Journal of Food Science and Technology (Iran)

Homepage:www.fsct.modares.ir

Scientific Research

Investigation of the physical properties of starch extracted from saffron corm and its use in dairy dessert formulation

Sanaz Nadafimoghadam[1], Hojjat Karazhian[2], Zohreh Abdi-Moghadam*[3]

1- Graduated of master of Food Safety and Hygiene, School of Medicine, Gonabad University of Medical Sciences, Gonabad, Iran

2- Department of Food Science and Technology, Torbat-e Heydarieh Branch, Islamic Azad University, Torbat-e Heydarieh, Iran

3- Department of Nutrition, and Food Sciences, School of Medicine, Gonabad University of Medical Sciences, Gonabad, Iran

ARTICLE INFO

Article History:

Received:2024/9/20

Accepted:2025/1/27

Keywords:

corn starch,

saffron corm,

rheological properties,

dairy dessert,

texture analyzing

DOI: **10.22034/FSCT.22.163.151.**

*Corresponding Author E-

z.abdimoghadam1@gmail.com

ABSTRACT

Starch is the most important source of stored energy in plants, which is abundantly found in cereal grains and tuberous plants. Due to the improvement of textural characteristics and rheological properties, it can be used to adjust the consistency of dairy food products. Saffron corms have a significant amount of starch and large quantities of saffron seeds are produced in the country every year. The purpose of this research is to prepare a dairy dessert with different percentages of saffron corm starch replaced with corn starch and to investigate the physical and rheological properties as well as the possibility of using saffron corm starch in dairy dessert formulation. First, the extraction of saffron corm starch was done with the help of water and centrifuge, and the tests of paste transparency, minimum gelling concentration, swelling power, solubility, water absorption and determining the flow behavior of the samples were done using common models of power law, Herschel model. Buckley and Bingham model were used to fit shear stress data on shear degree. Then, 5 dairy dessert samples were prepared with 0 (control), 5, 10, 15 and 20% of saffron corm starch replaced with corn starch and the texture, wateriness, color and sensory evaluation of the desserts were investigated. The fitting of the models showed that among the existing models, only the power law model expresses the flow behavior of the samples well. The consistency coefficient of the samples, K, varied from 0.865 to 0.557 and the flow behavior index number for saffron corm starch was 0.36. Apparent viscosity also decreased with increasing shear rate. The texture evaluation results of the desserts also showed that the stickiness, stickiness, gummy property, and hardness of the dessert decreased with the increase in the concentration of starch replacement, and the consistency of the samples did not change significantly, and the increase in saffron corm starch resulted in a soft texture. With the increase in the percentage of saffron corm starch, watering and brightness (L*) also decreased, and the analysis of sensory properties showed that the level of satisfaction with color, smell, texture, taste, and overall acceptability decreased. According to the findings of the present study, saffron corm starch suspension is one of pseudoplastic non-Newtonian fluids, and saffron corm starch sample is very suitable for use in formulations that require less viscous texture or more favorable mouthfeel. It was possible to produce a dairy dessert using saffron corm starch and it has a more suitable softness than the dessert made from corn starch, but it received less points in terms of colorimetry and overall acceptability.

1. Introduction

Starch is considered the most important source of stored energy in plants, found abundantly in cereal grains and tuberous plants [1]. Starch is stored in plants in a granular form [2]. From a functional perspective, the starch present in grains (corn, wheat, rice, etc.), legumes (beans, lentils, peas, etc.), tubers and roots (potato, sweet potato, cassava, etc.), and unripe fruits (fig, mango, apple, etc.) provides functionalities such as viscosity, water retention, mouthfeel, etc., when cooked and consumed directly or used in processed foods like bakery products, tortillas, pasta, etc [3,4]. The nutritional value of starch depends on external aspects and intrinsic characteristics such as granule size, amylose to amylopectin ratio, amylopectin distribution along the chain, and the arrangement of starch components in the granule [5]. The unique properties of starch have led to its extensive use in various industries, with the food industry being a major contributor [1]. The physicochemical properties of starch granules determine their functional properties as well as the speed and quality of their digestion in food products [2]. One of the important physicochemical properties of this product is its flowability and rheological characteristics [6]. Starch obtained from each plant source has a series of rheological properties that can be evaluated by incorporating it into a dairy dessert. Saffron (Crocus sativus L.) is one of the most expensive and unique spices in the world, extracted from the saffron flower. Other parts of the saffron flower, such as the stamen, petals, and saffron corm, also contain unique and valuable compounds whose extraction creates high added value [2]. The saffron plant has an underground stem called a corm, which reproduces vegetatively and only through corm cultivation due to its sterility [7].

Starch in the food industry is obtained from various sources including corn, rice, wheat, potatoes, cassava, bananas, and sorghum [8]. In addition to these sources, saffron crocus has a significant amount of starch, which is more than that of potatoes and less than that of rice. Starch constitutes about 80 percent of the weight of saffron corms. Therefore, one of the most important and cheapest uses of saffron corms is the production of starch. From saffron corms, starch can be extracted with an efficiency of about 43 percent. The starch from saffron corms has the highest amylose content. Additionally, edible films can be made from saffron starch [2]. Therefore, it is non-toxic for human consumption. To confirm this, one can refer to the study by Ein Afshar and colleagues, who isolated saffron corms using a solvent extraction method assisted by ultrasound. For the evaluation of acute and chronic toxicity, the extract was administered to male mice in three different doses: 1, 10, and 100 mg/kg. According to this study, saffron corms did not have significant acute and chronic toxicity on BALB/c mice, and although they had toxic effects on cancer cells, no cytotoxicity was observed on normal fibroblast cells [9]. Iran is also the largest producer of saffron in the world, and on the other hand, large quantities of saffron corm are produced in the country annually. Considering the area under saffron cultivation in Khorasan, and accounting for the number of saffron corms used for replanting or expanding saffron cultivation in the country, in the year 1396 (2017-2018), there were approximately 200,000 tons of completely surplus and waste saffron corms in the country [2].

Considering that the useful life of saffron fields for flowering varies from 5 to 10 years depending on the initial planting density, after this period, due to the excessive multiplication of corms and the lack of space for their vegetative growth, as well as soil degradation, the farm's yield significantly decreases. At this time, it is necessary to remove the saffron corms from the land for planting in a new field [10]. Since the size of the corm is one of the main and determining factors for flowering capacity in saffron [11], larger corms are selected for planting. As a result, smaller corms with low weight are not used for planting. Given that corms are toxic to young animals [12], they cannot be used as livestock feed either. Therefore, a large amount of small, low-weight corms is considered waste annually [2]. Considering the extensive area under saffron cultivation in Khorasan Razavi, which the Deputy of the Agricultural Jihad Organization announced as 96,000 hectares in 2024 [13], and according to research, land that has been cultivated with saffron once is no longer suitable for this crop, we will soon see an explosive increase in saffron corm production. Therefore, if we can extract valuable and practical materials from these surplus saffron corms, we can produce high-value-added materials from a waste product [2]. Dairy desserts are widely popular among different age groups. Semi-solid dairy desserts are a group of dairy desserts whose main components include milk, thickener (starch or hydrocolloid), sucrose, flavoring, and coloring agents [14]. Nowadays, a wide range of semi-solid dairy desserts with various formulations, textures, flavors, appearances, and processing conditions are available on the market. However, the rheological and sensory properties of this group of products are significantly influenced by the characteristics of the initial ingredients, such as the type of starch [15]. By preparing a dairy dessert with saffron corm starch, the physical and rheological properties, as well as the feasibility of using saffron corm starch in the formulation of dairy desserts, can be examined. The aim of this research is to determine the physical properties of starch paste, assess the feasibility of producing dairy dessert using saffron corm starch, and evaluate the flow properties of the dairy dessert made with saffron corm starch, comparing it with the dairy dessert made from corn starch.

2.Materials and Methods

2-1- Raw materials

In this study, saffron corms from Torbat-e Heydarieh were used to extract starch, and for preparing a dairy dessert, low-fat ultra pasteurized milk from Pegah, Hooman ultra-cream, and Noosh Gol rosewater were used, while sugar, cornstarch, gelatin, and vanilla were purchased from the store.

2-2- Starch extraction

To extract starch, saffron corm weighing less than 10 grams were preferably harvested during dormancy (June to July) from the fields. Their outer skins were removed and then washed with distilled water (Figure 1), sliced, and dried. The dried samples were ground into a fine powder using a grinder and passed through a 35-mesh sieve. Three times the weight of the powder was added as water, and it was mixed with a mechanical stirrer at 650 RPM for two hours. The mixture was then passed through a filter cloth (sterile gauze) and the extraction process was repeated on the filter. The two layers below the filter were mixed, and after some time, when the starch settled, the upper liquid was removed with a pipette. The settled starch granules were completely separated from the water by centrifugation at 2000 RPM for 10 minutes. The upper liquid was removed again, and the starch was separated using a spatula and a small amount of distilled water, transferred to a tray, and dried in an oven at 35 degrees Celsius until the next day. Finally, they were ground and stored in a polyethylene container [2].

