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Investigating the rheological properties of dough and evaluating physiochemical properties of Sangak bread using whey powder and hydrocolloids of guar and tragacanth

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ABSTRACT

In current study, whey powder, guar and tragacanth gums were used at the different levels of 0.1, 0.3 and 0.5%, and in a mixed forms of 0.25% whey powder and 0.25%. Guar gum, 0.25% of whey powder and 0.25% of tragacanth gum in the formulation of Sangak bread to improve farinographic and extensograph properties of dough and physicochemical and sensory properties of bread. The results showed that the highest water absorption and dough development time and the lowest weight loss and firmness were observed in the sample containing 0.5% tragacanth gum. The samples containing guar gum and tragacanth and the sample containing 0.25% whey powder and 0.25% guar gum had the longest dough stability time. Tragacanth gum had the greatest role in reducing the degree of softening and increasing the farinograph quality number. Guar gum was more effective than other ingredients in improving dough extensibility. The effect of tragacanth gum and guar on dough resistance was increasing and decreasing, respectively. The highest energy was observed in the sample containing 0.25% whey powder and 0.25% tragacanth gum. The additives used improved the odor, color and chewability of Sangak bread. Thus, the sample containing 0.5% tragacanth gum (1 priority) and the sample containing 0.25% whey powder and 0.25% tragacanth gum (2 priority) has been introduced as the best samples.

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1. Introduction

Retrogradation shortens the shelf life of bread and other bakery products. In fact, retrogradation is a phenomenon during which the external and internal characteristics, smell, taste, and chewability of the bakery product change, which results in retrogradation in bread. In the phenomenon of retrogradation, the transfer of aromatic substances and moisture from the inner parts of the bread to the crust causes the loss of the smell and taste of the bread [1 and 2]. To improve the quality characteristics of bread, increase marketability and reduce the rate of retrogradation of bread (increasing the shelf life of bread), different solutions have been proposed by food industry experts. One of these solutions is the use of additives such as hydrocolloids. Tragacanth gum is one of the indigenous and widely used gums in the food industry. This gum is called by different names such as Ketra, Kathira, Qata and gum tragacanth. This gum is considered one of the most important plant gum extracts and it is extracted from a plant belonging to the *Leguminosa* family, *Papilionidiae* subfamily and *Astragalus* genus [3]. Tragacanthin is a water-soluble component of Tragacanth gum, which is highly hydrophilic due to its special polysaccharide structure and creates a colloidal solution. This component constitutes 30% of Tragacanth. Tragacanthic acid is a water-insoluble component that can swell and form a gel [4]. Due to its unique components, Tragacanth gum has been used as an anti-stale compound in Brotchen, Tost, gluten-free, Tufton, half-baked, and Berber bread, respectively [5, 6, 7, and 8]. Guar gum is one of the other commonly used gums in the food industry, especially in bread and baking products. Guar gum which belongs to the legume group, is obtained from the endosperm of guar plant after removing the shell and germ. Guar is a cheap gum that can be dissolved in cold mixtures. Even in low concentrations, it creates a high viscosity. Some types of it creates maximum viscosity during 2-20 hours. Hejrani *et al.* (2019) reported that guar gum acted as an anti-staling additive and improved the quality of Barbary bread [9]. Also, Sahraiyan *et al.* (2013) used guar gum with the aim of improving the technological and sensory characteristics of bread and reducing the rate of retrogradation during storage. The results of these researchers indicated the positive performance of this gum [10]. Whey powder also has many and proven uses in the bakery industry. Whey is a liquid that is a byproduct of the production process of cheese and other dairy products. The main component of whey is (α-lactalbumin and β-lactoglobulin) and sugar (lactose). Lactose affects the color of the crust and the taste of bread. In addition, it improves the volume and sensory properties of bread [11]. Sahraiyan *et al.* (2020) and Moradkhani *et al.* (2016) used whey powder for various purposes in the formulation of sorghum gluten-free bread, bread containing rye flour and frozen dough, respectively [12, 13]. The results of these researchers had a common point based on improving the bread texture and increasing the shelf life.

Therefore, in this research, due to the importance of additives in improving the texture and sensory characteristics and postponing the retrogradation process, whey powder and guar and tragacanth gums were used in the formulation of Sangak bread. The quality of Sangak bread was checked.

2- Materials and methods

Materials

Flour with an extraction degree of 93% from Behnam factory (Torbat-e Heydarieh city, Khorasan Razavi province), guar gum and tragacanth from Rihan Gum Parsian company (Golestan city, Gorgan province), whey powder from Pegah company (Mashhad city, Khorasan Razavi province), baker's yeast *Saccharomyces Cerevisiae* from Razavi Yeast Company (Mashhad city, Khorasan Razavi province) and food salt were purchased from

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Soda Salt Factory (Khorasan Razavi province, Sabzevar city). Other chemical and laboratory materials were obtained from reputable companies.

Methods

Farinograph

This test was performed with Farinograph device (Brabander, model 816100001, made in Germany) to determine water absorption, dough expansion time, stability time, dough softness and Farinograph quality number based on AACC standard (2000) with number 54-21 [14].

Extensograph

The experiment was performed using an extensograph device (Brabander, model 860704, made in Germany) to determine tensile strength, maximum height, tensile strength coefficient and energy according to the AACC standard (2000) with number 54-10 [14].

