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Effect of germinated soybean flour and ultrasonic wave on physicochemical and sensory properties of gluten-free rice cake

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ABSTRACT

The objective of this study was to investigate the effect of replacing of rice flour with different ratio (0, 10 and 20 % w/w based on rice flour) germinated and non-germinated soy flour with ultrasonic pretreatment (0, 4, and 6 min) on the cake batter on the physicochemical and sensory characteristics of rice cake. A factorial experiment with a completely randomized design with three replications was used for data analysis. The use of germination soy flour in rice cake formulations and ultrasonic pretreatment on batter cake, significantly improved the technological characteristics and sensory attributes of the samples ($p< 0.05$). Compared with the non-germination soy flour, the germinated groups had higher contents of moisture, protein, fiber, and also improved volume, porosity and softness, significantly ($p< 0.05$). The sample formulations containing of 20 % w/w germinated soy flour with ultrasonic pretreatment for 6 min indicated the highest ranked of the technological characteristics (volume, porosity, and firmness) and sensory attributes (texture and overall) and unfortunately showed a higher darkness (L value) and redness (a value) and received low sensory scores of tastes and color compared to the other sample and control. The optimized formulation for the technological characteristics (volume, porosity, and firmness) and all sensory attributes preference had a germinated soy flour content of 10% with ultrasonic pretreatment for 6 min ($p< 0.05$). These achievements will pave the way for using the combination technologies involving the germination treatment with sonication pretreatment for improving physicochemical and sensory characteristics of cake produced by gluten-free flour blend.

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1. Introduction

Today, the demand for gluten-free products from celiac patients, gluten-sensitive people, or health-conscious people has increased significantly. Celiac disease, with a prevalence of 1% in the world, is an autoimmune systemic disorder and an inflammatory disease of the gastrointestinal tract, which occurs due to the contact of gluten with the cells of the small intestine with symptoms such as diarrhea, lack of growth, fatigue and anemia [1]. Based on the definition of the American Food and Drug Administration, the maximum permissible level of gluten in gluten-free foods is up to (ppm) 20. The European Union has also declared foods containing less gluten (up to 100 ppm) as low-gluten foods and foods containing up to 20 ppm gluten as non-gluten-free [2]. After bread, cake as a snack is the most consumed product of cereal products in different societies, especially among teenagers and young people. Wheat flour is the main ingredient in the formulation of all kinds of cakes, which, due to the presence of gluten protein, and as a result, by forming a gluten network, improves the strength and structure of the product and creates the appropriate texture and consistency of the dough produced [3]. Rice, corn, and potato flours are suitable substitutes for wheat flour in the production of gluten-free bakery products, which are usually used in combination [4]. Alghetti et al. (2014) produced gluten-free bread with soft texture, optimal volume and uniform porosity by combining quinoa flour and rice flour [5]. The decrease in nutritional value and the decrease in the quality of the final product are always two controversial challenges in the production and introduction of gluten-free products. The owners of the food industry also state the decrease in shelf life and the decrease in the pleasantness of consuming gluten-free foods as obstacles to the industrial production of these products [6]. Using soybean flour (*Glycine max* (L.) Merr) is a suitable option in the formulation of gluten-free bakery products such as cakes, cookies or bread with the aim of increasing the protein content and due to the absence of gluten [7]. Soybeans are used in the food industry with the two goals of increasing the nutritional value and technological quality (emulsification, foaming, thickening and moisture absorption) of food formulations [8]. Dhingra and Jude (2001) did not report a significant change in the sensory characteristics of the final product by replacing wheat flour with 10% soybean flour [9]. Anti-nutritional factors such as trypsin inhibitor and phytic acid are among the worrying factors in the use of soybean flour in food formulations[10]. During the germination process, the amount of vitamins, fibers, and minerals in soybeans increases and the activity of trypsin and phytase inhibitory enzymes decreases in it. Also, in sprouted soybeans, the amount of water absorption increases and the bean flavor decreases [7]. Sepahi et al. (2019) increased the nutritional value of gluten-free biscuits by adding live sprout soybean flour as a rich source of fiber and protein, without losing sensory characteristics [11]. Cake batter is a type of emulsion that is formed by mixing the components of the formula and by entering air in it. The proper distribution of air in the texture of the cake dough plays an effective role in increasing the appropriate volume and customer friendliness. The use of ultrasound technology as a physical method in the production of all kinds of cakes, in addition to reducing the consumption of chemical compounds such as emulsifiers, improves the texture of the dough by creating pitting phenomenon [12]. Olsevich et al. (2020) increased the characteristics of flowability, uniformity and volume by sonicating the dough during the preparation stages [13]. The removal of wheat flour in the formulation of gluten-free cakes reduces the quality of the dough and ultimately reduces the quality of the final product. Therefore, in this research, the use of sprouted soybean flour and ultrasonic waves in improving the physicochemical and sensory characteristics of gluten-free cake has been investigated.