[DOI: 10.22034/FSCT.22.163.151]

Figure 1: (a) Saffron corms without tunics (b) Fully peeled saffron corms

2-3- Preparing a dairy dessert

To prepare 920 grams of dessert, mix 756 grams of low-fat milk with 45 grams of cream and place it in a water bath until the temperature reaches 40 degrees Celsius. Then, slowly add a mixture of dry ingredients including 54 grams of sugar, 36 grams of corn starch, saffron corm, and 0.75% gelatin, and keep it at 40 degrees Celsius for 10 minutes to hydrate the solid particles, stirring continuously during this period. Next, heat the product in a warm water bath to 90 degrees Celsius and maintain this temperature for 10 minutes. After this period, place the dessert in a cooling flask until the product temperature reaches 40 degrees Celsius. Then, add 1 gram of vanilla and 28 grams of rosewater and stir for 1 minute. Finally, cool the product to 4 degrees Celsius and keep it at this temperature until further testing. In this study, saffron corm starch was used to replace starch in the dairy dessert formulation in amounts of 0%, 5%, 10%, 15%, and 20% by weight [16].

2-4- Starch dough tests

2-4-1- Transparency of starch paste

According to the Ehtiati method (2018), a 1 percent starch suspension was prepared, and gelatinization was carried out by heating in a boiling water bath for 30 minutes. After cooling the tubes at room temperature for 10 minutes, the percentage of light transmission through the sample was measured using a Unico model spectrophotometer at a wavelength of 650 nanometers against distilled water as the control sample [17].

2-4-2- Least gelation concentration

A starch suspension (5-10% w/w) was prepared and after heating for one hour in boiling water, it was cooled to 4 degrees Celsius and stored in the refrigerator for 2 hours. By inverting the tubes, the concentration of the starch paste that does not flow in the tube will be the least starch gelation concentration [18].

2-4-3- Swelling power, solubility, and water absorption

To determine the swelling and solubility of starch, one gram of the samples was weighed and mixed with 30 milliliters of distilled water. Then, they were placed in a water bath at 95 degrees Celsius for 30 minutes and stirred regularly. The mixture was brought to room temperature with cold water over a period of 5 minutes. Next, it was centrifuged at 7000 rpm for 15 minutes, and the clear supernatant was transferred to a container with a known weight. It was dried at 120 degrees Celsius for 4 hours and weighed, and the solubility was calculated according to equation 1. The swelling power and water absorption were also calculated according to equations 2 and 3 [19].

Equation (1) $$\text{solubility} = \frac{\text{Weight of dried upper liquid}}{\text{Initial dry starch weight}} \times 100$$

Equation (2) $$\text{water absorption} = \frac{\text{Weight of the sediment in the centrifuge tube}}{\text{Dry weight of starch}}$$

Equation (3) $$\text{Swelling power} = \frac{\text{residual sediment}}{\text{Initial dry starch weight} \times (100 - \text{solubility})}$$

2-4-4- Rheological parameters

The measurement of viscosity and rheological parameters, flow behavior index (n) and consistency coefficient (k), was conducted using a rotational viscometer (Bohlin model 88 Visco, UK) with a suitable spindle at a temperature of 25 degrees Celsius and within a shear rate range of 0 to 150 reciprocal seconds. In practice, the above parameters were determined by fitting well-known rheological models (Equations 4, 5, and 6) to the shear stress-shear rate test data [20, 21].

2-4-4-1- Power Law Model

The power law model is the most common model for predicting the behavior of non-Newtonian food fluidity, and other models are almost derived from this model in some way. In this model, the relationship between shear stress (τ) and shear rate ($\dot{\gamma}$) is expressed as equation 4:

Equation (4) $$\tau = k\dot{\gamma}^n$$

In this equation, k is the consistency coefficient and n is the flow behavior index (dimensionless). k represents the magnitude of the fluid's viscosity, and n indicates how closely the fluid's behavior approaches that of a Newtonian fluid. In Newtonian fluids, n equals 1, and consequently, k is exactly equal to the fluid's viscosity. If $n < 1$, the fluid is called a shear-thinning or pseudoplastic fluid; if $1 < n < \infty$, the fluid is called a shear-thickening or dilatant fluid.

2-4-4-2- Herschel-Bulkley model

There are other plastic fluids whose behavior cannot be described by the power law model, but more suitable models like the Herschel-Bulkley model are used for them. If a sample has a yield stress

Equation (5) $$\tau = \tau_{0H} + k_H(\dot{\gamma})^{n_H}$$

In the above equation, τ_{0H} , k_H and n_H are the yield stress (Pa), consistency coefficient ($Pa\,.\,S^n$), and the flow behavior index of the Herschel-Bulkley model (dimensionless), respectively.

2-4-4-3- Bingham model

There are other plastic fluids whose behavior cannot be described by Herschel-Bulkley models and power law, but a more suitable model called Bingham is used for them. The mathematical form of this model is given by Equation 6:

Equation (6) $$\tau = \tau 0 + \eta B\gamma$$

In this context, $\tau 0$ and ηB are the yield stress (Pa) and Bingham plastic viscosity (Pa.s), respectively.

2-4-4-4- Evaluation of Rheological Models

To select the best and most suitable model that can effectively predict and describe the behavior of the produced samples, the commonly used statistical parameter, the coefficient of determination (R^2), was employed. This value ranges between zero and one. The larger the coefficient of determination, the greater the correlation between the values predicted by the model and the numerical values obtained from the experiment.

2-5- Dairy dessert tests

2-5-1- Texture analysis

[DOI: 10.22034/FSCT.22.163.151]

The texture profile analysis of the samples was conducted using a texture analyzer (LLOYD TA Plus Ametek, UK) after 72 hours of storage at 7 degrees Celsius. A penetration speed of 1 millimeter per second was considered. The cylindrical probe had a length of 20 millimeters and a diameter of 2.3 centimeters. For this purpose, the dessert samples were cut into dimensions of 20×20×20 millimeters. The device's force was set to 500 Newtons, and the probe speed was set to 20 millimeters per minute. Each test was conducted in duplicate. In this test, hardness (Newtons), cohesiveness, gumminess (Newtons), chewiness (Newton millimeters), adhesiveness (Newtons), and stickiness (Newton millimeters) were measured [16].

2-5-2- Syneresis

To measure syneresis, 10 grams of the sample were placed in a centrifuge tube of the weighing device and then centrifuged at a speed of 5000 rpm for half an hour. The amount of the separated supernatant was weighed and then divided by the initial amount (10 grams of the sample) to report the syneresis percentage according to Equation 7 [22].

Equation (7)

$$\textbf{syneresis} = \frac{\textbf{weight of liquid separated from dairy dessert}}{\textbf{total weight of the sample}} \times \textbf{100}$$

2-5-3- Color measurement

In order to evaluate the color and determine the colorimetric factors (*L, *a, and *b) for the dairy dessert, a colorimeter (HunterLab Reston, VA made in U.S.A) was used [23].

2-5-4- Sensory Evaluation

The sensory evaluation of the dairy dessert was conducted based on a 9-point hedonic test. A score of 9 is the highest and a score of 1 is the lowest. In this test, dairy desserts with different percentages of saffron corm starch were evaluated by 14 home tasters based on color, aroma, taste, texture, and overall acceptability.

2-6- Statistical Analysis

In this research, a completely random statistical design was used, and the tests were repeated three times. For the analysis of sensory evaluation results, SPSS software version 21 and a one-way ANOVA test were used.

3- Results and Discussion

3-1- Physicochemical and rheological properties of saffron corm starch

3-1-1- Transparency of starch paste

The transparency of starch paste plays a fundamental role in food applications, especially in gel products. During the gelatinization of starch at low concentrations, the granules swell and eventually break apart, forming granule particles. The smaller the created particles, the lighter passes through, and the greater the transparency [24]. The transparency result of the 1% corm starch saffron suspension in this study was 1.804%, which is lower than the transparency of untreated corn starch at zero time in the study by Golkar et al. (2020), which was 2.15%. Transparency is related to the reduction in the degree of starch polymerization and consequently the partial breakdown of glycosidic bonds between glucose units and the subsequent release of amylose [25]. Some researchers have confirmed this occurrence, while others have rejected it [26-28]. Shokrollahi et al. (2023), who studied the effect of air and argon plasma on the transparency of sorghum starch, obtained a transparency level of 14.02% for the control sorghum starch paste [29], which is higher than the transparency level of the saffron corm starch paste (1.804%). The increase in hydroxyl groups leads to more hydrogen bonding with water molecules and increased transparency [24]. The presence of hydrophilic and bulky carboxyl groups and the repulsion between them can also contribute to increased transparency [30].