The method of making Sangak bread

The preparation of bread was based on the study of Hosseini Esfahani and Fadavi (2019) with little variations [8]. The formulation of Sangak control bread included: 100% flour (1000 grams), 1% table salt (10 grams), 3% yeast (30 grams) and required water (based on farinograph water absorption percentage). According to Table 1, the other samples contained different levels of guar gum and tragacanth (0.1, 0.3 and 0.5% based on the flour percentage) and whey powder (0.1, 0.3 and 0.5% based on the percentage of flour). To prepare bread, firstly, flour, yeast, salt and additives were weighed and mixed uniformly in the mixing tank. Then the water required for each treatment was added according to the water absorption rate of farinograph with a temperature of 30-40 degrees Celsius and stirring was done at medium speed for 10 minutes until the ingredients were completely mixed. Then 5 minutes was given to absorb the flour particles well. Dough was rested for 90 minutes at 30 degrees Celsius, spread on special wooden paddles and placed in the oven at 270 degrees Celsius for 4 minutes. After baking, the samples were cooled in the manner of bakeries on nails installed on the wall and finally packed in polythene bags until testing.

Table 1 Treatments

Treatments	Ingredients (%)		
	Whey powder	Guar gum	Tragacanth gum
1(Control)	-	-	-
2	0.1	-	-
3	0.3	-	-
4	0.5	-	-
5	-	0.1	-
6	-	0.3	-
7	-	0.5	-
8	-	-	0.1
9	-	-	0.3
10	-	-	0.5
11	0.25	0.25	-
12	0.25	-	0.25

Weight loss

In order to determine the weight loss, the weight of the chins and bread was measured after baking and cooling for 2 hours, and the weight loss of the bread was calculated through equation 1 [15].

Relation (1)

weight loss (%) = (Weight of bread dough balls- the weight of the bread after baking)/ (Weight of dough balls) x100

Texture firmness

The compression test was performed according to AACC standard method (2000) with number 74-09 by means of a texture analyzer (TA-XT plus C model manufactured by Stable micro systems, England) 2 hours after baking. For this purpose, 3 x 3 cm pieces were cut from the samples and tested by a cylindrical probe with a diameter of 25 mm, at a speed of 1 mm/s and a distance of 5 mm. Finally, the firmness of the bread was reported in grams of force [14].

Sensory characteristics

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In this research, a five-point hedonic scoring system (1: very bad and 5: very good) was used for sensory evaluation. For this purpose, sensory evaluation forms were provided to 9 food science students. The taste judges randomly evaluated the samples in suitable conditions, and a time interval was observed between each sample and drinking water. It should be noted that bread samples were compared and evaluated in terms of sensory parameters such as smell, taste, color and chewability [16].

3. Results and Discussion

3.1. Dough farinograph parameters

In Table 2, the amount of water absorption, development time, degree of dough softening and farinograph quality number of produced samples containing different levels of whey powder and guar and tragacanth gums are presented. As the results show, all the produced samples except the sample containing 0.1% whey powder had higher water absorption compared to the control sample (the sample without whey powder and guar and tragacanth gums). The presence of tragacanth gums at all consumption levels and guar gum at the levels of 0.3 and 0.5% were effective in increasing the dough development time compared to the control sample. Meanwhile, whey powder in the presence of 0.25% guar gum or tragacanth played a role in increasing the dough development time. The presence of whey powder, guar and tragacanth gums led to a decrease in the degree of dough softening of the produced samples compared to the control sample. Whey powder did not have any positive effect on the improvement of dough farinograph quality number. This was despite the fact that the Farinograph quality number of the samples containing guar and tragacanth gums was higher than the control sample.

Table 2 The effects of different treatments on dough farinography

Treatments	Dough farinography				
	Water Absorption (%)	Dough Development Time (min)	Dough Stability Time (min)	Degree of Dough Softening (BU)	Quality Number
1(Control)	62.00±0.00^{d}	3:27±0:00^{c}	3:00±0:00^{cd}	81.00±0.00^{a}	55.00±0.00^{f}
2	62.07±0.50^{d}	3:26±0:03^{c}	2:67±0:29^{d}	73.67±4.93^{ab}	53.67±2.08^{f}
3	62.50±0.50^{cd}	3:30±0:03^{c}	2:89±0:27^{cd}	69.66±1.52^{b}	56.67±2.08^{ef}
4	63.00±0.00^{bcd}	3:22±0:02^{c}	2:42±0:07^{d}	79.33±1.15^{a}	51.00±1.00^{f}
5	62.60±0.53^{cd}	3:28±0:06^{c}	3:12±0:05^{cd}	71.00±1.73^{b}	56.33±0.58^{ef}
6	63.50±0.50^{abcd}	3:47±0:03b^{c}	3:73±0:37^{bc}	49.00±3.00^{cd}	73.33±2.31^{cd}
7	64.23±0.68^{ab}	4:13±0:09^{a}	4:29±0:06^{ab}	45.33±0.58^{de}	80.00±2.64^{bc}
8	63.67±0.58^{abc}	4:32±0:03^{a}	4:79±0:01^{a}	36.00±2.648^{f}	93.33±3.518^{a}
9	64.00±0.00^{abc}	4:18±0:03^{a}	4:40±0:09^{ab}	38.33±1.15^{ef}	89.00±1.00^{ab}
10	64.90±0.52^{a}	4:17±0:02^{a}	4:70±0:67^{a}	34.00±3.46^{f}	98.33±9.29^{a}
11	64.23±0.35^{ab}	4:08±0:29^{a}	3:64±0:11^{bc}	52.67±4.58^{cd}	72.33±3.21^{cd}
12	64.33±0.67^{ab}	3:67±0:06^{a}	3:17±0:35^{cd}	55.00±2.88^{c}	66.33±4.04^{de}