2- Materials and methods

2-1- Materials

White rice flour (Golestan company), sugar (Golestan company), sunflower liquid oil (Laden company), pasteurized milk (Pegah Hamedan company), eggs (Saha Hamedan company), baking powder and vanilla (Golha company) used in the cake formulation Gluten-free products were obtained from a reputable store in the city. Freshly harvested and dried soybeans (Raqam

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Sahar) were obtained in bulk form from a store that supplies edible grains and legumes. Other chemicals used were obtained from Merck, Germany.

2-2- Methods

2-2-1- Preparation of soybean flour and sprouted soybean flour

Soybeans (one kilogram) were first washed with distilled water and then, with the aim of preventing the growth of mold, they were immersed in a solution containing 0.7% sodium hypochlorite (volume-volume) with a ratio of twice the weight of soybeans for 10 minutes. They were rinsed three times with sterile distilled water. Half of the beans (500 g) were dried in the open air and after grinding, they were passed through a sieve with a mesh of 100 in order to obtain soybean flour with uniform particles. The other half of the beans (500 g) were soaked in sterile distilled water at room temperature (25 °C) for 6 hours and then transferred to steel trays and covered with cotton cloth for optimal oxygen transfer. After three days, the germinated seeds were completely dried in an electric oven (Parsin Teb, Iran) at a temperature of 60 degrees Celsius until the moisture content reached 10% (based on wet weight) and after being ground (Chili model, Pars Khazar, Iran) from Sieves were passed with 100 mesh[14].

2-2-2- Evaluation of the chemical characteristics of rice flour, sprouted soybean flour and sprouted soybean flour

Chemical characteristics (percent moisture, ash, protein, total fiber and fat) of rice flour based on the Iranian national standard number 11136 [15] and young and sprouted soybean flour based on the Iranian national standard number 2357 [16], evaluation and determination became

2-2-3- Preparation of dough and cake production

Gluten-free rice cake (control sample) based on 100 grams of rice flour using rice flour (100 grams), sugar (65 grams), eggs (65 grams), milk (50 grams), baking powder (1.5 grams)) and vanilla (1 gram) were prepared. The ingredients used in the preparation of the cake were mixed and prepared in three precise steps. In the first stage, sugar, eggs and vanilla were mixed, in the second stage, other liquid and semi-liquid ingredients of the formula, including water and oil, were added and mixed. In the last step, the solid ingredients of the formula, including all kinds of flours, were added and mixed. After preparation, the dough was poured into special cake papers that were placed in the molds. The dough was baked in a laboratory oven (Alton, Iran) at a temperature of 180 degrees Celsius for 40 minutes. After cooling at room temperature, the necessary evaluations were done on the produced cakes [17]. Samples containing sprouted soybean flour and sprouted soybean flour with 10% and 20% replacement with rice flour (in weight-weight ratio) were produced and evaluated, respectively, compared to the control sample. Ultrasonic pretreatment with a nominal power of 750 watts and a frequency of 20 kHz. By inserting an ultrasonic probe made of titanium (JY92-IIDN, Co. Ltd., Ningbo, China) with a diameter of 13.5 mm, which penetrated into the dough to a depth of 2 cm, at zero, 4 and 6 minutes on the formulation of production doughs. applied

2-2-4- Paste viscosity

The viscosity of different dough formulations was measured with a Brookfield viscometer (Brookfield, RV2T, USA) and using spindle number 5, at a shear speed of 10 rpm, at a temperature of 25 degrees Celsius, and in three repetitions [18].

2-2-5- Cake physicochemical tests

After 2 hours of baking the cakes, their moisture was determined using the method of drying in an electric oven (Parsin Tab, Iran) at 103 degrees Celsius and after the weight of the samples was fixed using the standard method (AACC 44-15), the ash was removed using From the electric furnace and using the standard method (AACC 0801), raw fiber was measured using the standard method (AACC 3210) and their volume using the displacement method of rapeseeds (AACC 3210) [19].

