Journal of Food Science and Technology (Iran)

Homepage:www.fsct.modares.ir

Scientific Research

Physicochemical, antioxidant and sensory properties of stirred yogurt enriched with aqueous-alcoholic extract of Fenugreek seed

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ARTICLE INFO

Article History:
Received:2024/3/25
Accepted:2024/12/11

Keywords:

Fenugreek seed extract,

yogurt enrichment,

physicochemical properties,

antioxidant activity

DOI: 10.22034/FSCT.22.158.238.

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ABSTRACT

Yogurt is one of the most common types of fermented dairy products due to its pleasant flavor and texture and consistency, and it can be easily mixed with other nutrients. Fenugreek with the scientific name (*Trigonella foenum-graceum*) is a hidden plant, and the fenugreek seed, which is the most important medicinal part of this plant, contains flavonoids, sesqui-terpenes, sterols, and mucilage fibers. In the present study, the aqueous-alcoholic extract of fenugreek seeds at four levels (zero, 0.2, 0.4 and 0.6%) on some physicochemical characteristics (pH, acidity, hydration and viscosity), the amount of phenolic compounds, The antioxidant activity and sensory properties (taste, texture, color and overall acceptance) of the enriched stirred yogurt were evaluated during 14 days of storage. The results of data analysis showed that the sample containing 0.6 percent has the lowest and highest pH and acidity indicators, respectively. Also, by increasing the storage time up to 14 days and decreasing the pH, the amount of water content of all the samples increased significantly ($P<0.05$). The results showed that with a significant decrease in the content of phenolic compounds during the storage period, adding fenugreek seed extract to the amount of 0.6% in a period of 1 and especially 7 days increased the antioxidant activity and then, up to the storage time of 14 days, the antioxidant activity was low in some samples and with a very slight change in some samples ($P<0.05$). Also, the highest and lowest values of viscosity were 3500 centipoise (the control sample on the first day) and 703 centipoise (the sample containing 0.6% on the fourteenth day) ($P<0.05$). Finally, by examining the results of sensory properties, the sample containing fenugreek seed extract was able to get an acceptable score from the sensory evaluators compared to the control sample. Among the types of enriched and control yogurt formulations, the sample containing 0.6% extract had the highest degree of desirability in terms of sensory properties when stored for 1 day.

[DOI: 10.22034/FSCT.22.158.238]

1- Introduction

Yogurt is a fermented dairy product and is included in the milk and dairy group in the food pyramid, and one serving is equivalent to one glass. Nutritionally, this product is easily digested, has high nutritional value, and is a rich source of carbohydrates, protein, fat, vitamins, calcium, and phosphorus. Due to the protein, fat, and lactose components that are partially broken down during the fermentation process, yogurt is a more digestible product than milk, as yogurt is able to maintain the microbial flora of the digestive tract and has anti-tumor and anti-cholesterol properties [1]. After the fermentation process, stirred yogurt is similar to regular yogurt, with the difference that later in the process, yogurt clots are mixed in to give it a smoother and more uniform texture. This process prevents the whey from separating from the yogurt clots, which in turn results in a product with a distinct texture and higher quality. Also, due to the stirring process, lactic acid is released in stirred yogurt, which in turn reduces the sour taste and increases the sweetness of the product. Experts agree that excessive energy intake from any source, combined with a sedentary lifestyle, leads to weight gain and obesity, cardiovascular disease, cancer, cataracts, and chronic diseases. The health benefits of consuming plant-based foods are partly attributed to the presence of phenolic compounds, which counteract the risks of the aforementioned diseases. These effects are achieved by preventing lipid oxidation, protein cross-linking, DNA mutation, and tissue damage. Although phenolic compounds and some of their derivatives are very effective in preventing autoxidation, only some of them are permitted to be used as antioxidants in foods, and food manufacturers use permitted antioxidants, which are mainly phenolic in nature, to prevent product quality degradation and preserve their nutritional value [2]. The term natural antioxidants refers to compounds that occur naturally in animal or plant tissues. They are also formed during cooking or processing of foods and can be extracted. Natural antioxidants are found in almost all plants, microorganisms, fungi, and even animal tissues. The most important group of natural antioxidants are phenolic compounds, of which tocopherols, flavonoids, and phenolic acids are the most important. The most important natural antioxidants in foods are phenolic and polyphenolic compounds of plant origin, which are classified as free radical scavengers and are abundant in many fruits and vegetables [3].

Fenugreek, with the scientific name (*Trigonella foenum-graceum*), is a dicotyledonous plant with separate petals, which is part of the Rosaceae order, the Pea family, the Lepidoptera subfamily, and the genus (*Trigonella L.*) of the (*Trifolia*) group [4]. Fenugreek has a tonic, laxative, appetite-stimulating, expectorant, antipyretic, milk flow stimulant, and blood sugar lowering effect. This plant also contains large amounts of iron, phosphorus, and vitamin D [5, 6]. The main constituents of fenugreek seeds, which are the most important medicinal part of this plant, include saponins, alkaloids, and mucilage fibers (50%). The amount of protein in this plant is high, and the flavonoids in this plant are in the form of glycosides and can be separated by paper chromatography. The most important of them include the arabinoside flavonoid (Orientin), the C-glycoside flavonoid (Vitexin), and the quercetin [7].

In a study conducted by, fenugreek powder was substituted for fatty foods at 20, 30, and 60 percent of the diet and three fractions prepared from fenugreek (defatted, saponin-containing, and crude saponin, all of which were included in the diet at an equivalent of 30 percent fenugreek powder) for 2 weeks, and the results showed a decrease in the ratio of total blood cholesterol to HDL cholesterol [8]. Also, the fiber-rich fraction of fenugreek extract (79.4% fiber), trigonelline purified from fenugreek at a dose of 50 grams per kilogram of body weight orally, and a decoction prepared from fenugreek (40 grams in 300 milliliters of water) were able to significantly reduce blood sugar in various studies [9, 10, 11].