3-1-2- Least gelation concentration

Increasing the least gelation concentration means increasing the amount of starch required to form a gel-like texture that does not flow in the container [18]. In this study, concentrations of 5% to 10% were prepared in three replicates, and only the 10% concentration in all three replicates did not revert to gel. Sujka and Jamroz (2013) reported that the minimum gelation concentration of sonicated corn starch is higher compared to the untreated sample [18]. Golkar et al. (2020) also compared the minimum gelation concentration of sonicated samples (corn starch and corn starch gum-arabic) and untreated samples, finding that the sonicated corn-gum arabic sample at 45°C had the highest minimum gelation concentration (approximately 9.5%), while the other samples had lower concentrations [25].

3-1-3- Swelling power, solubility, and water absorption

The swelling power indicates the extent of interactions between the chains in the amorphous and crystalline regions. In other words, the swelling power parameter reflects the ability of starch granules to hydrate during the cooking and heating process at 90°C [31], which was found to be 9.31% for saffron corm starch. In the study by Nadian et al. (2022), the water absorption and swelling of quinoa starch (Titicaca) were significantly higher than those of pioneer wheat starch. The swelling power for wheat starch was 8.25%, and for quinoa starch, it was 9.35% [31], placing the swelling power of saffron corm starch (9.31%) between these two values. The low amylose content and high amylopectin with long chains in quinoa starch [32], as well as the smaller particle size and granules in starch, have increased its water absorption and swelling compared to wheat starch [33]. Lindeboom in 2005, also referred to the inverse relationship between amylose content and swelling power [34]. Therefore, it can be inferred that saffron corm starch also has a low amylose content. In the study by Shokrollahi et al (2023), the swelling power for sorghum starch in the control state without the influence of air and argon plasma was 4.01 [29], which is less than the swelling power of saffron corm starch. The swelling power of wheat starch has also been reported in the range of 12.64 to 16.75 g/g [31]. Taziki Shamsabadi and Razavi (2023) estimated the swelling power of wheat starch in their research to be 13.11 g/g [35], and these numbers are higher than the swelling power of saffron corm starch.

Heidari et al. (2021) demonstrated that starch swelling depends on the pre-gelatinization temperature [36]. Shokrollahi et al. (2023) stated in their study that increasing temperature leads to increased swelling, likely due to the enhanced mobility and energy of water molecules, which facilitates their penetration into the granule and the overcoming of intra- and intermolecular hydrogen bonds [29]. Partial breakdown of these hydrogen bonds exposes hydroxyl groups, making them available for hydrogen bonding with water molecules. Additionally, during depolymerization, new hydroxyl groups are formed, which can establish hydrogen bonds with water molecules, thereby increasing swelling. The introduction of hydrophilic carboxyl groups and the repulsion between their negative charges may also contribute to increased swelling. Furthermore, amylopectin is the primary factor responsible for water absorption and granule swelling, and its extensive depolymerization results in reduced swelling. Increased granule porosity and the presence of a sponge-like structure enable granules to absorb water; however, they lose it during centrifugation [37]. Taziki Shamsabadi and Razavi (2023) also concluded that in the presence of garden cress seed gum, the swelling power of starch significantly increased by 69% as the replacement concentration of the gum increased up to 15%

[DOI: 10.22034/FSCT.22.163.151]

[35]. Hydrocolloids enhance the interaction between starch molecules, leading to a more compact granule network. This compaction increases the forces acting on the granules, facilitating water penetration into the granular network and enhancing starch granule swelling. This process also promotes amylose dissolution and leaching into the continuous phase. However, the leached amylose and hydrocolloids form a film around the granules, preventing further swelling and polymer leaching.

Starch solubility refers to the loss of molecular order within the granules and the increase in soluble solids in the continuous phase. Increased solubility and amylose leaching into the continuous phase contribute to starch retrogradation, a crucial functional property of starch. Retrogradation is a significant issue in starch-based processed products, leading to syneresis during storage, reducing the sensory acceptability of food products, and shortening their shelf life [38]. In this study, the solubility of saffron corm starch was found to be 11.76%. The solubility of wheat and quinoa starch, as reported by Nadian et al. (2022), was 12.9% and 14.19%, respectively [1], both higher than that of saffron corm starch. The solubility of native wheat starch at 95°C has been reported to range between 5% and 7% [38], while in the study by Taziki Shamsabadi and Razavi (2023), it was approximately 8%. They stated that starch granule solubility was influenced by the substitution of garden cress seed gum and sucrose. Statistically, the replacement of these components did not result in significant changes in solubility percentage; however, the presence of garden cress seed gum led to a significant increase in wheat starch solubility, raising it from approximately 8% to 21% [35]. An increase in starch solubility in the presence of hydrocolloids was also reported by Lotfi et al. (2017) [39]. Wongsagonsup et al. (2014) reported that as the swelling of cross-linked starches increased, solubility also increased, whereas reduced swelling led to decreased solubility [40].

Water absorption is also directly related to the amount of amylose leaching from the granules during gelatinization. In this study, the water absorption of saffron corm starch was found to be 8.23 g/g, which is higher than the water absorption of wheat and quinoa starch (6.14 g/g and 6.67 g/g, respectively) in the study by Nadian et al. (2022) [1]. Therefore, the amount of amylose leakage from the granules in saffron corm starch is higher than in wheat and quinoa.

Heydari et al. (2021) showed that increasing the starch concentration in the dispersion leads to an increase in water absorption capacity and a significant decrease in viscosity [36]. Hedayati et al. (2018) also investigated the effect of sucrose and glucose on the water absorption of corn starch. They reported the water absorption of corn starch in the control state as 8.70 g/g. Their water absorption test results showed that with the increase in sugar concentration, the water absorption of starch significantly decreased (p value < 0.05) [41]. Amylose is a factor that prevents the swelling of starch granules. The findings of Hirashima et al. (2005) have shown that sugars bind to the amylose chains within starch granules and prevent their release from the starch granules during gelatinization [42]. Sucrose has a greater effect in reducing the water absorption of starch compared to glucose. Sucrose is a disaccharide and, compared to glucose, which is a monosaccharide, it has a greater effect in inhibiting granule swelling [41]. Mirzababaee et al. (2022) demonstrated that by employing high hydrostatic pressure technology, the applications of starches in the food industry can be expanded, and the use of the high hydrostatic pressure process can lead to an increase in the hydration capacity of starch [43].

[DOI: 10.22034/FSCT.22.163.151]

3-1-4- Rheological parameters

To determine the flow behavior of the samples, the common power law models, the Herschel-Bulkley model, and the Bingham model were used to fit the shear stress data against the shear rate. The fitting results are presented in Tables 1, 2, and 3.

Table 1: Rheological parameters of the power law model of production samples

Treatment	K	n	R^2
Saffron corm starch	0.865	0.36	0.98
Corn starch	0.557	0.46	0.98

$(\tau = k\gamma^{n})$

Table 2: Rheological parameters of Herschel's exact model of production samples

Treatment	$_0H\tau$	k_H	n_H	R^2
Saffron corm starch	3.570	0.035	1.120	0.85
Corn starch	2.250	0.021	1.010	0.80

$$(\tau = \tau_{0H} + k_H(\dot{\gamma})^{n_H})$$

Table 3: Rheological parameters of Bingham model of production samples

Treatment	0τ	η_B	R^2
Saffron corm starch	2.246	0.023	0.90
Corn starch	1.940	0.025	0.94

$(\tau=\tau\ 0+\ \eta B\gamma)$

Fitting the models showed that among the existing models, only the power law model adequately represents the flow behavior of the samples. The first important finding that can be inferred is that the value of n for both produced samples fall within the range of zero to one, which indicates that we have observed the rheological behavior of shear-thinning or pseudoplastic non-Newtonian fluids.

Plotting the shear stress curve against shear rate for the saffron corm starch sample and the corn starch sample showed that the shear stress is non-linearly proportional to the shear rate. In other words, the shear stress is not a linear function of the shear rate, and the slope of the curve or viscosity is not constant. Therefore, it can be concluded that these two samples exhibit non-Newtonian flow behavior (Figure 2).