2-2-6- The porosity and color of the cake

The image processing method was used to evaluate the porosity of the core of the cakes and their color. In this way, first, 25 mm slices were prepared from the brain of the samples, and then the samples were photographed with the help of a model scanner (HP) with a resolution of 300 pixels. The images were checked by the software (Image J) and the porosity was calculated by converting the images into gray images and then

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into binary images and by calculating the ratio of bright to dark points as an indicator of the porosity of the samples [20]. By activating the color space in the (Plugins) section, the active (LAB) space and color indicators (L), (a) and (b) were determined [21].

2-2-7- hardness of cake texture

The firmness of the cake texture was evaluated using a Centam model texture tester (Universal Test Machin, STM50, Iran). In this way, 2 hours after cooking, the samples were cut by a very sharp knife in the form of rectangular cubes with dimensions of 2 x 2.5 x 2.5 cm and then by a circular probe with a diameter of 10 cm and a speed of 50 mm. It was compressed by 40% per minute and the force required to compress the samples was reported as the degree of stiffness in Newtons [20].

2-2-8- Sensory test

The samples were cut 2 hours after production and after coding with the help of 10 trained people regarding the characteristics of color, aroma, smell and taste, texture and overall acceptance using a 5-point Hedonic Scale. were evaluated. In this evaluation, the number 5 was very good, the number 4 was good, the number 3 was average, the number 2 was weak and the number 1 was very weak [17].

2-3- statistical analysis method

This research is based on the factorial method and based on a completely random statistical design with two factors, the ratio of replacing soy flour with rice flour in a weight-weight basis based on rice flour (at five levels of 0% (control), 10% sprouted soybean flour (GSF10%) , 10% sprouted soybean flour (NGSF10%), 20% sprouted soybean flour (GSF 20%) and 20% sprouted soybean flour (NGSF 20%), duration of ultrasound (at three levels zero, 4 and 6 minutes) and in three Data analysis was done with statistical software (SPSS) and comparison of means was done based on Duncan's multi-range test at a significance level of 5%.

3. Results and Discussion

3-1- Physicochemical characteristics of the used flours

The results of Table 1 showed that compared to sprouted soybean flour, sprouted soybean flour had more moisture, protein, fiber, and less fat. Mishra (2016) reported a decrease in fat (from 21 to 15.2 percent), an increase in protein (from 37.2 to 42 percent) and fiber (from 5.4 to 10.2 percent) during soybean germination. It was consistent with the results in Table 1 [14]. Chauhan et al. (2015) reduced the amount of fat (from 6.68 to 4.7 percent), increased the amount of protein (from 15.05 to 16.5 percent) and fiber (from 9.52 to 12.9 percent) during Amaranth seed germination reported [22]. In general, the change in the chemical composition of seeds after germination is directly related to the type and conditions of their germination. The increase and decrease in the amount of protein and fat in seeds during the germination process is related to the increase in the activity of enzymes producing amino acids and fat hydrolyzing enzymes, as well as the consumption of seed fat to produce germination energy [14]. Carbohydrates are also significantly reduced during germination due to being broken into simpler sugars due to the activity of alpha-amylase enzymes [23]. The decrease in the value (pH) in sprouted soybean flour can be attributed to the mentioned phenomenon.

Table 1 Physicochemical properties of rice flour, non-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF)

Physicochemical properties (%)	Rice flour	non-Germinated Soybean flour (NGSF)	Germinated Soybean Flour (GSF)
Moisture	9.25 ± 0.11	6.85 ± 0.32	8.69 ± 0.51
Ash	0.81 ± 0.14	0.42 ± 0.09	0.47 ± 0.07
Fiber	1.22 ± 0.10	2.79 ± 0.22	7.22 ± 0.48
Protein	8.11 ± 0.21	30.11 ± 1.1	32.12 ± 1.6
Fat	1.85 ± 0.13	24.34 ±1.10	19.12 ± 1.09
pH	6.49 ± 0.43	6.72 ± 0.11	6.66 ± 0.79

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2-3- dough viscosity

Changes in the viscosity of gluten-free rice cake dough by replacing rice flour with different amounts of sprouted and sprouted soybean flour and also pre-treatment with ultrasound are shown in Figure 1. The results showed that by substituting sprouted and sprouted soybean flour as well as increasing the sonication time, the dough viscosity of the samples increased significantly ($p<0.05$). Viscosity of dough containing sprouted soybean flour was significantly reduced compared to sprouted soybean flour. Compared to other samples and the control sample, the highest viscosity was measured in the dough of the samples containing 20% young soybean flour and 6 minutes before ultrasound treatment ($p<0.05$). The addition of sprouted and unripened soybean flour, due to the presence of proteins containing protein disulfide groups, significantly increases the dough strength and viscosity of the samples.