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

Whey proteins by affecting the disulfide bonds of the gluten network and by strengthening the bonds of glutenin and gliadin in the dough network and improving the complex of this protein complex with starch lead to an increase in the resistance of the dough against the farinograph stirring force. It has also increased the quality number of farinography. By increasing the amount of protein in the dough formula, the water absorption networks and the gluten network in the dough were strengthened, thereby increasing the amount of water absorption, development time, and dough resistance [10 and 12]. Also, as mentioned, the presence of guar and

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tragacanth gums in the formulation of Sangak bread dough was effective in increasing water absorption, development time and stability of the dough, and farinograph qualitative number and reducing the degree of dough softening. The increase in dough water absorption as a result of adding gum to the dough formula is due to the hydrophilic nature of these hydrocolloids. Also, with the increase of gum, water absorption has increased due to the increase in the number of hydroxyl groups and more hydrogen bonds with water molecules [17]. Rodriguez-Garcia *et al.* (2012) also reported similar results and acknowledged that gums are hygroscopic compounds and by adding them to the formulation of bakery products, the water absorption of dough can be increased [18].

Gharaie *et al.* (2015) found an increase in dough water absorption by adding gum tragacanth and guar to the bread formula. These researchers attributed the reason to the creation of a three-dimensional structure as a result of the presence of gum in the formulation to absorb more water. Also, the branched chains of hydrocolloids cause a kind of interference in the formation of connections between proteins in order to form a protein network and increase the dough development time [19].

Sahraiyan *et al.* (2013) reported using cress seed and guar gum in the formulation of mixed bread containing wheat-rice flour that the dough development time increased with the increase in the consumption level of both types of gum and their combination. These researchers stated that during mixing, flour ingredients absorb moisture to form dough. Therefore, as the number of hydrophilic compounds (compounds with hydroxyl groups such as hydrocolloids) increases in the initial formulation of baking industry products, the mixing time to form dough increases [10]. Ribotta *et al.* (2005) attributed the increase in dough consistency (increase in dough stability time) to the formation of a complex between hydrocolloids and gluten protein, caused by the reaction between functional groups in the structure of hydrocolloids and amino groups in the structure of gluten, which the complex formed increases the consistency and stability of the dough. According to these researchers, if the hydrocolloid is anionic in nature (the presence of a carboxyl or sulfate group), it establishes an ionic bond with the amino group of the gluten protein through an electrostatic reaction. But if the hydrocolloid is neutral in nature, the hydroxyl group in its structure reacts with the amino group of the gluten protein through hydrogen bonding. The decrease in the degree of softening of the dough can be related to the increase in its stability and consistency due to the addition of hydrocolloids [20]. In general, it can be concluded that the addition of tragacanth gum and guar increased the strength and stability of the dough and reduced the degree of its softening.

3.2. Dough extensograph parameters

In Table 3, the results of dough extensibility, in Table 4, resistance to extension and maximum resistance on dough extension, in Table 5, the ratio of tensile strength to elasticity and the ratio of maximum tensile strength to elasticity are presented. Table 6 shows the energy required for stretching the dough after 45, 90, and 135 minutes under the influence of different levels of whey powder and guar and tragacanth gums. As the results show sample containing 0.25% whey powder and 0.25% guar gum and the sample containing 0.25% whey powder and 0.25% guar gum had the highest elasticity after 45 and 90 minutes. Also, based on the results of tensile strength and maximum tensile strength of the dough, it can be observed that the effect of tragacanth gum on these two parameters was increasing and the effect of guar gum on these two parameters was decreasing. In this way, the presence of tragacanth gum and guar in the formulation of Sangak bread dough led to an increase and a decrease in the tensile strength of the dough, respectively, compared

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to the control sample (sample without additives). The highest ratio of tensile strength to dough elasticity was observed in the sample containing 0.25% whey powder and 0.25% tragacanth gum after 45 minutes, and the sample containing 0.5% tragacanth gum and the sample containing 0.25% whey powder, and 0.25% of tragacanth gum after 90 and 135 minutes. Also, the results of the ratio of the maximum tensile strength to the elasticity of the dough showed the highest value of this ratio in the sample containing 0.5% of tragacanth gum at 45, 90 and 135 minutes. The greatest effect on the ratio of tensile strength to extensibility and maximum tensile strength to extensibility was due to the presence of tragacanth gum, especially at the level of 0.5%. The highest amount of energy required for stretching the dough was observed in the sample containing 0.25% whey powder and 0.25% tragacanth gum after 135 minutes.