[DOI: 10.22034/FSCT.22.163.151]

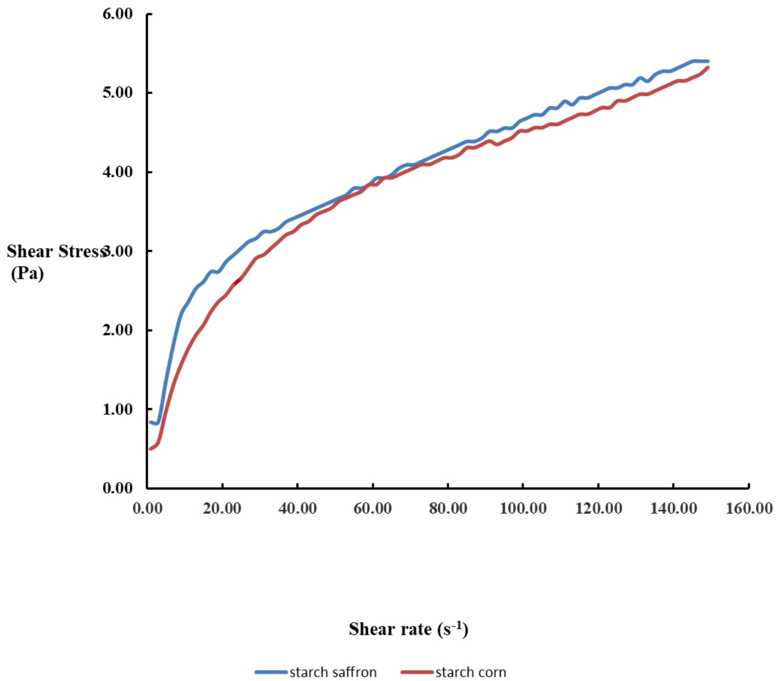

Figure 2- Shear stress curve against shear rate for saffron corm starch and corn starch

[DOI: 10.22034/FSCT.22.163.151]

The consistency coefficient or k represents the viscosity index of the food material. Changes in the consistency coefficient indicate the type of viscosity behavior in response to shear rate. The consistency coefficient values of the samples, K, varied from 0.865 to 0.557. In the saffron corm starch sample, intermolecular interactions and internal depressions that lead to increased viscosity and increased molecular drag limitation due to interactions between polymer chains may have caused the viscosity to increase. As the results of Tables 1 and 2 indicate, the samples exhibit yield stress. Yield stress refers to the minimum shear stress required to initiate flow. Yield stress represents an initial stress for the fluid to start flowing, as at values lower than the yield stress, the fluid cannot flow and behaves like a solid [44].

The yield stress of the samples based on the Bingham model (which had a higher coefficient of determination compared to the Herschel-Bulkley model) was found to be 2.246 for saffron corm starch and 1.940 for corn starch. Figure 2 shows the flow behavior of the samples. It can be observed that the samples are classified as non-Newtonian fluids in terms of rheology. The relationship between apparent viscosity and shear rate of the produced samples is shown in Figure 3. As observed, a decrease in apparent viscosity is seen in both samples. At low shear rates, a significant decrease in viscosity occurs with increasing shear rate, but at higher shear rates, this decrease happens at a slower rate. Therefore, the viscosity of the samples decreased with increasing shear rate (Figure 3).

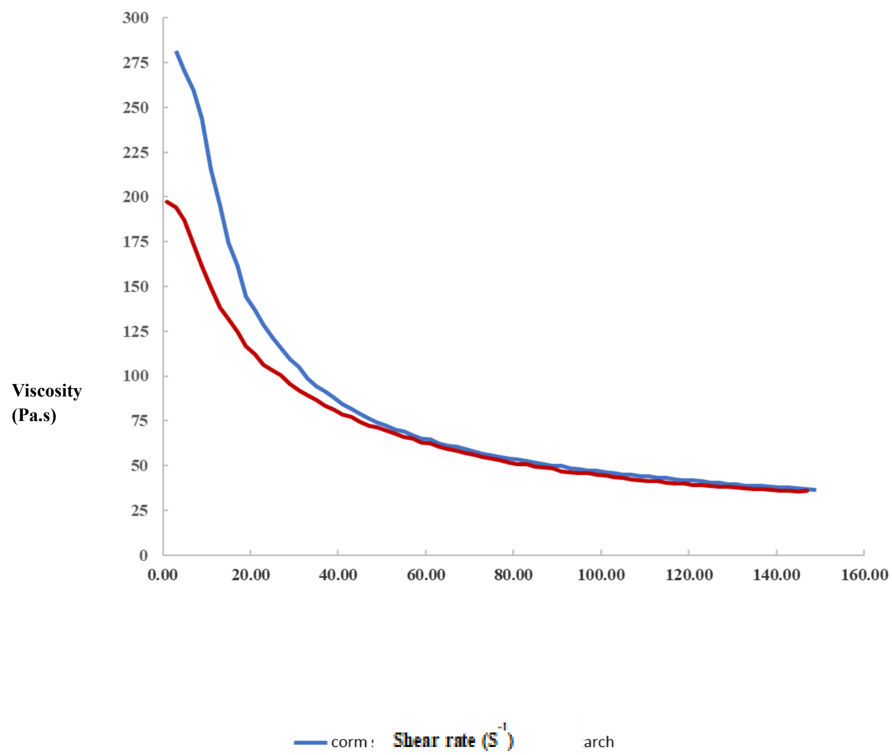

Figure 3- Viscosity curve against shear rate for saffron corm starch and corn starch

As the relationship between apparent viscosity and shear rate of the samples indicates, an increase in shear rate resulted in a decrease in apparent viscosity. It is worth mentioning that there is a correlation between the decrease in viscosity and the increase in shear rate. In this way, it can be said that at low shear rates, the decrease in viscosity occurs rapidly, but at higher shear rates, this decrease happens at a slower pace. Mc Clements (1999) explained this phenomenon by stating that with an increase in shear rate, the amount needed to overcome Brownian motion, the emulsion particles align more in the direction of flow and exhibit less resistance to flow, which leads to a decrease in viscosity [45]. This trend of viscosity changes with shear rate will be of significant importance in enhancing pump efficiency in the food industry producing non-Newtonian products. The reduction in viscosity with increasing shear rate depends on the disengagement of macromolecular chains under the influence of the shear field (alignment with the shear direction) and the potential breaking of polymer structures in the solution. At low shear rates, viscosity decreased suddenly with changes in shear rate, while at higher concentrations, this decrease was more gradual. Shear thinning occurs because molecules align in the shear direction. As the shear rate increases, polymers with long chains, which are randomly and chaotically arranged, align in the flow direction, reducing the connections between the polymer's side chains. The viscosity at low shear rates is responsible for creating consistency in food products; whereas the viscosity at high shear rates indicates the product's viscosity at different stages of the process. Since the viscosity of the solution decreases with increasing shear rate, the pumping efficiency of such fluids increases with the pump flow rate. Research shows that non-Newtonian behavior is significant when the flow behavior

[DOI: 10.22034/FSCT.22.163.151]

index is less than 0.6. This characteristic is particularly important in the formulation of oil-in-water emulsions, where the emulsion flows easily when exiting the container, yet prevents particle separation due to gravity, maintaining emulsion stability [46]. Szczesniak and Farkas (1962) showed that a solution of a biopolymer with a high n tends to create a viscous and sticky texture in the mouth. When high viscosity and a desirable mouthfeel are required, a sample with a low n should be chosen. Therefore, saffron corm starch is very suitable for use in formulations that require a less viscous texture or a more desirable mouthfeel. This result indicates that adding saffron corm starch improves the viscosity characteristics of dairy desserts and increases consumer satisfaction.

3-2- Physical and rheological properties of dairy desserts prepared with different percentages of corm starch, saffron, and corn starch

3-2-1- Texture

Texture parameters were calculated from the texture profile analysis curve and are shown in Tables 4 and 5. Research has shown that the textural properties of food products are largely influenced by the nature and structure of the components and the interactions present among the formulation materials [48]. According to the obtained results, the hardness of the dessert decreased with the increase in saffron starch concentration to 20%, with the greatest difference observed in the control sample with 20% saffron starch. The reason for the decrease in texture hardness is the lack of formation of a dense gel network [16]. Similar results were obtained by Arora et al. (2007) and Jain et al. (2013). They found that replacing sucrose with various strong sweeteners reduces the texture hardness in dairy desserts. However, these researchers observed a significant increase in firmness over time, attributing it to the strengthening of the gel structure of the dairy dessert during low-temperature storage [49,50]. The results of the statistical analysis of sample continuity showed that there is a statistically significant difference between the samples at the 5% level, with the highest continuity level corresponding to the 10% sample. This indicates that the presence of saffron corm starch in the dairy dessert formulation leads to a change in the brittleness of the final product compared to the control sample. The gumminess property is also obtained from the product of the continuity parameter and hardness, and considering that the hardness parameter has decreased among the produced samples, it was expected that the gumminess property would also decrease, with the greatest difference being between the control sample and the sample containing 20% saffron starch.