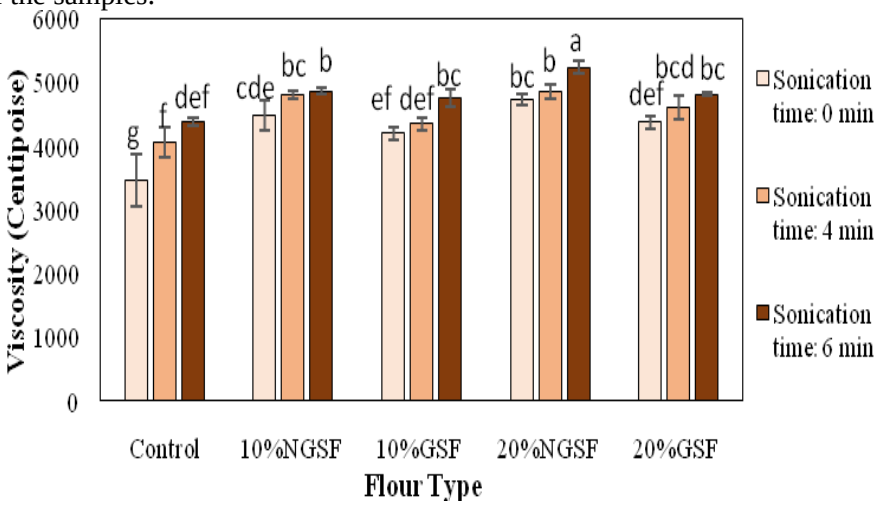

Fig 1 Effect of rice flour (Control) replacement withnon-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF) on viscosity of gluten free cake batter. Different letters are significantly different ($P<0.05$).

Ultrasound waves in low intensity or short time have little effect on the quality of proteins. One of the effective factors in increasing the dough viscosity of bakery products during the ultrasonic process is the denaturation or breaking of the hydrophilic and hydrophobic bonds of proteins under the effect of ultrasonic waves, and as a result, the increase in foaming, water absorption, and finally the viscosity of the dough [25]. Maqsoodlou et al. (2019) stated that applying ultrasound by destroying the structure of the granules and reducing the internal bonds of starch increases their solubility and with the help of the cavitation phenomenon, it causes better aeration in the dough tissue, which contributes to increasing the viscosity of the dough [26].

3-3- Qualitative characteristics of gluten-free rice cake

3-3-1- moisture, ash, protein, fat and fiber

Comparing the averages of moisture, ash, protein, fat, and fiber of the samples (Table 2) showed that by replacing rice flour with soybean flour (sprouted or sprouted), the moisture, protein, and fiber content of the final product increased significantly compared to the control sample, but the ash content changed. It was not significant

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($p<0.05$). Applying ultrasound and increasing its time increased the amount of moisture in all treatments and the control, but did not have a significant effect on their protein, fat, and fiber content ($p<0.05$). The lowest amount of moisture was observed in the control cake sample without sonication (18.07 percent) and the highest in the samples containing 20 percent sprouted soybean flour (21.55 percent) with 6 minutes of ultrasonic treatment of the dough. The results of Table 2 showed a significant increase in protein and fiber and a decrease in fat in samples containing sprouted soybean flour compared to sprouted ($p<0.05$). This increase can be related to the increase of protein and fiber and the decrease of fat in sprouted soybean flour, which was consistent with the results of Chauhan et al. (2015) [22]. According to the report of Rosales-Jorales et al. (2009), the increase in protein content and decrease in fat in samples containing sprouted soybean flour can be attributed to the increase in the activity of soybean lipase and protease enzymes during germination [27]. The increase in moisture content of samples containing sprouted soybean flour is related to the increase in the amount of protein and fiber due to its addition to the product. Adding sprouted soybean flour to the cake formulation increased the moisture content of the final product containing this type of flour compared to the product containing sprouted soybean flour due to the increase in the hydrophilic nature of proteins. Mohammadzadeh Milani et al. (2018) announced that with 10% replacement of wheat flour with sprouted soybean flour compared to sprouted soybean flour in the formulation of Berberi bread dough, the moisture level of the product increased by 7%, which was consistent with the results of Table 2[28]. .

