acceptance desirability belongs to the T1 treatment, which has similar overall acceptance desirability, and the lowest overall acceptance desirability is in the jelly treatment with licorice extract and whey powder (p≥0.05).

Table.13. Analysis of variance of sensory index of acceptability.

Source of Variation	df	SS	MS	F	P
Treatment	10	5.81067	1.45267**	217.90	0.000
Error	22	0.06667	0.066677		
Total	32	5.87733			
Coefficient of Variation	0.05694			Correlation coefficient	97.72

* Means significant at the 0.05% level, the ** means significant at the 1% level, the ns sign is not significant at the 0.05% level.

General acceptance is a set of traits studied in research and sensory evaluation. Due to the fact that the amount of sensory desirability in all jelly treatments decreased significantly (p≥0.05) with an increase in the percentage of sucrose replacement. After the control treatment, the T1 treatment with the minimum amount of licorice extract replacement of 21.25% licorice extract and 3.5% whey powder was evaluated as favorable by the evaluators and with the continued increase in the process of replacing licorice extract with sucrose and also decreasing The amount of gelatin and the replacement of whey powder showed a significant decrease in the sensory desirability of overall acceptance (p≥0.05). The worst level of sensory desirability of overall acceptance belonged to the treatment with 85% licorice extract and 14% whey powder.



T = control treatment T1 = treatment with 21.25% licorice extract and 3.5% whey powder T2 = treatment with 42.56% licorice extract and 3.5% whey powder T3 = treatment with 75.63% licorice extract and 3.5% whey powder T4 = treatment with 85% licorice extract and 3.5% whey powder T5 = treatment with 21.25% licorice extract and 10.5% whey powder T6 = treatment with 42.56% licorice extract and 10.5% whey powder T7 = treatment with 75.63% licorice extract and 10.5% whey powder T8 = treatment with 85% licorice extract and 10.5% whey powder T9 = treatment with 21.25% licorice extract and 14% whey powder T10 = treatment with 42.56% licorice extract and 14% whey powder T11 = treatment with 63.75% licorice extract and 14% whey powder T12 = treatment with 85% licorice extract and 14% Whey powder.

Figure.12. Sensory score of general acceptability of jelly treatments.

4. Conclusion

The use of licorice extract in the formulation of jelly treatments showed significant effects on the acidity index (p≥0.05). By increasing the use of licorice extract, the Brix, synersis and total sugar percentage of each jelly treatment decreased significantly. By increasing the percentage of sweet extract and whey powder to 100% and 14%, the gel forming power decreased significantly. The brightness index (L*) of the jelly treatments decreased significantly with the increase in the concentration of extract and whey powder (p≥0.05). The yellowness index (b*) and redness index (a*) of the jelly treatments increased significantly with the increase in the concentration of extract and whey powder (p≥0.05). The amount of water activity of the jelly treatments increased significantly by reducing the amount of sucrose in the jelly formulation and increasing the whey powder (p≥0.05). After the control treatment, the T1 treatment with the minimum amount of licorice extract replacement of 21.25% licorice extract and 3.5% whey powder was evaluated as favorable by the panelists..