Table 3 The effects of different treatments on extensibility of dough

Treatments	Extensibility of dough (mm)		
	45 min	90 min	135 min
1(Control)	140.00±0.00^{b}	158.00±0.00^{a}	156.00±0.00^{a}
2	139.00±6.08^{ab}	146.33±5.68^{abc}	139.00±1.73^{bc}
3	150.67±2.08^{ab}	150.00±2.64^{ab}	150.00±4.00^{ab}
4	149.00±5.29^{ab}	150.67±2.52^{ab}	144.67±6.51^{abc}
5	151.67±10.69^{ab}	157.30±5.68^{a}	146.33±4.62^{a}
6	150.33±1.15^{ab}	157.00±1.73^{a}	150.00±9.64^{a}
7	139.67±1.53^{b}	146.00±8.89^{abc}	147.00±6.08^{abc}
8	148.33±4.04^{ab}	148.67±1.15^{abc}	152.67±1.53^{ab}
9	138.33±2.31^{b}	139.33±2.08^{bc}	140.00±1.73^{bc}
10	137.67±4.93^{b}	137.00±2.64^{c}	132.67±6.43^{c}
11	155.33±2.31^{a}	158.00±5.29^{a}	153.33±4.16^{ab}
12	154.67±6.35^{a}	155.00±3.60^{a}	152.67±4.62^{ab}

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

Table 4 The effects of different treatments on resistance to extension and Maximum resistance on dough extension

Treatments	Resistance to extension (BU)		
	45 min	90 min	135 min
1(Control)	136.00±0.00^{f}	160.00±0.00^{a}	181.00±0.00^{cd}
2	144.67±1.53^{def}	166.00±7.00^{abc}	181.00±6.81^{cd}
3	140.00±4.36^{ef}	168.67±2.88^{ab}	186.33±12.74^{bcd}
4	146.00±1.00^{cdef}	170.33±2.31^{ab}	187.67±8.08^{bcd}
5	155.67±11.85^{bcdef}	163.67±6.03^{a}	166.00±9.85^{d}
6	144.00±1.005^{def}	160.00±5.57^{a}	166.33±4.73^{d}
7	166.00±12.77^{abcd}	187.70±17.47^{abc}	184.00±3.60^{bcd}
8	152.33±7.57^{bcdef}	176.67±9.02^{abc}	184.00±6.00^{bcd}
9	162.67±14.01^{bcde}	194.33±11.37^{bc}	206.00±6.24^{ab}
10	170.67±7.51^{ab}	200.67±6.43^{c}	203.67±3.78^{ab}
11	168.00±5.51^{abc}	185.33±5.519^{a}	190.33±13.57^{bc}
12	186.33±7.94^{a}	217.67±0.58^{a}	225.33±4.62^{a}
Treatments	Maximum of resistance to extension (BU)		
	45 min	90 min	135 min
1(Control)	138.00±0.00^{f}	164.00±0.00^{ef}	184.00±0.00^{cd}
2	148.67±1.15^{def}	166.67±6.43^{def}	177.00±7.00^{cd}

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3	141.00±3.60^{f}	168.33±2.21^{def}	186.67±13.32^{bcd}
4	147.00±1.73^{ef}	170.33±3.21^{def}	188.33±8.38^{bcd}
5	161.33±10.02^{bcdef}	166.00±7.21^{ef}	166.67±10.26^{d}
6	151.00±1.73^{cdef}	162.00±5.29^{f}	167.00±5.29^{d}
7	174.33±15.50^{abc}	191.30±20.03^{bcd}	186.33±4.72^{bcd}
8	158.33±7.77^{cdef}	178.677±9.02^{cdef}	184.00±6.00^{cd}
9	171.33±15.14^{abcd}	198.43±12.34^{abc}	207.67±7.09^{ab}
10	182.67±7.57^{ab}	207.33±7.57^{ab}	209.33±2.31^{ab}
11	169.00±5.57^{abcde}	187.00±5.29^{bcde}	191.31±13.00^{bc}
12	186.67±8.18^{a}	218.00±1.00^{a}	226.00±4.62^{a}

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

Table 5 The effects of different treatments on ratio number and maximum ratio number of dough