Arab Salehi Nasrabadi et al. (2019) observed in a study of the enrichment of stirred yogurt with purslane oil (*Portulacaoleracea*) that there was a statistically significant difference in the anti-radical activity of the samples during 21 days of storage with 7-day intervals [12]. Gad and El-Salam (2010) also found that adding rosemary and green tea extracts did not reduce the antioxidant properties of yogurt during storage, and it can be said that these compounds increased the antioxidant and health-promoting properties of yogurt [13]. Therefore,

[DOI: 10.22034/FSCT.22.158.238]

considering the importance of using functional products in the nutritional diet, the aim of this study is to investigate the production of stirred yogurt containing fenugreek extract on its physicochemical, sensory, rheological, and antioxidant properties.

2- Materials and methods

2.1. Materials

The materials used in this study included raw milk, starter (LAT BY 1-63, Lactina Company, Bulgaria), low-fat dry milk powder (Fontara Company, New Zealand), and fenugreek seeds, which were purchased and prepared from stores in Sabzevar city.

2.2. Method for preparing aqueous-alcoholic extract

To prepare the hydroalcoholic extract using the maceration method, the fenugreek seeds were first washed, dried, and then mill. For this purpose, 50 gr of mill grain was poured into an erlenmeyer flask and 500 ml of 96% ethanol and 500 ml of deionized distilled water were added. The erlenmeyer flask was closed with aluminum foil and stirred for 72 hours. The components in the erlenmeyer flask were filtered with Whatman filter paper and the filtered liquid was concentrated to 50% volume using a rotary evaporator at 45°C. The obtained extract was placed in an oven at 45°C for 72 hours to thicken it and was sterilized using a 0.22 micron filter and prepared for use [14].

2.3. Yogurt production

Before preparing yogurt, first, dried starter containing a combination of Lactobacillus bulgaricus and Streptococcus thermophilus starter bacteria was added at a rate of 2% to 500 ml of sterile skimmed milk, and 2 ml of this prepared mixture was inoculated for every 1000 ml of milk to prepare yogurt. To prepare yogurt, milk solids with a fat content of about 1.4% were standardized to 12% using skimmed milk powder. Then, the milk temperature reached 70°C using a heater while the mixing operation with the homogenizing mixer was carried out continuously. After that, different levels of fenugreek seed extract were added to the milk samples in a bain-marie and the treatments were thoroughly mixed and homogenized for 10 minutes at 70°C using a homogenizer. Then, the resulting milk reached a temperature of 85°C and was heat treated at this temperature for 30 minutes and then quickly cooled to 45°C. When the milk temperature reaches 45°C, 2 ml of starter is prepared, inoculated into 1000 ml of milk and poured into 1000 gr plastic containers. The containers containing the sample were incubated at 45°C until reaching an acidity equivalent to 80°D. Then, the containers containing the produced yogurt were cooled to 5°C and the desired tests were performed on them at 1, 7, and 14 days after production [15].

2.4. Measurement of pH

The pH of yogurt samples was measured using a pH meter (model HI99164, Hanna Company, USA) at a temperature of 25°C [16].

2.5. Measurement of Acidity

First, 9 gr of yogurt sample was added with distilled water and then titrated with 1/10 normal sodium hydroxide in the presence of phenolphthalein reagent until a pink color appeared. Acidity was reported as a percentage of lactic acid [16].

2.6. Measurement of syneresis

In this test, the yogurt samples were well mixed and homogenized, and 25 gr of the yogurt samples were weighed and poured onto Whatman filter paper that was in a funnel above a glass container, and placed in a refrigerator at 4°C for 120 minutes. Then, the weight of the liquid collected in the glass container was subtracted from the weight of the empty glass container, and the results were expressed as a percentage using the following equation [17].

$$\text{Yogurt syneresis} = \frac{\textit{Initial weight of yogurt sample}}{\textit{weight of liquid released}} \times 100 \quad (1)$$

2.7. Measurement of phenolic compounds

The total phenolic compounds were determined using the Folin-Ciocalteu method. Gallic acid was used to draw the standard curve. The total amount of phenolic compounds in the product was calculated in terms of gallic acid using the equation obtained from the standard curve, and the results were expressed in terms of milligrams of gallic acid per gram of yogurt sample produced [18].

[DOI: 10.22034/FSCT.22.158.238]

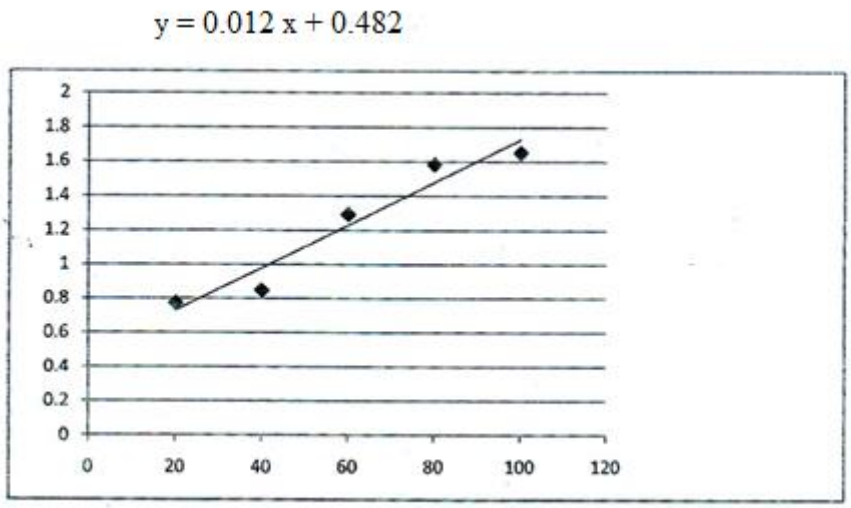


Fig 1 Gallic acid standard curve

2.8. Measurement of antioxidant activities

Antioxidant activity was measured using diphenylpicrylhydrazyl reagent, which is a stable radical compound with a purple color that is reduced by electron-donating elements or hydrogen in antioxidant compounds to yellow diphenylpicrylhydrazine. In this method, 1 cc of different concentrations of yogurt extract was added in 3 replicates to 80% ethanol and 3.5 ml of 0.01 g (DPPH) solution. After shaking for 30 seconds by vortex and 30 minutes of incubation at room temperature, the light absorption of the samples was read at a wavelength of 517 nm against a blank. Also, for the control sample, 1 ml of 80% ethanol was used instead of the extract, and the percentage of free radicals (DPPH) was calculated using the following formula:

$$I\% = \frac{\text{Ablank}}{\text{Asample} - \text{Ablank}} \times 100 \qquad (2)$$

In this formula, (Ablank) represents the absorbance of the negative control, which lacks essential oil and extract, and (Asample) represents the absorbance of different concentrations of essential oil and extract [19].