Table 4- Parameters of hardness, cohesion and viscosity of dairy desserts produced from saffron corm starch

Parameters / Sample	Hardness 1 (N)	Cohesiveness	Gumminess (N)
Control	0.930896± 0.008[a]	0.60823488±0.004[c]	0.566222071±0.009[a]
5 %Sample	0.707537±0.027[c]	0.603386692±0.006[c]	0.42700802±0.014[c]
10 %Sample	0.697292±0.038[c]	0.628216022±0.013[a]	0.437785125±0.014[c]
15 %Sample	0.76446±0.057[b]	0.591670678±0.006[d]	0.452492375±0.038[b]
Sample 20%	0.52037±0.017[d]	0.61368826±0.005[b]	0.319298406±0.008[d]

Different letters in each column show the statically significant differences (P<0.05)

[DOI: 10.22034/FSCT.22.163.151]

The results related to the adhesion force of the produced dessert samples (Table 5) also showed that by adding saffron corm starch to the dessert formulation, the adhesion force of all samples generally decreased compared to the control dessert. This phenomenon is likely due to the lack of strong gel formation at higher starch replacement concentrations. Overall, the highest adhesion force in terms of quantity was related to the control treatment. Similar results were obtained by Hashemi et al. (2015) in the replacement of inulin with vegetable oil and lactulose with part of the sugar in ice cream [51]. In gel-like structures, the interaction between stabilizers and other components occurs, and sucrose helps stabilize this structure [52]. It seems that the water absorption by saffron corm starch leads to a texture in the final dairy dessert that has appropriate adhesion. Ghahremani et al. (2014) reported that the increase in hardness, adhesiveness, and cohesiveness in mayonnaise with the higher percentage of replacing egg with wood extract is due to the fact that at higher amounts, wood extract is capable of forming a more robust gel, the emulsion structure becomes more stable, and the hardness, adhesiveness, and cohesiveness of the sauce increase [53]. As mentioned in the discussion on the hardness of the dough, it seems that saffron corm starch plays a key role in the softness of the dough. Considering the relationship between dough softness and chewability, which Boland et al. (2006) have pointed out, the effect of saffron corm starch on the chewability of the dough can be explained. They stated that the time required for chewing the gel before baking significantly increases with the softness of the gel, and harder gels take longer to chew [54]. Therefore, as previously mentioned, in the production samples, the increase in saffron corm starch resulted in a softer dough, and consequently, with increased softness, the chewing time is expected to decrease.

Table 5- Chewing parameters, Adhesive Force of dairy desserts produced from saffron corm starch

Parameters / Sample	Adhesive Force (N)	Chewiness (Nmm)
Control	0.322501187±0.012^{a}	7.241234855±0.159^{a}
Sample 5%	0.202257435±0.010^{c}	5.388023488±0.316^{b}
Sample 10%	0.217796049±0.033^{c}	5.570080752±0.182^{b}
Sample 15%	0.232646156±0.038^{b}	5.760257134±0.505^{b}
Sample 20%	0.109280359±0.003^{d}	3.897107476±0.116^{c}

Different letters in each column show the statically significant differences ($P<0.05$)

3-2-2- Syneresis

The degree of syneresis from the gel structure depends on the texture hardness, size, and arrangement of the cavities and pores present in the network. The water retention of desserts produced from saffron corm starch is shown in Figure 4.

As seen in Figure 4, the water release of the samples containing saffron corm starch is lower than that of the control sample, indicating greater stability of the dairy desserts containing saffron corm starch, which is a desirable characteristic. Among the samples with different percentages of saffron corm starch, the lowest water release corresponds to the 20% sample, followed by the 10%, 15%, and 5% samples, which have increased water release. Therefore, with the increase in the percentage of saffron corm starch, the water release has significantly decreased, which can lead to longer preservation. Majzoobi et al. (2014) also reported that in the control sample, with the lowest dry matter and hardness, the highest water release was observed because the weak gel structure in this sample did not have a high capacity to retain water. In the treatments containing wheat germ, with the increase in percentage and particle size, the water retention capacity significantly increased, or the water release significantly decreased [55]. Overall, some combinations, such as fruit pieces or concentrated extracts, can reduce syneresis by absorbing the product's free water. As Mehrabi and Goli (2018) effectively used a combination of corn starch and gelatin to reduce syneresis in date honey-based dairy desserts [22].

[DOI: 10.22034/FSCT.22.163.151]

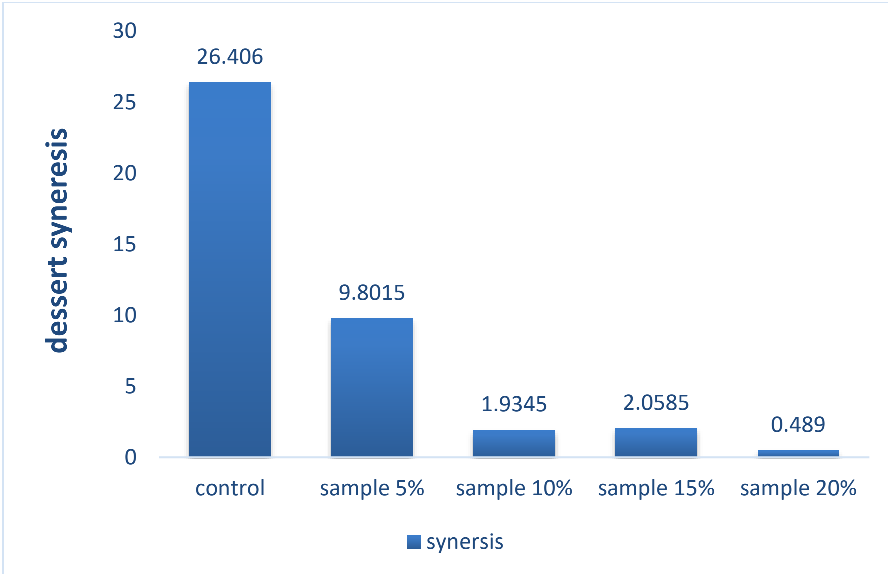

Figure 4- syneresis of desserts produced from saffron corm starch

These results were consistent with the study by Jridi et al. (2015), which reported that date products are a good source of thickening agents (dietary fibers) that are involved in reducing the spontaneous syneresis of the formulation and can be used as a natural additive in the formulation of new dairy products with high nutritional value [56]. In the study by Zabihi and Karazhiyan (2022), based on the obtained results, adding millet flour to dairy desserts significantly increased the water-holding capacity of the dessert. Water absorption capacity depends on various factors, including the type of grain, grinding duration, pretreatment, and other processing conditions of the grains and the ingredients, particularly the amount of damaged starch [57].

3-2-3- color

In color measurement, the increase in parameters *a and *b corresponds to the increase in the redness and yellowness of the samples, respectively, and the factor *L indicates the brightness of the sample. The parameters *L, *a, and *b for 5 dairy dessert samples with different percentages of saffron corm starch are shown in Table 6.

Table 6 - Colorimetric parameters of desserts produced from saffron corm starch

Treatment	*b	*a	*L
Control	12.44±0.014^{b}	-3.44±0.044^{a}	90.85±0.074^{a}
Sample 5%	11.92±0.016^{e}	-3.40±0.038^{b}	90.62±0.079^{b}
Sample 10%	12.14±0.033^{d}	-3.35±0.037^{c}	90.27±0.096^{e}
Sample 15%	12.36±0.021^{c}	-3.40±0.044^{b}	90.4±0.101^{d}
Sample 20%	12.986±0.009^{a}	-2.883±0.004^{d}	90.52±0.032^{c}

Different letters in each column show the statically significant differences (P<0.05)

[DOI: 10.22034/FSCT.22.163.151]

As observed in Table 6, the sample with 10% saffron corm starch had the least brightness, while the control sample had the most brightness. In terms of the redness parameter, the sample with 20% saffron corm starch had the highest redness, while the control had the lowest. However, in terms of yellowness, the sample with 5% saffron corm starch showed the least yellowness, and the 20% sample showed the most yellowness. In general, with the increase in the percentage of saffron corm starch from 0 to 20%, the brightness (*L) decreased, while the redness (*a) and yellowness (*b) increased. The evaluation of the color of dairy dessert by Mehrabi and Gholi (2018) also showed that with changes in the percentage of starch and date honey, there are no significant changes in the *L factor; however, increasing the date honey from 17% to 22% increases the *a factor (redness) and from 5.19% to 22% increases the *b factor (yellowness) [22]. which is similar to the results of this study in this regard. Also, Majzoobi et al. (2014) reported that the *L factor, which indicates the lightness of the sample, was lower in all samples examined in the treatments containing wheat germ compared to the control sample. In each treatment, with the increase in the percentage of wheat germ, the *L factor decreased, or in other words, the samples became darker. In the treatments containing raw and processed wheat germ, the levels of colorimetric components *a and *b were lower than the control sample, and in the treatments containing wheat germ, with an increase in particle size and percentage of wheat germ, the redness-greenness and yellowness-blueness values significantly increased [55]. In another study, Jrjdi et al. (2015) reported that the addition of date syrup to dairy desserts resulted in an increase in the color parameters of the product. In general, different reducing sugars such as glucose and fructose are present in date honey. The interaction between reducing sugars in date honey and dairy dessert milk proteins occurs during the Maillard reaction (non-enzymatic browning), which can lead to the formation of colored compounds in the product. Increasing the amount of this interaction in the dessert formulation has enhanced the color indices [56]. According to the results of Zabihi and Karazhiyan (2022), the addition of millet flour significantly increases the *a and *b components and decreases the *L component in dairy desserts. It was determined that millet flour, due to its water absorption, reduces light scattering and consequently decreases the lightness (*L) level [57]. According to the results of Mahmoodzadeh and Ahmadi Dastgerdi (2020), with the increase in the amount of inulin and the storage duration in the formulation of chocolate dairy dessert, the brightness index decreased [58]. Abd El-khair (2009) showed that the addition of inulin to chocolate milk resulted in a decrease in *L in the samples, but the values of *a and *b increased compared to the control sample [59]. Tárrega and Costell Vanilli, Tarrega, et al. (2006) observed similar results in a study of dairy desserts containing inulin (2007) in a study of dairy desserts [14].