Table 2 Effect of rice flour (Control) replacement withnon-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF) on physicochemical properties of gluten free cake.

Treatment	Sonication time (min)	(Moisture %)	(Ash %)	(Protein %)	(Fat %)	(Fiber %)
Control	0	$18.07^{f} \pm 0.12$	$0.94^{cd} \pm 0.02$	$7.99^{It\ is} \pm 0.01$	$14.30^{d} \pm 0.45$	$0.43^{c} \pm 0.01$
	4	$18.77^{It\ is} \pm 0.21$	$0.94^{cd} \pm 0.01$	$8.04^{It\ is} \pm 0.05$	$14.27^{d} \pm 0.16$	$0.43^{c} \pm 0.09$
	6	$18.98^{It\ is} \pm 0.13$	$0.94^{cd} \pm 0.03$	$8.03^{It\ is} \pm 0.03$	$14.36^{d} \pm 0.36$	$0.44^{c} \pm 0.03$
10% NGSF	0	$18.95^{of} \pm 0.25$	$0.95^{bcd} \pm 0.02$	$9.09^{d} \pm 0.07$	$15.08^{c} \pm 0.20$	$0.52^{b} \pm 0.02$
	4	$19.09^{cd} \pm 0.22$	$0.96^{abcd} \pm 0.01$	$9.06^{d} \pm 0.04$	$15.09^{c} \pm 0.20$	$0.52^{b} \pm 0.02$
	6	$19.51^{ab} \pm 0.12$	$0.94^{cd} \pm 0.01$	$9.07^{d} \pm 0.05$	$15.11^{c} \pm 0.26$	$0.54^{b} \pm 0.03$
10% GSF	0	$19.35^{bc} \pm 0.07$	$0.95^{bcd} \pm 0.02$	$9.35^{c} \pm 0.05$	$14.84^{c} \pm 0.47$	$0.54^{b} \pm 0.05$
	4	$19.42^{b} \pm 0.09$	$0.95^{bcd} \pm 0.02$	$9.36^{c} \pm 0.03$	$14.85^{c} \pm 0.26$	$0.54^{b} \pm 0.03$
	6	$19.65^{ab} \pm 0.20$	$0.94^{cd} \pm 0.01$	$9.38^{c} \pm 0.05$	$14.87^{c} \pm 0.32$	$0.55^{b} \pm 0.01$
20% NGSF	0	$19.38^{bc} \pm 0.08$	$0.97^{abc} \pm 0.01$	$10.12^{b} \pm 0.02$	$15.72^{a} \pm 0.31$	$0.72^{a} \pm 0.04$
	4	$19.51^{ab} \pm 0.12$	$0.97^{abc} \pm 0.02$	$10.13^{b} \pm 0.1$	$15.73^{a} \pm 0.26$	$0.73^{a} \pm 0.02$
	6	$19.59^{ab} \pm 0.23$	$0.97^{abc} \pm 0.01$	$10.10^{b} \pm 0.05$	$15.77^{a} \pm 0.83$	$0.74^{a} \pm 0.01$
20% GSF	0	$19.58^{ab} \pm 0.12$	$0.96^{abc} \pm 0.01$	$10.48^{a} \pm 0.03$	$15.40^{b} \pm 0.33$	$0.75^{a} \pm 0.02$
	4	$19.67^{ab} \pm 0.14$	$0.96^{abcd} \pm 0.02$	$10.51^{a} \pm 0.03$	$15.43^{b} \pm 0.41$	$0.74^{a} \pm 0.04$
	6	$19.77^{a} \pm 0.28$	$0.97^{abc} \pm 0.03$	$10.55^{a} \pm 0.06$	$15.42^{b} \pm 0.55$	$0.75^{a} \pm 0.05$

Different letters are significantly different ($P<0.05$).