2.9. Measurement of viscosity

The viscosity of the produced samples was measured using a Brookfield viscometer (R-DVII). In this experiment, after initial tests, spindle number 6 was selected as the appropriate spindle for viscosity measurement. All tests were performed at a temperature of 5°C and under identical conditions, so that the viscosity of the samples was read at a speed of 70 rpm and after 15 seconds of spindle rotation [20].

2.10. Sensory properties evaluation

In order to evaluate the quality of the produced product and achieve the best formulation, yogurt samples containing the extract were subjected to the judgment of relevant judges. After preliminary training, 10 people were selected as evaluators and, using the hedonic scale method (5 points), they evaluated the prepared yogurt samples in terms of taste, texture, color, and overall acceptance of the product. Thus, the maximum score (5) indicates that the sample is excellent and the lowest score (1) indicates that the sample is very poor. For this purpose, a table was prepared for scoring individuals [21].

2.11. Statistical analysis

Statistical analysis of data was performed in a completely randomized design with 3 replications. Results were analyzed using SAS software at a significance level of 5%, and Excel software was used to draw graphs.

3- Results and Discussion

3.1. Investigating changes in the pH of yogurt

[DOI: 10.22034/FSCT.22.158.238]

The effect of fenugreek seed extract variables and storage time on the pH of yogurt is shown in Figure (1). Changes in pH in yogurt samples containing extract during 14 days of storage showed a significant effect ($P<0.05$). In fact, on the first day, as the percentage of fenugreek seed extract increased to 0.6%, the pH index decreased, which is due to the activity of starter bacteria in yogurt and the production of lactic acid [22]. The results of the analysis of variance of the interaction effect of fenugreek seed extract and storage time showed that with increasing the amount of extract from 0.2 to 0.4 percent and storage time from one to 10 days, the numerical value of pH showed a decreasing trend. It is worth noting that the lowest pH value was obtained at 0.6% fenugreek extract and a duration of 14 days. One of the characteristics of fenugreek seeds, which is the most important medicinal part of this plant, is that it contains at least 50% mucilage fibers. It can be predicted that increasing the amount of fenugreek seed extract in the produced samples and the subsequent formation of a gel state will delay the inactivation of starters during storage, even at low temperatures, and will have an effect on the pH index and can cause it to decrease [23].

3.2. Investigating changes in the acidity of yogurt

The effect of the independent variables of fenugreek seed extract and storage time on the acidity of yogurt is shown in Figure (1). The results of the analysis of variance showed that the linear effect of both independent variables on changes in the acidity of the produced yogurt was significant ($P<0.05$). One of the reasons that can be considered is that, with increasing storage time, fenugreek seed extract is effective in increasing the acidity parameter, so that it helps to increase the substrate and ultimately the growth of microorganisms, and subsequently leads to the consumption of milk sugar, a decrease in pH, and an increase in acidity [24].

Also, the results of the analysis of variance for the interaction between two variables showed that with increasing the amount of fenugreek seed extract and storage time, changes in yogurt acidity increased. Accordingly, by increasing the concentration of fenugreek seed extract from 0.2 to 0.6 percent and the storage time up to about 14 days, the acidity of yogurt showed an upward trend, and the optimal value of this index was 80.39 percent. Considering the changes in pH and acidity indices of yogurt, and in parallel, the changes in acidity were lower in samples containing fenugreek seed extract. This lower value, proportional to the concentration of this independent variable in the samples under test, can be associated with controlling the acidity and pH values in yogurt and, in the next stage, masking the sour taste of the product during storage. The results obtained are consistent with the research of Lotfizadeh Dehkordi et al. (2013) [15].

3.3. Investigating changes in the syneresis of yogurt

One of the major disadvantages of yogurt is syneresis, which can be directly related to factors such as the degree of physical disturbance, sudden decrease in pH, and lack of proper temperature control during incubation, which ultimately causes the protein network to collapse [25].

The results of the analysis of the effect of fenugreek seed extract and storage time on the amount of yogurt syneresis showed that the linear effect of both variables on the amount of syneresis was significant ($P<0.05$). As mentioned previously, pH changes can be an influential factor in the syneresis of yogurt and the wrinkling of the three-dimensional structure of the protein network, which leads to a decrease in the binding strength of whey proteins and their release from yogurt. For this reason, the amount of syneresis increased over time. Therefore, it can be said that there is a direct relationship between the amount of syneresis of the samples and changes in pH [26].