Treatments	Ratio number		
	45 min	90 min	135 min
1(Control)	0.98±0.00^{c}	1.02±0.00^{d}	1.16±0.00^{c}
2	0.97±0.04^{c}	1.14±0.04^{cd}	1.27±0.04^{bc}
3	0.93±0.02^{c}	1.13±0.04^{cd}	1.24±0.12^{c}
4	0.98±0.03^{c}	1.13±0.03^{cd}	1.30±0.08^{bc}
5	1.02±0.09^{bc}	1.04±0.04^{d}	1.14±0.10^{c}
6	0.95±0.01^{c}	1.02±0.04^{d}	1.13±0.05^{c}
7	1.18±0.10^{ab}	1.29±0.19^{abc}	1.26±0.03^{c}
8	1.03±0.02^{bc}	1.19±0.07^{bcd}	1.20±0.05^{c}
9	1.17±0.10^{ab}	1.39±0.07^{ab}	1.47±0.02^{ab}
10	1.24±0.01^{ab}	1.46±0.07^{a}	1.53±0.04^{c}
11	1.08±0.05^{abc}	1.41±0.04^{a}	1.24±0.13^{c}
12	1.20±0.06^{a}	1.17±0.04^{cd}	1.48±0.06^{ab}
Treatments	Maximum Ratio number		
	45 min	90 min	135 min
1(Control)	1.00±0.00^{d}	1.04±0.00^{e}	1.18±0.00^{d}
2	1.00±0.03^{d}	1.14±0.04^{de}	1.27±0.03^{cd}
3	0.94±0.01^{d}	1.12±0.04^{de}	1.25±0.12^{cd}
4	0.99±0.03^{d}	1.13±0.02^{de}	1.30±0.08^{bcd}
5	1.07±0.09^{cd}	1.05±0.04^{e}	1.14±0.10^{d}
6	1.00±0.01^{d}	1.03±0.02^{e}	1.15±0.05^{d}
7	1.25±0.12^{ab}	1.31±0.22^{abcd}	1.28±0.01^{cd}
8	1.06±0.03^{cd}	1.20±0.07^{bcde}	1.19±0.03^{d}
9	1.24±0.10^{ab}	1.42±0.08^{ab}	1.49±0.02^{ab}
10	1.33±0.00^{a}	1.51±0.07^{a}	1.58±0.06^{a}
11	1.08±0.05^{bcd}	1.18±0.04^{cde}	زی1.25±0.13
12	1.20±0.06^{abc}	1.41±0.03^{abc}	1.48±0.06^{ab}

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

Table 6 The effects of different treatments on energy of dough

Treatments	Energy of dough (cm^2)		
	45 min	90 min	135 min

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1(Control)	28.00±0.00^{d}	36.00±0.00^{c}	42.00±0.00^{bc}
2	32.33±1.53^{cd}	36.00±2.64^{c}	36.67±1.15^{cd}
3	32.33±1.52^{cd}	38.00±0.00^{c}	41.00±1.73^{bcd}
4	32.33±1.53^{cd}	38.67±1.15^{c}	40.00±2.00^{bcd}
5	36.00±4.00^{bc}	37.67±3.21^{c}	36.00±1.73^{d}
6	32.00±0.09^{cd}	36.00±2.00^{c}	35.67±0.58^{d}
7	34.67±3.05^{bc}	40.00±4.00^{c}	39.33±3.05^{bcd}
8	33.33±2.31^{cd}	38.67±1.15^{c}	40.66±1.15^{bcd}
9	33.33±2.71^{cd}	39.67±2.88^{bc}	41.67±1.52^{bc}
10	34.67±2.30^{bc}	40.00±2.00^{bc}	39.33±2.31^{bcd}
11	40.00±1.52^{ab}	45.00±1.00^{ab}	44.33±3.05^{b}
12	43.33±2.00^{a}	51.00±1.00^{a}	50.67±1.53^{a}

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

Based on the results of dough extensograph characteristics, it was found that the performance of samples containing gum, especially tragacanth gum, and samples containing the combination of both types of additives (whey powder and gum) were better than the extensograph characteristics of samples containing whey powder alone. But according to the results obtained from the sample containing 0.25% whey powder and 0.25% guar gum and the sample containing 0.25% whey powder and 0.25% tragacanth gum, the positive performance of this additive (whey powder) on improving the extensograph properties of dough should not be ignored. The change in extensibility, tensile strength and the ratio of tensile strength to extensibility can be explained as the two constituents of gluten, namely glutenin and gliadin, are responsible for creating viscous (expandability) and elastic (elasticity) properties in the dough, respectively. Tensile ability and tensile strength indicate elasticity and expansion ability, respectively. Strengthening or weakening of glutenin and gliadin changes the values of stretchability and tensile strength, which increases or decreases the ratio of tensile strength to stretchability depending on the ratio of changes. To compare different treatments, the ratio of tensile strength to stretchability is a more suitable measure to other data. Increasing the value of this ratio (resistance coefficient) to some extent indicates the improvement of the kneading properties of the dough, and very low or very high values indicate that it is not suitable for kneading. The increase in stretchability, tensile strength, the ratio of tensile strength to stretchability and energy required as a result of adding 0.25% of whey powder (in mixed samples) indicates that whey powder leads to an increase in the elastic state of the dough, and as a result, the samples containing it (the sample containing 0.25% whey powder and 0.25% guar gum and the sample containing 0.25% whey powder and 0.25% of tragacanth gum) is able to maintain a greater amount of gas produced in the dough, which helps to improve the texture of the bread. During the resting time of the dough, the S-H groups provided by the whey powder, in the absence of oxygen, lead to the reduction of gluten disulfide bonds and increase the elasticity of the dough. Based on the results of the dough extensograph analysis, the effective role of adding guar gum and tragacanth to flour and their presence in the Sangak bread dough formula was proven to improve the dough's extensograph characteristics.

Grobelnik Mlakar *et al.* (2009) and Wu *et al.* (2009) considered the presence of gum in the bread formula as a factor in increasing the tensile strength of the dough [21, 22]. These researchers attributed the reason to the structural stability of gluten during rest. Ketabi *et al.* (2008) reported an increase in resistance coefficient (ratio of tensile strength to stretchability) by adding a series of

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hydrocolloids at different levels to flour. According to these researchers, the reason for this was the increase in consistency (stability) of the dough due to the addition of hydrocolloids [23]. Sahraiyan *et al.* (2013) obtained similar results as a result of adding guar gum and cress seed gum to the Berberi bread formula, and in general, adding gum to the bread dough formulation was considered to be an effective factor on bread dough defects and improving farinograph and extensograph parameters of the dough [10].