3-2-4- Sensory evaluation

In order to examine consumer reactions to the consumption of this new dairy dessert made from saffron corm starch, a sensory evaluation test was used, and the parameters of color, odor, texture, taste, and overall acceptance of different treatments were examined and compared. The results of this parameter evaluation, which is an average of the assessments of 14 individuals, are presented in the spider chart.

As shown in Figure 5, the control sample received the highest score in terms of color, texture, and taste. Majzoobi et al. (2014) also reported that the score for the control sample was very good, and in treatments containing wheat germ, a very good score was estimated up to the 5% level. However, with an increase in the percentage of raw wheat germ beyond 5%, the score significantly decreased and was estimated to be good.

[DOI: 10.22034/FSCT.22.163.151]

Therefore, although there were slight differences in the acceptance of the control and wheat germ-treated dairy dessert samples, no significant changes were observed in the panelists' preference for product selection up to the 5% level [55].

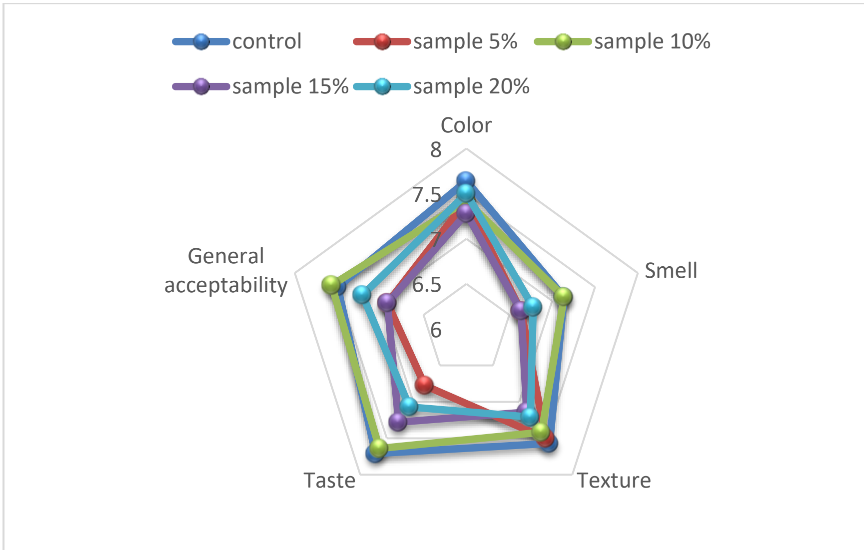

Figure 5- Sensory evaluation of dairy desserts with different percentages of saffron corm starch

In terms of smell, none of the treatments showed a significant difference compared to the control sample (p>0.05). In another study, Zabihi and Karazhiyan (2022) reported that with the increase in millet flour, the taste and smell of the dairy dessert decreased according to the evaluators. According to the evaluators, the sweetness of the dessert samples was not affected by different concentrations of millet flour, but a significant difference was observed between the control sample and the other samples [57]. According to Figure 5, the 15% sample received the lowest score in terms of color and texture, which was consistent with the results of the instrumental color analysis, but there was no significant difference in the statistical analysis compared to the control sample (p>0.05). In the study by Miani Sar yazdi et al. (2016), adding different amounts of gelatin did not have a significant impact on the color, taste, and sweetness of the product according to the evaluators. This indicates that adding gelatin to the dessert does not affect its color, taste, and sweetness [16]. Mahmoodzadeh and Ahmadi dastgerdi (2020) showed that the appearance and color of different chocolate dessert samples containing inulin and stevia were similar to each other [58]. Similar results were obtained by Arcia et al. (2011), who used inulin as a fat replacer in low-fat dairy desserts. They reported that yogurt containing long-chain inulin had a better texture and structure compared to the control sample [60]. Zabihi and Karazhiyan (2022) also reported that by adding millet flour, the color scores of the samples decreased, and with the increase in millet flour concentration, the color score increased. From a texture perspective, the samples containing millet flour were softer and more desirable. One of the most important factors affecting the textural acceptance of dairy desserts is the gel-like consistency of the sample. With the increase in millet flour, the gelation and

[DOI: 10.22034/FSCT.22.163.151]

hardness significantly decreased [57]. In the present study, although there was no significant difference in the overall acceptability of saffron corm starch-containing dairy desserts compared to the control dessert, the highest overall acceptability score was given to the dessert containing 10% saffron starch, followed by the control sample and the 20% sample. Miani Sar yazdi et al. (2016) reported that with the increase in gelatin content in dairy desserts, the texture hardness and overall acceptability increased, except for the sample without malt powder and containing 2% gelatin, which was excessively hard and had reduced acceptability [16]. The study by Zabihi and Karazhiyan (2022) also found that the highest overall acceptability score was given to the control sample, followed by the sample containing 50% millet flour [57]. Similar results were obtained by Mahmoodzadeh and Ahmadi Dastgerdi (2020) [58]. However, according to the statistical analysis results, there was no significant difference in color, taste, aroma, texture, and overall acceptability with the replacement and increase in the percentage of saffron corm starch.

4- Conclusion

According to the findings of the present study, the transparency of a 1% saffron corm starch suspension is 1.804%, and the minimum gel concentration of saffron corm starch is 10%. The solubility of saffron corm starch was 11.6%, the water absorption of saffron corm starch was 8.23 g/g, and the swelling power of saffron corm starch was 9.31%. Considering the values related to the starch of other products, it can be concluded that the starch extracted from saffron corm has the necessary capability and potential for use in starch-containing products and can show similar performance in the formulation of baked goods. Additionally, the saffron corm starch suspension is classified as a pseudoplastic non-Newtonian fluid. The saffron corm starch sample is very suitable for use in formulations that require a less viscous texture or a more desirable mouthfeel. The production of dairy desserts using saffron corm starch is feasible and has better flow properties compared to desserts made from corn starch, including a reduction in dessert hardness with an increase in starch substitution percentage. The cohesiveness of the samples changed significantly with the increase in substitution percentage, with the highest cohesiveness corresponding to the 10% saffron starch sample. Additionally, the adhesion force decreased with the addition of saffron corm starch in the dessert formulation in all samples. The increase in saffron corm starch in the produced samples resulted in a softer texture, and consequently, with the increase in softness, it is expected that the chewing time will be reduced. With the reduction of the hardness parameter among the dairy dessert samples, the gumminess property also decreased. Additionally, the syneresis of the dairy dessert, which is considered an undesirable characteristic, reached its lowest level in the dairy dessert containing 20% saffron corm starch, which helps in better preservation of the product. In terms of color parameters, with the increase in the percentage of saffron corm starch from 0 to 20%, brightness (*L) decreased, while redness (*a) and yellowness (*b) increased. Statistical analysis of the sensory properties of dairy desserts in terms of color, texture, aroma, taste, and overall acceptability did not show a significant difference ($p > 0.05$).

Further research in this area could lead to the production of modified starch from saffron corm, resulting in improved physical, chemical, and rheological properties of the resulting dispersion, thereby making its application more suitable in starch-containing product.

5- References

[1] Nadian Narges AMH, Abbas Tabar Ahangar Hossein, Arabi Azam. Comparison of functional and physicochemical properties of quinoa starches of TTKA and Pishgam wheat starches Iranian Journal of Food Science and Industry. April 2022;19.

[2] Ain Afshar Soudabeh SP. Production of antioxidant extract, starch and edible film from saffron seed wastes Saffron Promotion Magazine. 2017;Volume 01 - Number 02 - Extension 02 .

[3] Perez S BP, Gallant DJ ed. By Bemiller J, and Whistler R, Academic Press NY Structural features of starch granules I, in Starch :Chemistry and Technology. 2009:149-92.