Contrary to expectations, in examining the interaction effect of fenugreek seed extract and storage time, comparing the mean data from these two variables, it was found that there was a significant difference between all means, and the highest percentage of syneresis occurred at 0.4 and 0.6 percent extract and on day 14 ($P<0.05$). This phenomenon in the present study can be explained by the fact that, due to the survival and activity of yogurt starter bacteria during storage, especially at low temperatures, and as a result of their hydrolysis and digestion of product proteins, the amount of

[DOI: 10.22034/FSCT.22.158.238]

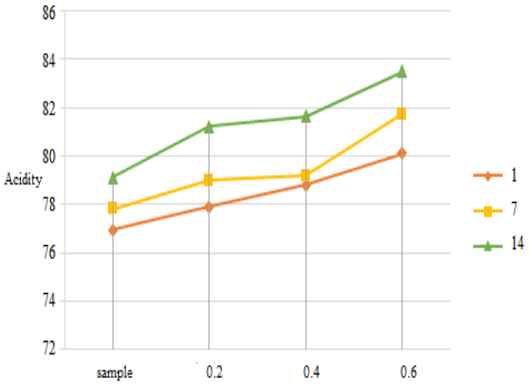
syneresis of the samples increases over time because the proteins that cause the desired texture lose their properties and the bond with them is broken [24]. On the other hand, given the presence of mucilage fibers in fenugreek seeds, it was expected that adding this extract to the formulation would reduce the percentage of syneresis, which in fact did not occur, and is consistent with the research of Blecker et al. (2001). Also, García-Pérez et al. (2006) showed that adding one gram per 100 ml of orange fiber to yogurt reduces syneresis, improves creaminess, and increases gel firmness and product adhesion [27, 28].

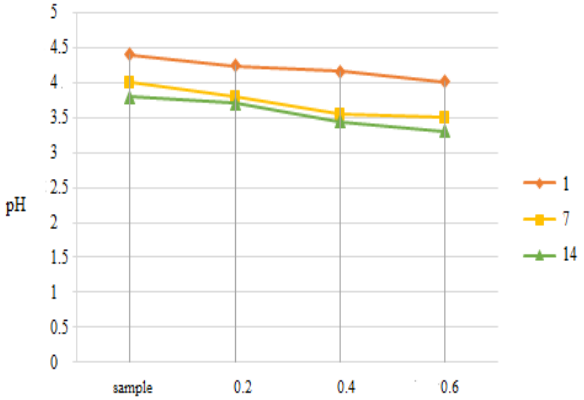
Table 1 The effect of different levels of Fenugreek seed extract on the amount of changes in pH, acidity and syneresis of yogurt

Amount of extract (%)	Day	pH	Acidity	Syneresis
Sample	1	4.15±0.01^{a}	74.89±0.03^{a}	10.12±0.06^{a}
0.2	1	4.09±0.05^{d}	75.92±0.05^{b}	12.54±0.04^{d}
0.4	1	4.05±0.05^{c}	77.84±0.07^{f}	14.22±0.02^{f}
0.6	1	4.01±0.02^{f}	80.01±0.05^{e}	14.88±0.10^{j}
Sample	7	4.05±0.02^{b}	76.45±0.06^{c}	11.12±0.07^{b}
0.2	7	3.98±0.04^{g}	78.49±0.04^{g}	13.34±0.05^{e}
0.4	7	3.86±0.04^{i}	78.95±0.03^{i}	13.79±0.03^{h}
0.6	7	3.73±0.01^{j}	80.76±0.01^{l}	14.57±0.28^{k}
Sample	14	4.01±0.01^{e}	79.87±0.04^{d}	11.68±0.04^{c}
0.2	14	3.81±0.03^{h}	81.02±0.02^{h}	12.87±0.17^{g}
0.4	14	3.69±0.02^{k}	81.89±0.01^{j}	14.11±0.31^{i}
0.6	14	3.47±0.01^{l}	83.77±0.17^{k}	15.83±0.02^{l}

±: Values indicate standard deviation

a-l: Averages with different superscripts in the same row have a significant difference (less than 0.05).





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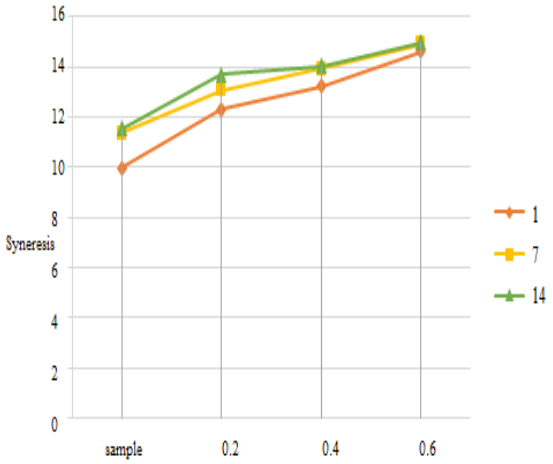

Fig 2 Changes related to pH, acidity and syneresis of yogurt containing Fenugreek seed extract

3.4. Investigating the phenolic compounds of yogurt

Plants are rich sources of natural antioxidants. Plant antioxidant compounds are generally phenolic in nature and include compounds such as tocopherols, carotenoids, phenolic acids (benzoic acid and cinamic acid derivatives), flavonoids and di-terpenes [29].

Among the variables studied on the amount of phenolic compounds, the linear effect ($P<0.05$) of fenugreek seed extract on phenolic compounds was significant, which was consistent with the research of Forgani et al. (2017) [30]. The results of the analysis of variance for the interaction between two variables showed that with increasing the amount of fenugreek seed extract and storage time, the amount of phenolic compounds in the yogurt product will have an upward trend. The highest amount of phenolic compounds related to the 0.6 percent extract level was observed on the first day of storage and the lowest amount of compounds measured in the control samples in all three time intervals.

The high levels of phenolic compounds in fenugreek lead to the enrichment of yogurt containing fenugreek aqueous-alcoholic extract in terms of phenolic compounds compared to the control yogurt. Flavonoids, sesquiterpenes, and sterols are among the abundant antioxidant compounds found in fenugreek, along with coumarin, tannins, and carotenoid compounds [31]. Another reason for the presence of phenolic compounds at high levels in the extract on the first day is the presence of unsaturated fatty acids in fenugreek seeds and the presence of fat in the initial milk for product production. With increasing fenugreek extract concentration, the antioxidant activity increased significantly, but over time, this activity decreased somewhat, which was due to the presence of phenolic compounds at the beginning of the activity, and at the end of the storage period, due to the presence and increased activity of the lipase enzyme, the production of fatty acids increased, and in return, the antioxidant activity decreased somewhat, which is consistent with the studies of Pedram Nia et al. (2022) [32].