References

1. *Rodbotten M, Martinsen BK, Borge GI, Mortvedt HS, Knusten SH, Lea P, Naes T. A cross-cultural study of preference for apple juice with different sugar and acid contents. Food Quality and Preference. 2009; 20: 277-284.*
2. *Fiszman SM, Lluch MA, Salvador A. Effect of gelatin on microstructure of acidic milk gels and yoghurt and on their rheological properties. International Dairy Journal. 2016; 9: 895–901.*
3. *Khan Ahmadi M, Naqdi Badi HA, Akhundzadeh Z, Khalighi Sigaroudi F, Mehr Afarin A, Shahriari S, Haji Aghaei R. A review of the medicinal plant Licorice L glabra Glycyrrhiza. Quarterly Journal of Medicinal Plants. 2011; 12(46): 1-12.*
4. *Shekarpour rudbari R, Motamedzadegan A, Hosseini Parvar S, Ovysipour M. The effect of hydrolysis intensity on nitrogen recovery and molecular size of white chin shark (Carcharhinus dussumieri) protein. Electronic Journal of Food Processing and Preservation.2010; 2(2): 99-110.*
5. *Haskaraca G, Demirok E, Kolsarıcı N, Öz F, Özsaraç N. Effect of green tea extract and microwave pre-cooking on the formation of heterocyclic aromatic amines in fried chicken meat products. Food Research International. 2014; 63: 373-381.*
6. *Katibeei Moradi Z, Haghighi Khammami M, Kiyomurthi H, Dehfanzadeh H, Tamdani Jahormi S. Whey recycling, a suitable approach to prevent environmental damage. Environmental Research and Technology. 2019; 5(7): 91-99.*
7. *Ebrahimzadeh MA, Hosseinimehr SJ, Hamidinia A, Jafari M. Antioxidant and free radical scavenging activity of Feijoa Sellowiana fruits peel and leaves. Pharmacology. online. 2008; 1: 7-14*
8. *Atai Nokabadi F, Nahchiri N, Karamat J, Momeni Shahraki M. Investigating the effect of replacing wheat flour with mung bean powder on texture, physicochemical and sensory characteristics of sponge cake. Iran Food Science and Industry Research Journal. 2022; 18(2): 195-202.*
9. *Peng Z, Regenstein JM. Comparison of water gel desserts from fish skin and pork gelatin using instrumental measurements. Journal of Food Science. 2007; 72 (4):197-201.*
10. *Hosseini Nejad M, Mohteshmi M, Kamali S, Elahi M. Optimization of low-calorie fruit jelly powder formulation using sucralose and isomalt sweeteners. Research and Innovation in Food Science and Technology (JRIFST). 2014; 4(1): 65-74.*
11. *Yen GC, Chen HY. Antioxidant Activity of Various Tea Extracts in Relation to Their Antimutagenicity. Journal of Agriculture and Food Chemistry. 1995; 43(1): 27-32. Doi: 10.1021/jf00049a007.*
12. *Akbari Lalaei A, Dehpour joibari A, Rezaei S, Hashemian SF, Taheri M, Kiaei M, and Eshghi Z. Investigating the antioxidant effects of the ethanolic extract of green algae collected from the wetlands of Sari city. 2014.*
13. *Yazdani F, Bardani Amiri Z, Shahiri Tabarestani H. Preparation of low-calorie sour tea jelly with chicken skin gelatin and stevia and checking its quality properties. Food Science and Nutrition, 2021; 18(3): 55-68.*
14. *Hossain Md F, Parvez Md A Kh, Munshi Md M K, Khalil Md I, Huque R. Effect of radiation and chemical treatments on guava (Psidium guajava L.) to delay ripening in relation to organoleptic biochemical and microbiological properties. International Journal of Current Microbiology and Applied Sciences 2014; 3(12): 19-36.*
15. *Mohammadi M, Mohibi Gh, Bolourian MM, Barmaker R, Ehsandost, A. Identification of bioactive compounds of Cystoseria.sp brown algae extract and evaluation of physicochemical and sensory properties of edible jelly enriched with it. Food Science and Nutrition. 2018; 17: 25-38.*
16. *Syukri D, Fitriani D, Jaswandi, Dewi KH. Using stevia powder to make low calorie Bolu Kemojo(Kemojo Cake)-Traditional Snack in Riau Province, Indonesia. Food Science and Technology. 2023; 11(1): 1-6.*
17. *Khosravi A, Masoud Nia A, Ziabari SF. Investigating the effect of Shirin Bayan on the physicochemical and sensory properties of gluten-free cookies containing millet and soybean flour. Iranian Journal of Food Science and Technology. 2021; 18(115): 37-47.*
18. *Wani SH, Gull A, Allai F, Safapuri TA. Effects of incorporation of whey protein concentrate on physicochemical, texture, and microbial evaluation of developed cookies. Cogent Food & Agriculture. 2015; 1: 1-9.*
19. *Sabohi MR, Baranji S, Nateghi L. Investigating the effects of using stevia and isomalt sweeteners to produce low-calorie milk chocolate. Iran food science and industry. 2019; 17(99): 31-44.*
20. *Gallagher E, O'Brien CM, Scannell AGM, Arendt EK. Evaluation ofsugar replacers in short dough biscuit production. Journal of Food Engineering. 2003; 56(2): 261–263.*