3.3. Weight loss

Table 7 presents the results of weight loss. As the results show, the weight loss of all production samples containing whey powder, guar gum and tragacanth gum was lower than the control sample. This means that the additives used in the formulation of Sangak bread had an effective role in maintaining the moisture of the bread and at the same time reducing the weight loss. Therefore, based on the findings of current research, the highest weight loss was related to the control sample, and the lowest was jointly related to the sample containing 0.5% tragacanth gum and the sample containing 25% whey powder and 0.25% guar gum. Sahraiyan *et al.* (2021) used whey powder in the formulation of bread containing sorghum flour. The results of these researchers indicated an increase in moisture content and a decrease in weight loss [24]. Stathopoulus and Okennedy (2008) reported that by adding milk casein to flour, milk casein led to the strengthening of the gluten network and increased water absorption of the dough, as a result of which the moisture retention of the produced samples increased and the weight loss decreased as a result [25]. Sahraiyan *et al.* (2020) used different compounds such as whey powder, various hydrocolloids, water and oil in the form of napkins to maintain moisture and reduce the weight loss of bread. The results of these researchers showed whey powder due to the formation of a quasi-network similar to the gluten network and the presence of protein and lactose sugar in it and guar and cress seed gums due to their hydroxyl groups were successful in increasing the moisture content of the dough and maintaining it during the baking process, which it led to a decrease in weight loss compared to samples without handkerchiefs [12]. Hosseini Esfehani and Ghasem Fadavi (2019) found a direct relationship between the amount of added gum and the moisture content of the bread as a result of adding tragacanth gum and guar to the formulation of Tufton bread. These results can be due to the nature of hydrophilicity, the ability to connect and retain water of the gums, which are able to create a three-dimensional structure and form a gel; Therefore, the gums retained more moisture in the structure of the bread during the baking process and storage time [8]. McCarthy *et al.* (2005) reported based on their research that gums interact with water because of their hydrophilic nature, and reduce the diffusion of water and the stability of its presence in the system. This is effective in increasing water absorption and maintaining the moisture of the final product during the cooking and storage process [8]. Sahraiyan *et al.* (2013) stated that the samples containing gum had more moisture and less weight loss compared to the sample without it, which was reported to be due to the high ability to retain water due to the presence of hydroxyl groups in the gum structure. Rodriguez-Garcia *et al.* (2012) also reported similar results and acknowledged that gums are hygroscopic compounds and when added to bakery products, they increase product moisture [18]. Hejrani *et al.* (2017) obtained similar results by adding guar gum and xanthan gum in bread formula [27].

Table 7 The effects of different treatments on weight loss and firmness of sangak bread

Treatments	Weight loss (%)	Firmness (g)
1(Control)	37.66±0.00[a]	327.70±43.46[a]

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2	23.49±3.21[bc]	216.41±15.34[b]
3	23.77±1.86[bc]	199.00±23.14[bc]
4	22.66±1.55[bc]	188.74±7.23[bc]
5	29.89±1.88[b]	172.55±12.36[bc]
6	23.89±1.66[bc]	321.10±46.44[a]
7	26.12±1.64[bc]	373.30±60.63[a]
8	23.20±3.86[bc]	386.70±19.85[a]
9	27.51±3.20[bc]	205.06±5.36[bc]
10	20.05±3.90[c]	129.73±8.66[c]
11	20.58±2.22[c]	212.20±2.34[bc]
12	24.77±3.92[bc]	160.01±20.43[bc]

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

3.4. Firmness of bread texture

The results presented in Table 7 show the firmness of Sangak bread texture under the influence of adding whey powder and guar and tragacanth gums. As the results show the sample containing 0.5% tragacanth gum has the lowest firmness and the control sample, the sample containing 0.1% tragacanth gum, the sample containing 0.3% guar gum and the sample containing 0.5% guar gum jointly have the highest firmness in compared with other production samples. In general, it can be concluded that the presence of additives, especially whey powder and tragacanth gum, played an effective role in improving the texture of Sangak bread. Creating more spongy texture in bread samples containing whey powder resulted in softer bread. The reason for this can be attributed to the strengthening of the gluten network by the protein present in the added components and as a result, increasing the ability to retain the produced gas during the fermentation process in the dough texture. It seems that the softness and firmness of the texture immediately after cooking is caused by the amount of gas produced in the dough and the ability of the gas to expand in the texture in the first seconds of cooking. Lieke *et al.* (2011) achieved similar results due to the addition of protein compounds such as dairy powders to the bread formula and their positive performance in reducing the stiffness of the bread texture and the rate of retrogradation of the final product compared to the control sample (sample without additives). Increasing the firmness texture of bakery products during the storage period (from the moment of leaving the oven) and its retrogradation is a complex process. Several factors such as retrogradation of amylopectin, rearrangement of polymers in the amorphous region, reducing the amount of moisture or distribution of moisture between the amorphous and crystalline regions are involved in this process. Any factor that can be effective in maintaining moisture during the baking process and after, has a role in reducing the stiffness of the bread texture and slowing down the process of retrogradation [28]. Sahraiyan *et al.* (2021) and Sahraiyan *et al.* (2020) using whey powder in bread formulation reported similar results to the findings of the current research based on the reduction of bread texture stiffness as a result of adding whey powder to the formulation [24 and 12]. On the other hand, the results showed that the presence of gum, especially tragacanth gum, at the levels of 0.3% and 0.5% decreased the hardness of the bread texture compared to the control sample. The presence of hydrocolloids prevents the association of amylose and amylopectin polymers during bread storage and slows down the process of retrogradation of starch, thereby reducing the rate of retrogradation and thus the stiffness of the bread texture. Also, the decrease in the stiffness of the bread texture with increasing gum concentration can be explained due to the greater reaction of hydrocolloids with water compared to starch, because hydrocolloids contain hydroxyl groups in their structure and