3.5. Investigating the antioxidant activities of yogurt

The results of the antioxidant properties are given in Table (2). The results of the analysis of the effect of fenugreek seed extract and storage time on the antioxidant activity of yogurt showed that the linear effect of both variables on the level of this index was significant ($P<0.05$). With increasing the amount of fenugreek seed extract (0.6%), the percentage of free radical inhibition also increased, which can be attributed to the high levels of flavonoids, carotenoid compounds, and various terpenes in the fenugreek plant [31]. Ghasemi Kia et al. (2022) showed that protein extracted from fenugreek seeds with the help of ultrasound waves, as a natural product, has a significant ability to inhibit free radicals (DPPH). They also stated that the possible function of the free radical scavenging ability of the studied samples may be related to

[DOI: 10.22034/FSCT.22.158.238]

electron diffusion or hydrogen transfer to free radicals from various hydroxyl groups present in the protein structure, and as a result, it can stop the free radical chain reaction [33].

The results of the analysis of variance for the interaction between two variables showed that increasing the amount of fenugreek seed extract and storage time will increase the antioxidant activity in the yogurt product. Also, the highest antioxidant activity of the yogurt product was observed at the level of 0.6% and on the first day of storage ($P<0.05$). In addition to the activity of the lipase enzyme, which could be related to the presence of fatty compounds in fenugreek extract and milk, Habibi Najafi et al. (2018) also acknowledged that peptides resulting from proteolysis of yogurt samples can show different antioxidant levels, such that with the passage of time and increasing hydrolysis rates, the antioxidant activity in some samples decreased by the twentieth day, and in some samples, it was either accompanied by a very slight change or remained unchanged, which results are also consistent with the present study. The reason for this decrease could be related to greater hydrolysis and breakdown in regions of bioactive peptides that have antioxidant properties [34].

3.6. Investigating the viscosity of yogurt

The effect of independent variables on the viscosity of yogurt is shown in Table (2). According to the results of the analysis of variance of the data, it is observed that fenugreek seed extract had a significant effect on viscosity changes, so that the linear effect ($P<0.05$) showed a decreasing trend. The decrease in viscosity can be due to changes in the pH index and the minimization of protein solubility can lead to a denatured state of this macromolecule. On the other hand, viscosity is an indicator of protein stability, so at pH higher than 4.6, ionic repulsion between casein micelles makes their aggregation difficult [35]. With mucilage fibers in fenugreek seeds, it was expected that with increasing the concentration of fenugreek seed extract, the viscosity would also increase, but this did not happen, and this was in contrast to the studies of Zomorodi (2012) using wheat fiber and Shariatmadar Tehrani and Sharifi (2017) using fibrillum from basil and stem in yogurt products [36, 37].

The results of the study of the interaction between fenugreek seed extract and storage time also showed that by increasing the fenugreek extract from 0.2 to 0.4 percent, the viscosity first increased, and then by increasing the concentration from 0.4 to 0.6 percent, the viscosity index decreased. In addition, by increasing the storage time to 14 days, the viscosity parameter decreased significantly. Finally, the highest and lowest viscosity values were 3500 centipoise (control sample on the first day) and 703 centipoise (sample containing 0.6% on the fourteenth day), respectively. These relatively small changes are consistent with the results of Lotfizadeh Dehkordi et al. (2013) and Hosseini and Saifi (2022), who used extracts of the plant Tragopogon graminifolius and Thyme, respectively. In both studies, the cause was considered to be the lack of proper gel formation, as during the process of binding free water with macromolecules, especially proteins in milk, it causes stability of the protein network and restriction of water movement, and stronger bonds can be created between water and protein. However, the use of plant extracts can disrupt the establishment of water-protein bonds and increase viscosity due to changes in pH and competition with water in milk, and affect the textural properties of yogurt [15, 38]. In yogurt production, it is very necessary to examine properties such as rheological properties, which mainly include viscosity, texture firmness and appearance, and the syneresis property, which is actually the property of yogurt to thicken, is very essential. These properties depend on several important factors, including the amount of yogurt solids, the amount of fat, the amount of proteins present, the type and ratio of proteins, the type and concentration of stabilizers or thickeners used, and processing conditions such as heat treatment [39].

Table 2 The effect of different levels of Fenugreek seed extract on the amount of phenolic compounds, antioxidant activity and viscosity of yogurt

Amount of extract (%)	Day	Phenolic compounds	Antioxidant activity	Viscosity

[DOI: 10.22034/FSCT.22.158.238]

Sample	1	466±0.01[a]	56.91±0.01[a]	3567±0.04[c]
0.2	1	490±0.05[c]	69.70±0.03[b]	1950±1.28[c]
0.4	1	497±0.04[e]	70.71±0.03[c]	3200±1.20[c]
0.6	1	499±0.01[g]	70.98±0.03[d]	3050±6.50[c]
Sample	7	465±0.02[b]	57.95±0.06[a]	1782±0.40[b]
0.2	7	491±0.04[d]	75.66±0.04[b]	1022±0.02[b]
0.4	7	495±0.04[f]	78.57±0.03[c]	1167±0.66[b]
0.6	7	495±0.01[h]	79.87±0.01[d]	1159±0.30[b]
Sample	14	466±0.01[a]	45.71±0.04[a]	1280±0.90[a]
0.2	14	491±0.03[d]	65.51±0.02[b]	759±1.50[a]
0.4	14	495±0.02[f]	67.24±0.01[c]	711±3.88[a]
0.6	14	493±0.01[i]	68.27±0.11[d]	703±3.96[a]

±: Values indicate standard deviation

a-l: Averages with different superscripts in the same row have a significant difference (less than 0.05).

3.7. Investigating the sensory properties of yogurt

Figure (2) shows the effect of fenugreek seed extract and storage time variables on the sensory properties including taste, texture, color, and overall acceptance of the produced yogurt. In most cases, control yogurt samples obtained higher sensory scores than samples containing fenugreek seed extract. Data review and analysis showed that the sample containing 0.6% extract had the greatest effect on the color and texture indices of the produced yogurt, while all three levels of extract consumed had no effect on the overall acceptance parameter ($P>0.05$), which was consistent with the research of Imamoglu et al. (2017), who stated in their results that using higher levels of a combination of saffron, thyme, and cumin essential oils reduced viscosity, subsequently changed mouthfeel, and ultimately reduced overall acceptance of the produced product [40].