[4] Bello-Perez LA A-AE. Starch, in: Starch-Based Materials In Food Packaging: Processing, Characterization And Applications. Elsevier Inc. 2017; Isbn: 978-012812257-0, 978-012809439-6.

[5] Bello-Perez LA F-SP, Agama-Acevedo E, Tovar J. Starch digestibility: past,present, and future. J Sci Food Agric. 2020 Nov;100(14):5009-16.

[6] Karajian Hojjat RMA. Investigation of flowability characteristics of date paste. Journal of Food Science and Technology. autumn 2018(2nd).

[7] Alvarezorti, M., Gomez Gomez, L., Rubio, A., Escriban pardo, J., Jimenez, F., and Fernandez, J.A. Development and gene expression in saffron corms. Acta Horticulturae 2004; 650: 141-148.

[8] G.O. Phillips, P.A. Williams Murphy, P. Starch. in: Handbook of Hydrocolloids, (Eds.), Woodhead Publishing Limited and CRC Press LLC.2000.

[9] Soodabeh E, T, Hakimi Zahra ,Emami Azadeh,. Acute and Subchronic Toxicity and Cytotoxicity of Saffron Corm Extract. Journal of Medicinal Plants and By-products. 2024;1:11-9.

[10] Saidi Rad MH, Shraiei; P.; Zarif Neshat,S The effect of packaging, temperature and storage time on the physical and mechanical properties and wastes of saffron (Crocus sativus L). bimonthly scientific-research journal of medicinal and aromatic plants of Iran. 2015;32 (1):14-22.

[11] Nassiri Mahallati, M., Koocheki, A., Boroumand Rezazadeh, Z., and Tabrizi, L. Effects of corm size and storage period on allocation of assimilates in different parts of saffron plant (Crocus sativus L.). Journal of Field Crops Research .2007; 5 (1): 155-166. (In Persian with English Summary).

[12] Srivastava R, Ahmed, H., Dixit, R.K., Dharamveer, S., Saraf. A Crocus Sativus L.: a comprehensive review. Pharmacognosy Reviews. 2010; 4(8):200-10.

[13] Ministry of Agriculture- Jihad (MAJ) (https://maj.ir/). [Internet]. 2024.

[14] Tárrega AC, E. Effect of inulin addition on rheological and sensory properties of fat-free starch-based dairy desserts. International Dairy Journal. 2006b;16(9): 1104-12.

[15] Toker OS, Dogan, M., Canıyılmaz, E., Ersöz, N. B. & Kaya, Y. The effects of different gums and their interactions on the rheological properties of a dairy dessert. 2013.

[16] Miani Sar yazdi Saeedeh AM, Aminifar Mehrnaz, Ghafarpour Mansour, Dastmalchi Farnaz, Maqsoodlou Yahya, Mohammadi Maryam. Investigating the physicochemical, textural and sensory characteristics of ultra-beneficial dairy dessert with uncoated barley malt. Biosystem Engineering of Iran (Agricultural Sciences of Iran) 2015; 47(3):501-509.

[17] Ehtiati A. Effect of hydrocolloids and salt on Pasting and rheological properties of sorghum starch. Faculty of Agriculture, Ferdowsi university of Mashhad, Mashhad. 2018.

[18] Sujka M JJ. Ultrasound-treated starch: SEM and TEM imaging, and functional properties. . Food Hydrocolloids. 2013; 31: 413-419.

[19] DEMIATE Ivo Mottin KV. Cassava starch in the Brazilian food industry. Food Science and Technology (Campinas). June 2011; 0101-2061.

[DOI: 10.22034/FSCT.22.163.151]

[20] Kaya A, Sanghoon, K. & Sundaram, G. . Viscosity and color change during in situ solidification of grape pekmez. Food Bioprocess Technol. 2011; 4:241-6.

[21] Kaya A, & Belibagli, K.B. Rheology of solid Gaziantep pekmez. Journal of Food Engineering. 2002; 54:221-6.

[22] Mehrabi Zahra MG. Production of dairy dessert based on the formulation of date honey, corn starch and gelatin with the help of the method Response Level (RSM). Journal of Nutritional Sciences and Food Industries of Iran. 2017;13th year, number 3, autumn:115-25.

[23] Yam KLaP, S. E. A simple digital imaging method for measuring and analyzing color of food surface. *Journal of Food Engineering*. 2004; 61:137 – 142.

[24] Wu TY, Chang, C.R., Chang, T.J., Chang, Y.J., Liew, Y., & Chau, C.F. Changes in physicochemical properties of corn starch upon modifications by atmospheric pressure plasma jet. Food Chemistry. 2019; (283):46-51.

[25] Golkar A, Mohammadzadeh Milani J, Motamedzadegan A, Esmailzadeh Kenari R. Effect of thermal-ultrasound on the rheological properties of corn starch-Arabic gum paste. Food Science and Technology. 2020; 17(106):133-43.

[26] Huang Q LL, Fu X. . Ultrasound effects on the structure and chemical reactivity of cornstarch granules. Starch/Stärke. 2007; 59:371–8.

[27] Zhang Y GZ, Zhu L, Hong Y. Comparative study on the interaction between native corn starch and different hydrocolloids during gelatinization. International Journal of Biological Macromolecules Accepted. 2018.

[28] Zuo YYJ HP, Hemar Y,, M. A. Quantification of high-power ultrasound induced damage on potato starch granules using light microscopy. UltrasonicsSonochemistry. 2012;19:421–6.

[29] F. Shokrollahi FS, M.J. Varidi, A. Koocheki, F. Sohbatzadeh. The Effect of Non-thermal Plasma on Improvement of Functional Properties of Sorghum Starch. Iranian Food Science and Technology Research Journal May-June 2023;19:217-29.

[30] Ali, T. M., & Hasnain, A. (2013). Morphological, Physicochemical, and Pasting Properties of Modified White Sorghum (*Sorghum bicolor*) Starch. *International Journal of Food Properties*, *17*(3), 523–535. https://doi.org/10.1080/10942912.2012.654558.

[31] Kumar R, & Khatkar, B.S. Thermal, pasting and morphological properties of starch granules of wheat (Triticum aestivum L.) varieties. Journal of Food Science and Technology 2017; 54(8):2403-10.

[32] Jan, KN., Panesar, P., Rana, J., Singh, S. ,. Structural, thermal and rheological properties of starches isolated from Indian quinoa varieties. International Journal of Biological Macromolecules. 2017; 102:315-22.

[33] Matos M, Timgren, A., Sjöö, M., Dejmek, P., Rayner, M. . Preparation and encapsulation properties of double Pickering emulsions stabilized by quinoa starch granules. Colloids and Surfaces A Physicochemical and Engineering Aspects. 2013; 423:147-53.

[34] Lindeboom N, Chang, P. R., Falk, K. C.,Tyler, R. T. Characteristics of starch from eight quinoa lines. Cereal Chemistry. 2005; 82:216-22.

[35] Taziki, S., Razavi, S. M. A. (2023). 'Study of the Functional Properties and the Retrogradation Behavior of Native Wheat Starch in the Presence of Cress Seed Gum and Sucrose', *Iranian Food Science and Technology Research Journal*, 19(1), pp. 1-15. doi: 10.22067/ifstrj.2021.69660.1029 .

[36] Heydari A, Razavi, M. ,Hesarinejad, M., and Farahnaky,A. New Insights into Physical,Morphological, Thermal, and Pasting Properties of HHP-Treated Starches: Effect of StarchType and Industry-Scale Concentration. Starch. 2021;73:7-8.

[37] Chong WT, Uthumporn, U., Karim, A.A., & Cheng, L.H. . The influence of ultrasound on the degree of oxidation of hypochlorite-oxidized corn starch. LWT– Food Science and Technology. 2013; 50(2):439-43.

[38] Abedi E, Pourmohammadi, K., Jahromi, M., Niakousari, M., & Torri, L. . The effect of ultrasonic probe size for effective ultrasound-assisted pregelatinized starch. Food and Bioprocess Technology 2019; 12(11): 1852-62.

[39] Lutfi Z, Nawab, A., Alam, F., Hasnain, A., & Haider, S.Z. . Influence of xanthan, guar, CMC and gum acacia on functional properties of water chestnut (Trapa bispinosa) starch. International Journal of Biological Macromolecules. 2017; 103:220-5.

[40] Wongsagonsup R, Pujchakarn, N., Jitrakbumrung, S., Chaiwat, W., Fuongfuchat, A., Varavinit, S., Dangtip, S., & Suphantharika, M. . Effect of cross-linking on physicochemical properties of tapioca starch and its application in soup product. Carbohydrate Polymers. 2014 b;101: 656-65.

[41] Hedayati S, Majzoubi,M. ,Shahidi,F. , Kuchaki, A. ,Farhanaki, A,. The effect of sucrose and glucose on the functional properties of corn starch. Food science and industry. 2018;77: 15.