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have a greater tendency to bond with water molecules. As a result, they prevent the transfer of water from gluten to starch, because amylose and amylopectin present in starch recrystallize in the presence of water and form a polymer, which causes the hardness of bread [29]. Szumilo *et al.* (2010) reported that the addition of gums to bread formulation strengthened the structure of the dough and reduced its degree of loosening, which was effective in maintaining the produced gas during the fermentation process and softening the texture of the final product. The improvement of bread texture is due to the structure of the mentioned additives and their strong bond with wheat flour components. Also, the lipophilic part of the gums connects with the hydrophobic part of wheat proteins and by creating a strong negative charge in the complex, it leads to the proteins aggregation and strengthening the gluten network of the dough [30]. Nateghi (2020) stated that the reason for the decrease in hardness in breads containing sodium alginate and tragacanth gums can be due to the ability of these compounds to absorb and retain water in the dough. By adding hydrocolloids to bread, functional groups present in the structure of hydrocolloids form a complex with the amino group present in the structure of gluten and the gluten network is strengthened. Therefore, dough consistency and stability, resistance to dough stretching and dough tolerance to fermentation conditions increase, which reduces the hardness index of bread treatments [5].

3.5 Sensory characteristics of bread

Sensory characteristics are one of the indicators that are directly effective in consumer acceptability of the product. These parameters are highly dependent on the texture and appearance of the product [8]. Table 8 shows the score of the sensory characteristics of the samples of perpared breads. As the results show, all the bread samples, except for the samples containing tragacanth gum, had a higher odor score compared to the control sample at all consumption levels. The results of the evaluation of the taste score of the production samples indicated that there was no significant difference between the bread samples and the control sample ($P<0.05$). The findings obtained from measuring the color score of production samples proved the positive performance of the used additives (whey powder and guar and tragacanth gums) in the formulation of Sangak bread. In this way, the color score of the control sample was lower than the color score of other production samples. Similar results were observed with the color score for the chewability score of the production samples. It should be noted that the positive role of whey powder and tragacanth gum on increasing the chewability score was greater than that of guar gum.

Table 8 The effects of different treatments on sensory properties of sangak bread

Treatments	Sensory Properties			
	Odor	Taste	Color	Chewiness
1(Control)	3.33 ± 0.50^{e}	3.67 ± 0.50^{a}	3.44 ± 0.52^{b}	3.22 ± 0.44^{c}
2	3.67 ± 0.50^{cde}	3.89 ± 0.60^{a}	4.56 ± 0.53^{a}	3.44 ± 0.52^{bc}
3	3.78 ± 0.44^{bcde}	4.22 ± 0.67^{a}	4.22 ± 0.66^{ab}	4.78 ± 0.44^{a}
4	3.56 ± 0.53^{de}	3.78 ± 0.66^{a}	4.11 ± 0.60^{ab}	4.44 ± 0.73^{a}
5	4.56 ± 0.52^{ab}	4.33 ± 0.50^{a}	4.33 ± 0.50^{a}	4.22 ± 0.66^{ab}
6	4.44 ± 0.72^{abc}	4.33 ± 0.50^{a}	4.44 ± 0.53^{a}	4.00 ± 0.70^{abc}
7	4.78 ± 0.44^{a}	4.33 ± 0.50^{a}	4.33 ± 0.50^{a}	4.33 ± 0.50^{ab}
8	3.33 ± 0.50^{e}	4.22 ± 0.44^{a}	4.44 ± 0.73^{a}	4.56 ± 0.53^{a}
9	3.11 ± 0.33^{e}	3.56 ± 0.73^{a}	4.67 ± 0.50^{a}	4.44 ± 0.52^{a}
10	3.11 ± 0.33^{e}	3.44 ± 0.52^{a}	4.55 ± 0.52^{a}	4.22 ± 0.66^{ab}
11	4.33 ± 0.50^{abcd}	4.22 ± 0.66^{a}	4.67 ± 0.50^{a}	4.11 ± 0.78^{abc}
12	3.67 ± 0.71^{cde}	4.22 ± 0.44^{a}	4.67 ± 0.50^{a}	4.57 ± 0.53^{a}