The results of the analysis of variance of the interaction between fenugreek seed extract and storage time also indicated that adding the extract over time had a significant effect and led to a decrease in the overall acceptance parameter of the samples, according to the evaluators. The control sample had the highest sensory quality scores on the first day and the sample containing 0.2% extract had the lowest sensory quality scores on the 14th day ($P<0.05$). In fact, adding fenugreek seed extract did not have an adverse effect on the sensory properties of yogurt, but the desirability of yogurt decreased during storage. The results of the present study are consistent with the study of Soofi et al. (2019) because they used three levels to produce prebiotic low-fat yogurt containing inulin and stated that with increasing inulin concentration, the overall acceptance of yogurt samples first increased and then decreased; this is due to the effect of inulin in creating a creamy texture and taste similar to full-fat yogurts [41]. According to the research of Kakoei et al. (2007), whey protein concentrate instead of powdered milk in the preparation of yogurt, due to the greater hydrophilicity of serum proteins compared to casein, caused the texture of yogurt in the produced samples to become creamier, and this texture is desirable for most consumers and creates a pleasant mouthfeel. Therefore, during the storage period, the overall acceptance of the product improved and became closer to the control sample due to the production of more diacetyl and acidity compared to the control sample, as well as the improvement of the gel structure and consistency of the creamy yogurt [42].

[DOI: 10.22034/FSCT.22.158.238]

Fig 3 The effect of Fenugreek seed extract and storage time on the sensory properties of yogurt

4- Conclusion

This study investigated the effect of adding aqueous-alcoholic extract of fenugreek seed to yogurt. The results of the study of the interaction between fenugreek seed extract and storage time showed that increasing the extract level to 0.6% and a storage time of 14 days could have a significant effect on pH, acidity, and syneresis. By adding the extract level up to 0.6%, the amount of phenolic compounds on the first day and the antioxidant activity on the 7th day of storage showed the highest values, respectively. Changes in pH and acidity, with increasing levels of fenugreek seed extract consumption (sample containing 0.6% on the 14th day), the viscosity index value approached its lowest value (703 centipoise). According to the evaluators, in order to determine the overall acceptance index of the yogurt product, the control sample obtained the highest sensory quality scores on the first day, and the sample containing 0.2% extract obtained the lowest sensory quality scores on the 14th day.

5- References

[1] Çon, A.H., Çakmakçi, S., Çağlar, A., and Gökalp, H.Y. 1996. Effects of different fruits and storage periods on microbiological qualities of fruit-flavored yogurt produced in turkey. *Journal of Food Protection*, 59(4): 402-406.

[2] Mahiyan, R.A., Elhami Rad, A.H., and Jalali, M. 2015. Check active packaging has antioxidant properties in food products. *International Research Journal of Applied and Basic Sciences*, 9(7): 1163-1168.

[3] Antolovich, M., Bedgood, D.J.R., Bishop, A., Jardine, D., Prenzler, P., and Robards, K. 2004. LC–MS investigation of oxidation products of phenolic compounds. *Journal of Agricultural and Food Chemistry*, 52(4): 962-971.

[DOI: 10.22034/FSCT.22.158.238]

[4] Dini, M. 2006. Scientific name of medicinal plants used in traditional medicine. Forest and Rangeland Research Institute Publication, ISBN: 964-473-224-3. [In Persian].

[5] Ruby, B.C., Gaskill, S.E., Slivka, D., and Harger, S.G. 2005. The addition of fenugreek extract (Trigonella foenum-graecum) to glucose feeding increases muscle glycogen resynthesis after exercise. *Amino Acids*, 28: 71-76.

[6] Morcos, S.R., Elhawary, Z., and Gabrial, G.N. 1981. Protein rich food mixtures for feeding the young in Egypt. 1. Formulation. *Zeitschrift für Ernährungswissenschaft*, 20: 275-282.

[7] Niknam, R., Kiani, H., Mousavi, Z.E., and Mousavi, M. 2021. Extraction, Detection, and Characterization of Various Chemical Components of *Trigonella foenum-graecum* L. (Fenugreek) Known as a Valuable Seed in Agriculture. In: Naeem, M., Aftab, T., and Khan, M.M.A. (eds) Fenugreek. Springer, Singapore.

[8] Al-Habori, M., Al-Aghbari, A.M., and Al-Mamary, M. 1998. Effects of fenugreek seeds and its extracts on plasma lipid profile. a study on rabbits. *Phytotherapy Research*, 12(8): 572-575.

[9] Ribes, G., Sauvaire, Y., Baccou, J.C, Valette, G., Chenon, D., Trimble, E., and Loubatieres-Mariani, M.M. 1984. Effects of fenugreek seeds on endocrine pancreatic secretions in dogs. *Annals of Nutrition and Metabolism*, 28(1): 37-43.

[10] Zhou, J., Chan, L., and Zhou, S. 2012. Trigonelline: a plant alkaloid with therapeutic potential for diabetes and central nervous system disease. *Current Medicinal Chemistry*, 19(21): 3523-3531.

[11] Alarcon-Aguilara, F.J., Roman-Ramos, R., Perez-Gutierrez, S., Aguilar-Contreras, A., Contreras-Weber, C.C., and Flores- Saenz, J.L. 1998. Study of the anti-hyperglycemic effect of plants used as antidiabetics. *Journal of Ethnopharmacology*, 61(2): 101-110.

[12] Arab Salehi Nasrabadi, M., Ghorbani, M., Sadeghi Mahunak, A., and Khomeiri, M. 2019. Yogurt enrichment with Common purslane oil (Portulacaoleracea) and its physicochemical,antioxidant and sensory properties. *Journal of Food Science and Technology (Iran)*, 16(92): 23-36. [In Persian].