[42] Hirashima M, Takahashi, R. and Nishinari, K. . Changes in the viscoelasticity of maize starch pastes by adding sucrose at different stages. Food Hydrocolloids. 2005;19:777–84.

[43] Mirzababaee M, Ozmen, D., Hesarinejad, M., Toker, O., Yeganehzad, S. A study on the structural, physicochemical, rheological and thermal properties of high hydrostatic pressurized pearl millet starch. International Journal of Biological Macromolecules. 2022; 223:511-23.

[44] Steffe J. Rheoogical methods in food process engineering. East Lansing. 1996.

[45] MC Clements DJ. Food emulsions, principles, practice and techniques LLC:CRC press. 1999.

[46] Taherian AR, Fustier, P & Ramaswamy, H.S. Effect of added weighting agent and xanthan gum on stability and rheological properties of beverage cloud emulsions formulated using modified starch. Journal of Food Engineering. 2007;30:204-24.

[47] Szczesniak AS, & Farkas, E. Objective characterization of the mouth feel of gum solutions. Journal of Food Science. 1962;27:381–5.

[48] Shahidi F, Khalilian, s. , Mohebi, M. , Khazai, A. and Maghami Kia, h. . Investigating the effect of starch and guar on textural parameters, color and acceptability of carrot paste. Journal of food processing and preservation. 2012; 4(2):15-28.

[49] Arora S SVP, Yarrakula S, Gawande H, Narendra K, Sharma V, Sharma G S. . Textural and microstructural properties of burfi made with various sweeteners. Journal of texture studies. 2007; 38(6):684-97.

[50] Jain P KA, Jha A, Kumar R, Pandey S K. . Textural and sensory properties of lal peda manufactured with artificial sweeteners and bulking agents. International Journal of Dairy Technology. 2013; 66(1):119-26.

[51] Hashemi MK, H. Shekarforosh, SH. Evaluation of physicochemical, textural and sensory characteristics of synbiotic low-fat or low-sugar ice creams. Journal of food hygiene. 2014; 2 (18):71-81.

[52] Karajian, H. Chubak (Acanthophyllum glandulosum) root gum, Emerging Natural Hydrocolloids: Rheology and Functions, Book Chapter, 2019;371-396.

[53] Ghahremani N, Karajian, H. The effect of subsituting egg yolk with Acanthophyllum glandulosum gum on the rheological properties of mayonnaise. Food Research Journal 2015; 25(2):221-229.

[54] Boland A B DCM, van Ruth S M. . Influence of the texture of gelatin gels and pectin gels on strawberry flavour release and perception. Food chemistry. 2006; 96(3):452-60.

[55] Majzoobi, M. Ghiasi, F. Farhanaky, A. Physicochemical assessment of fresh chilled

dairy dessert supplemented with wheat germ. International Journal of Food Science and Technology 2016; 51, 78–86.

[56] Jridi M SN, Ben Salem M, Ayadi MA, Nasri M, Azabou S. . Tunisian date (Phoenix dactylifera L.) byproduct: Characterization and potential effects on sensory, textural and antioxidant properties of dairy desserts. Food Chemistry. 2015; 188:8-15.

[57] Zabihi F, Karazhiyan H. Physiochemical and Textural Properties of Dairy Dessert Containing Millet Flour as a Substitute for Rice Flour. FSCT 2022; 19 (123) :329-340.

[58] Mahmoodzadeh A, Ahmadi Dastgerdi,A. . The effects of Stevia (Rebaudioside) and Inulin on the Physicochemical, Antioxidant and Sensory Properties of Low-Calorie Chocolate Dairy Dessert. EJFPP. 2019;12(20(13-24).

[59] Abd El-khair, A.A. (2009). Production and evaluation of a high protein version of non-fat yogurt. *Research Journal of Agriculture and Biological Sciences*, 5(4): 310-316.

[60] Arcia P L NS, Costell E, Tárrega, A. Effect of inulin seeding on rheology and microstructure of prebiotic dairy desserts. Food Biophysics. 2011; 6(4): 440-9.

[DOI: 10.22034/FSCT.22.163.151]

مجله علوم و صنایع غذایی ایران

سایت مجله: www.fsct.modares.ac.ir

مقاله علمی_پژوهشی

بررسی خصوصیات فیزیکی نشاسته استخراجی پیاز زعفران و استفاده آن در فرمولاسیون دسر لبنی

ساناز ندافی مقدم[1]،حجت کاراژیان[2]،زهره عبدی مقدم[3*]

۱-دانش آموخته کارشناسی ارشد بهداشت و ایمنی موادغذایی، دانشگاه علوم پزشکی گناباد، گناباد، ایران

۲- گروه علوم و صنایع غذایی، دانشگاه آزاد اسلامی، واحد تربت حیدریه، تربت حیدریه، ایران

۳ -گروه تغذیه و علوم غذایی، دانشگاه علوم پزشکی گناباد، گناباد، ایران

اطلاعات مقاله

تاریخ های مقاله :

تاریخ دریافت: ۱۴۰۳/۶/۳۰

تاریخ پذیرش: ۱۴۰۳/۱۱/۸

کلمات کلیدی:

نشاسته ذرت،

پیاز زعفران،

خصوصیات رئولوژیکی،

دسرلبنی،

بافت‌سنجی

DOI:10.22034/FSCT.22.163.151.

* مسئول مکاتبات:

z.abdimoghadam1@gmail.com

چکیده

نشاسته، کربوهیدرات ذخیره‌سازی است که به دلیل بهبود ویژگی‌های بافتی و خواص رئولوژیکی میتوان از آن برای تعدیل قوام فراورده‌های غذایی لبنی، استفاده کرد. بنه زعفران مقدار نشاسته قابل توجهی دارد و سالانه مقادیر زیادی بنه زعفران در کشور تولید می شود. هدف از این پژوهش، تهیه دسر لبنی با درصد های مختلف نشاسته پیاز زعفران جایگزین با نشاسته ذرت و بررسی خصوصیات فیزیکی و رئولوژیکی و نیز امکان پذیری استفاده از نشاسته پیاز زعفران در فرمولاسیون دسر لبنی است. ابتدا استخراج نشاسته پیاز زعفران به کمک آب و سانتریفوژ انجام شد و آزمون‌های شفافیت خمیر، حداقل غلظت ژل دهی، قدرت تورم، حلالیت، جذب آب و تعیین رفتار جریان نمونه‌ها با استفاده از مدل‌های رایج قانون توان، مدل هرشل‌باکلی و مدل بینگهام برای برازش داده‌های تنش برشی بر درجه برش صورت گرفت. سپس ۵ نمونه دسر لبنی با ۰ (شاهد)، ۵ ، ۱۰ ، ۱۵ و ۲۰ درصد نشاسته پیاز زعفران جایگزین با نشاسته ذرت تهیه شد و بافت، آب اندازی، رنگ و ارزیابی حسی دسرها مورد بررسی قرار گرفت. برازش مدل‌ها نشان داد که از بین مدل‌های موجود تنها مدل قانون توان بخوبی بیانگر رفتار جریان نمونه‌ها می باشد. مقدار ضریب قوام نمونه‌ها،K، از ۰/۸۶۵ تا ۰/۵۵۷ متغیر بود و عدد شاخص رفتار جریان برای نشاسته پیاز زعفران ۰/۳۶ بود. ویسکوزیته ظاهری نیز با افزایش سرعت برشی، کاهش یافت. نتایج بافت سنجی دسرها نیز نشان داد نیروی چسبندگی، خاصیت صمغی بودن و سختی دسر با افزایش درصد جایگزینی نشاسته کاهش و پیوستگی نمونه‌ها تغییر معنی داری نداشته است و افزایش نشاسته پیاز زعفران منجر به نرمی بافت شد. با افزایش درصد نشاسته پیاز زعفران، آب اندازی و روشنایی (L^*) نیز کاهش یافت و آنالیز خصوصیات حسی برای هیچ کدام از تیمار ها در پارامتر های رنگ، بافت، طعم، بو و مقبولیت کلی معنی دار نبود ($p>0/05$). با توجه به یافته های مطالعه حاضر، سوسپانسیون نشاسته پیاز زعفران جزو سیالات غیرنیوتنی از نوع سودوپلاستیک است و نمونه نشاسته پیاز زعفران برای بکارگیری در فرمولاسیون هایی که بافت لزجی کمتر یا احساس دهانی مطلوب تر مورد نیاز است، بسیار مناسب است. تولید دسر لبنی با استفاده از نشاسته پیاز زعفران امکان پذیر بود و نسبت به دسر تهیه شده از نشاسته ذرت نرمی مناسب‌تری دارد اما از لحاظ رنگ‌سنجی امتیاز کمتری دریافت نمود و در هیچ پارامتر حسی از جمله طعم، بو و بافت اختلاف معنی داری با نمونه شاهد نداشت.