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

The results of this section also showed the positive effect of tragacanth and guar gum on improving the chewability and color of the produced breads. This is despite the fact that tragacanth gum did not have a positive effect on the odor score and only guar gum played a role in improving this parameter. Based on the results of their research, Sheikholeslami *et al.* (2018) reported that the color of bread samples improved as a result of adding gum, especially tragacanth gum, to the formulation. These researchers stated that improving the color or browning of bread crust is caused by non-enzymatic (Maillard) reactions between simple sugars and amino acids. According to these researchers, tragacanth gum consists of simple sugars, which participate in the maillard reactions, thus increasing the color of the bread and improving it [31]. Lebsi and Tzia (2011) reported that the presence of gum in bakery products improved the color of the inner texture. These researchers stated that the increase in the color intensity of the inner texture of bakery products and the improvement of this sensory parameter is due to the structural nature of the gum and the presence of amino acids in the consumed gums and the reaction between the mentioned compounds with the aldehyde compounds of the dough and finally the Maillard reaction [32]. Also, Lee and Inglett (2006) considered the presence of aldehyde compounds in gums to be one of the reasons for improving the taste of food containing gum [33]. Demirkesen *et al.* (2010) reported that adding gum to bread formulation improved the chewability and texture of the final product. The reason for improving the chewability and texture of the production samples containing gum was the presence of OH groups and other hydrophilic groups in the gum structure which increased the absorption of water, prevented the migration of crust water and prevented the bread from becoming rubbery and finally crispy [34]. Nateghi (2021) demonstrated that the presence of hydrocolloids, especially sodium alginate and gum, led to the reduction of dryness, improvement of freshness and increase of texture softness and chewability of bread, which played a role in improving the sensory properties of the manufactured product [5]. Hosseini Esfehani and Fadavi (2019) observed the improvement of the quality of production samples, especially in terms of texture and chewability, by adding a mixture of guar gum and tragacanth to the formulation of Tufton bread. These researchers stated that the presence of 0.3% of tragacanth gum and 0.7% of guar gum in the formulation resulted in the highest score of sensory characteristics compared to other bread samples [8].

4. Conclusion

Sangak bread is known as one of the traditional and popular breads in Iran, but unfortunately, the waste rate of this bread is high and its shelf life is low. On the other hand, due to the level of consumer awareness of the harms of chemical additives, the market of improvers obtained from natural compounds to improve the quality of traditional breads and increase their shelf life has flourished. Therefore, as mentioned earlier, in this research, whey powder and native gums such as guar and tragacanth were used to improve the quality and quantity of Sangak bread. Fortunately, satisfactory results were obtained regarding the improvement of farinograph and extensograph parameters of dough, reduction of weight loss, firmness of bread texture, and improvement of sensory characteristics such as smell, color and chewability as a result of the presence of these natural additives in the formulation of Sangak bread. In general, the sample containing 0.5% of tragacanth gum (first priority) and the sample containing 0.25% whey powder and 0.25% tragacanth gum (second priority) can be introduced as the best samples of this research.

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بررسی ویژگی‌های رئولوژیکی خمیر و خصوصیات فیزیکوشیمیایی نان سنگک با استفاده از پودر آب پنیر و هیدروکلوئیدها ی گوار و کتیرا

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چکیده

نان بخش مهمی از نیاز روزانه افراد جامعه را تأمین می‌کند و ضرورت برنامه‌ریزی پیرامون بهبود کیفیت آن احساس می‌شود. در تحقیق حاضر از پودر آب پنیر و صمغ‌های گوار و کتیرا هر کدام در سطوح ۰/۱، ۰/۳ و ۰/۵ درصد و به صورت ترکیبی در قالب دو تیمار ۰/۲۵ درصد پودر آب پنیر و ۰/۲۵ درصد صمغ گوار و ۰/۲۵ درصد پودر آب پنیر و ۰/۲۵ درصد صمغ کتیرا در فرمولاسیون نان سنگک با هدف بهبود ویژگی‌های فارینوگرافی و اکستنسوگرافی خمیر و خصوصیات فیزیکوشیمیایی و حسی نان سنگک حاصله استفاده شد. نتایج نشان داد بیشترین جذب آب و زمان توسعه خمیر و کمترین افت وزن و سفتی بافت در نمونه حاوی ۰/۵ درصد صمغ کتیرا مشاهده شد. نمونه‌های حاوی صمغ گوار و کتیرا و نمونه حاوی ۰/۲۵ درصد پودر آب پنیر و ۰/۲۵ درصد صمغ گوار دارای بیشترین زمان ثبات خمیر بودند. صمغ کتیرا بیشترین نقش بر کاهش درجه سستی خمیر و افزایش عدد کیفیت فارینوگراف داشت. صمغ گوار بیش از سایر ترکیبات بر بهبود کشش‌پذیری خمیر مؤثر بود. تأثیر صمغ کتیرا و گوار بر مقاومت به کشش خمیر به ترتیب افزایشی و کاهشی بود. بیشترین انرژی مورد نیاز برای کشش خمیر در نمونه حاوی ۰/۲۵ درصد پودر آب پنیر و ۰/۲۵ درصد صمغ کتیرا مشاهده شد. افزودنی‌های استفاده شده سبب بهبود امتیاز بو، رنگ و قابلیت جویدن نان سنگک شدند. در نهایت نمونه حاوی ۰/۵ درصد صمغ کتیرا (اولویت اول) و نمونه حاوی ۰/۲۵ درصد پودر آب پنیر و ۰/۲۵ درصد صمغ کتیرا (اولویت دوم) به عنوان نمونه‌های برتر معرفی می‌شود.

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