[13] Gad, A.S., and El-Salam, M.H.A. 2010. The antioxidant properties of skim milk supplemented with rosemary and green tea extracts in response to pasteurisation, homogenisation and the addition of salts. *International Journal of Dairy Technology*, 63(3): 349-355.

[14] Abpeikar, Z., Lohrasbi, P., and Monsefi, M.Z. 2015. The comparison of dill seed and leaf aqueous extracts (Anethum Graveolens L.) on histomorphometrical changes of rat uterus and ovaries. *Journal of Animal Research (Iranian Journal of Biology)*, 28(2): 116-124. [In Persian].

[15] Lotfizadeh Dehkordi, S., Shakerian, A., and Mohammadi, A., 2013. Effect of extract from Tragopogon graminifolius DC. on properties sensory, shelf life and the viscosity rate yogurt. *Journal of Medicinal Herbs*, 4(1): 49-57. [In Persian].

[16] Iran National Standards Organization. 2022. Milk and milk products-Determination of titrable acidity and pH-Test method. 2nd Revision, No. 2852. [In Persian].

[17] Tamime, A.Y., Barrantes, E., and Sword, A.M. 1996. The effects of starch based fat substitutes on the microstructure of set-style yogurt made from reconstituted skimmed milk powder. *International Journal of Dairy Technology*, 4(1): 1-10.

[18] Stoilova, I., Krastanov, A., Stoyanova, A., Denev, P., and Gargova, S. 2007. Antioxidant actirity of ginger extract (Zingiber officinale). *Food Chemistry*, 102(3): 764-770.

[19] Burits, M., and Bucar, F. 2000. Antioxidant activity of *Nigella sativa* essential oil. *Phytotherapy Research*, 14(5): 323-328.

[20] Sah, B.N.P., Vasiljevic, T., McKechnie, S., and Donkor, O.N. 2016. Physicochemical, textural and rheological properties of probiotic yogurt fortified with fibre-rich pineapple peel powder during refrigerated storage. *LWT-Food Science and Technology*, 65: 978-986.

[DOI: 10.22034/FSCT.22.158.238]

[21] Barrantes, E., Tamime, A.Y., and Sword, A.M. 1994. Production of lowcalorie yogurt using skim milk powder and fat-substitute. 3. Microbiological and organoleptic qualities. *Milchwissenschaft*, 49(4): 205-208.

[22] Talei, G.R., Meshkatalsadat, M.H., and Mosavi, S.Z. 2008. Antibacterial activity native medicinal plants extracts in Lorestan, Iran. *Journal of Gorgan University of Medical Sciences*, 10(1): 31-35. [In Persian].

[23] Kosikowski, F.V. 1981. properties of commercial flavored frozen yogurt. *Journal of Food Protection*, 44(11): 853-856.

[24] Tarakçi, Z., and Küçüköner, E. 2003. Physical, chemical, microbiological and sensory characteristics of some fruit-flavored yoghurt. *Yüzüncü Yıl Üniversitesi Veteriner Fakültesi Dergisi*, 14(2): 10-14.

[25] Vrese, M., Stegelmann, A., Richter, B., Fenselau, S., Laue, C., and Schrezenmeir, J. 2001. Probiotics-compensation for lactase insufficiency. *The American Journal of Clinical Nutrition*73(2): 421-429.

[26] Brüls, M., Foroutanparsa, S., Maljaars, C.E.P., Olsthoorn, M., Tas, R.P., and Voets, I.K. 2024. Investigating the impact of exopolysaccharides on yogurt network mechanics and syneresis through quantitative microstructural analysis. *Food Hydrocolloids*, 150: 109629.

[27] Blecker, C., Chevalier, J.P., Herck, J.C., Fougnies, C., Deroane, C., and Paquot, M. 2001. Inulin: Its pHysio-chemical properties and technological functionality. *Recent Research Development in Agriculture and Food Chemistry*, 5: 125-131.

[28] García-Pérez, F.J., Sendra, E., Lario, Y., Fernández-López, J., Sayas-Barberá, E., and Pérez-Alvarez, J.A. 2006. Rheology of orange fiber enriched yogurt. *Milchwissenschaft*, 61(1): 55-59.

[29] Rashmi, H.B., and Negi, P.S. 2022. Chapter 3 - Chemistry of plant extracts. Plant Extracts: Applications in the Food Industry, ISBN: 978-0-12-822475-5, pp:39-73.

[30] Forgani, S., Peighambardoust, S.H., and Olad Ghaffari, A. 2017. Investigating organoleptic and physicochemical properties of functional set yogurt incorporating oat milk. *Iranian Journal of Biosystem Engineering*, 48(3): 279-288. [In Persian].

[31] Hasanzadeh, E., Rezazadeh, S., Shamsa, S., Dolatabadi, R., and Zarringhalam, J. 2010. Review on phytochemistry and Therapeutic properties of Fenugreek (*Trigonella foenum-graceum*). *Journal of Medicinal Plants*, 9(34): 1-18. [In Persian].

[32] Pedram Nia, A., Sabetghadam, M., and Jalali, M. 2022. Optimization of chestnut (Aesculus hippocastanum) fruit extract extraction process by response surface methodology and evaluation of its antioxidant effect on the stability of soybean oil during shelf life. *Journal of Food Science and Technology (Iran)*, 18(120): 389-400. [In Persian].

[33] Ghasemi Kia, A., Ganjloo, A., and Bimakr, M. 2022. Optimization of ultrasound-assisted extraction of Fenugreek Seed protein and evaluation of its structural, functional Properties and antioxidant activity. *Journal of Food Science and Technology (Iran)*, 19(126): 39-55. [In Persian].

[34] HabibiNajafi, M.B., Fatemizade, S., and Tavakoli, M. 2018. Release of proteolysis products with aceinhibitory and antioxidant activities in probiotic yogurt containing different levels of fat and prebiotics. *International Journal of Peptide Research and Therapeutics*, 19(4): 275-380.

[35] Sodini, I., Remeuf, F., Haddad, S., and Corrieu, G. 2004. The relative effect of milk base, starter, and process on yogurt texture: a review. *Critical Reviews in Food Science and Nutrition*, 44(2): 113-137.

[36] Zomorodi, Sh. 2012. Physicochemical, rheological and sensory properties of stirred fruit yoghurt fortified by wheat fiber. *Journal of Food Research*, 22(4): 443-454. [In Persian].

[37] Shariatmadar Tehrani, H., and Sharifi, A. 2017. Investigating the possibility of producing synthetic biotic yogurt containing Lactobacillus kaisii and fibrillum from basil and stem. *Journal of Innovation in Food Science and Technology*, 9(1): 1-13. [In Persian].

[DOI: 10.22034/FSCT.22.158.238]

[38] Hosseini, M., and Saifi, T. 2022. The effect of aqueous-alcoholic extract of thyme and inulin on physicochemical properties of traditional Bokez Ilam yogurt. *Journal of Food Science and Technology (Iran)*, 19(126): 103-120. [In Persian].

[39] Abdi, S., Mir, N., and Dehghan Niri, M. 2013. Improvement of physical and sensory properties of dairy products using functional valuability of whey proteins. *Iranian Journal of Nutrition Sciences and Food Technology*, 7(5): 897-908. [In Persian].

[40] Imamoglu, H., Coggins, P.C., and Rowe, D.E. 2017. Influence of storage time and starches on texture attributes of conventional milk yogurt using response surface methodology. *International Food Research Journal*, 24(4): 1721-1727.

[41] Soofi, M., Alizadeh, A., and Mousavi Kalajahi, S.E. 2019. Optimization of low fat prebiotic yogurt processing containing inulin at different temperatures and shear stresses. *Journal of Food Science and Technology (Iran)*, 16(86): 109-118. [In Persian].

[42] Kakoei, H., Ehsani, M.R., and Mazlomi, M.T. 2007. Survey on diacetyl changes and sensory characteristics in yoghurt fortified with whey protein concentrate instead of milk powder. *Journal of Food Science and Technology (Iran)*, 4(2): 31-37. [In Persian].

[DOI: 10.22034/FSCT.22.158.238]

مجله علوم و صنایع غذایی ایران

سایت مجله: www.fsct.modares.ac.ir

مقاله علمی_پژوهشی

ویژگی‌های فیزیکوشیمیایی، آنتی‌اکسیدانی و حسی ماست همزده غنی شده با عصاره آبی-الکلی دانه گیاه شنبلیله

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اطلاعات مقاله

تاریخ های مقاله :

تاریخ دریافت:۱۴۰۳/۱/۶

تاریخ پذیرش: ۱۴۰۳/۹/۲۱

کلمات کلیدی:

عصاره دانه شنبلیله،

غنی‌سازی ماست،

ویژگی‌های فیزیکوشیمیایی،

فعالیت آنتی‌اکسیدانی

DOI:10.22034/FSCT.22.158.238.

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چکیده

یکی از متداول‌ترین انواع فرآورده‌های لبنی تخمیری به دلیل عطر و طعم مطلوب و بافت و قوام مناسبی، امکان اختلاط آن با سایر مواد مغذی به سهولت وجود دارد، ماست می‌باشد. شنبلیله با نام علمی (*Trigonella foenum-graceum*) گیاهی نهاندانه بوده و دانه شنبلیله که مهم‌ترین قسمت دارویی این گیاه است دارای فلاونوئیدها، سزکوئی‌ترپن‌ها و استرول‌ها و فیبرهای موسیلاژی می‌باشد. در مطالعه حاضر عصاره آبی-الکلی دانه شنبلیله در چهار سطح (صفر، ۰/۲، ۰/٤ و ۰/٦ درصد) بر برخی ویژگی‌های فیزیکوشیمیایی (pH، اسیدیته، آب‌اندازی و ویسکوزیته)، مقدار ترکیبات فنلی، فعالیت آنتی‌آکسیدانی و حسی (طعم، بافت، رنگ و پذیرش کلی) ماست همزده غنی شده در طی ١٤ روز نگهداری مورد بررسی قرار گرفت. نتایج آنالیز داده‌ها نشان داد نمونه حاوی ۰/٦ درصد به ترتیب دارای کمترین و بیشترین میزان شاخص‌های pH و اسیدیته است. همچنین با افزایش مدت زمان نگهداری تا ١٤ روز و نیز کاهش pH، میزان درصد آب‌اندازی تمام نمونه‌ها به طور معنی‌داری افزایش یافت ($P<۰/۰۵$). نتایج نشان داد که با کاهش معنی‌دار محتوای ترکیبات فنلی طی مدت نگهداری، اضافه کردن عصاره دانه شنبلیله به مقدار ۰/٦ درصد در مدت زمانی ۱ و بخصوص ۷ روز باعث افزایش فعالیت آنتی‌اکسیدانی شد و در ادامه تا زمان نگهداری ١٤ روز فعالیت آنتی‌اکسیدانی در بعضی نمونه‌ها کم و در برخی با تغییر بسیار جزئی همراه بود ($P>۰/۰۵$). همچنین بیشترین و کمترین مقدار ویسکوزیته ۳۵۰۰ سانتی‌پوآز (نمونه شاهد در روز اول) و ۷۰۳ سانتی‌پوآز (نمونه حاوی ۰/٦ درصد در روز چهاردهم) حاصل شد ($P<۰/۰۵$). در نهایت با بررسی نتایج حاصله از خصوصیات حسی، نمونه حاوی عصاره دانه شنبلیله توانست در مقایسه با نمونه شاهد، امتیاز قابل قبولی را از جانب ارزیابان حسی کسب نماید. در بین انواع فرمولاسیون ماست غنی شده و شاهد، نمونه ی حاوی ۰/٦ درصد عصاره در زمان نگهداری ۱ روز از لحاظ ویژگی‌های حسی از بالاترین درجه مطلوبیت برخوردار بود.

[DOI: 10.22034/FSCT.22.158.238]