3-3-2- Volume

The results of Figure 2 showed that by adding soybean flour in normal or sprouted form up to 20% of the weight of rice flour to the formulation of cakes, their volume increased significantly ($p<0.05$). The largest volume was measured in samples containing 20% of regular soybean flour (30.06 cubic centimeters) and sprouted (30.44 cubic centimeters) compared to the control sample (30.1 cubic centimeters). More protein and less starch. Soybean flour is effective in increasing the cake volume by increasing the strength of the dough and preventing the gelatinized temperature of the starch during baking [29]. In general, the higher the amount of dough protein, the longer the starch becomes gelatinized during cooking, which will be effective in increasing the volume of the produced cake [30]. Naghipour et al. (2017) stated that increasing the wall resistance of the air bubbles formed in the dough and maintaining them during the baking process is related to increasing the protein content of the gluten-free cake formula [31]. The increase in the volume of the samples containing sprouted soybean flour can be related to the decrease in the amount of fat

in the sprouted soybean flour, which leads to an increase in foaming and the preservation of air bubble cells in the dough [32]. Olasevich et al. (2020) reported that ultrasonic pretreatment of dough with a frequency of 35 kHz and at least 10 minutes increased the volume of gluten-free bakery products by increasing the viscoelastic properties and plasticity of the resulting dough by 2 times [33].

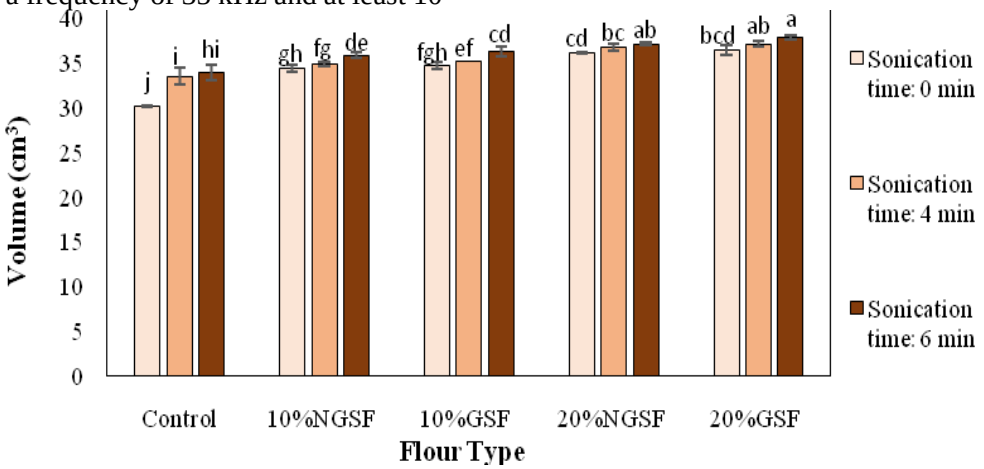

Fig 2 Effect of rice flour (Control) replacement withnon-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF) on volume of gluten free cake. Different letters are significantly different (P<0.05).

3-3-3- Porosity

The results of Figure 3 showed that the addition of normal and sprouted soybean flour significantly increased the porosity percentage of the produced cakes (p<0.05). The highest porosity was observed in the samples containing 20% sprouted soybean flour (23.7%) compared to the control sample (19.2%). Adding soybean flour in the sprouted or normal state to the dough of bakery products increases the water absorption capacity of the dough and by creating a uniform structure in the texture of the dough, it improves the proportional distribution of air bubbles in it [28]. The increase in the porosity of cakes containing sprouted soybean flour compared to regular soybean flour can be related to the increase in protein content and the decrease in fat content of sprouted soybean flour compared to regular soybean flour, which is caused by the increase in foaming of the dough and the formation of a resistant protein layer at the interface of air cells. Keeping air bubbles in it. This result was consistent with the results of P. Carli et al. (2021) [32]. According to Figure 3, ultrasonic pretreatment of the dough for 6 minutes significantly increased the porosity of the produced cakes (p<0.05). Tan et al. (2011) stated that they used ultrasonic waves for mixing operations in sponge cake at 3, 6 and 9 minutes, they concluded that the use of these waves at 6 minutes accelerates oxidation and increases dough aeration. And finally, the porosity of the product increases [34]. Shahson Tabrizi et al. (2014) reported the use of ultrasonic waves for up to 5 minutes as a process aid in increasing the number of air bubbles and texture porosity of bakery products[35].

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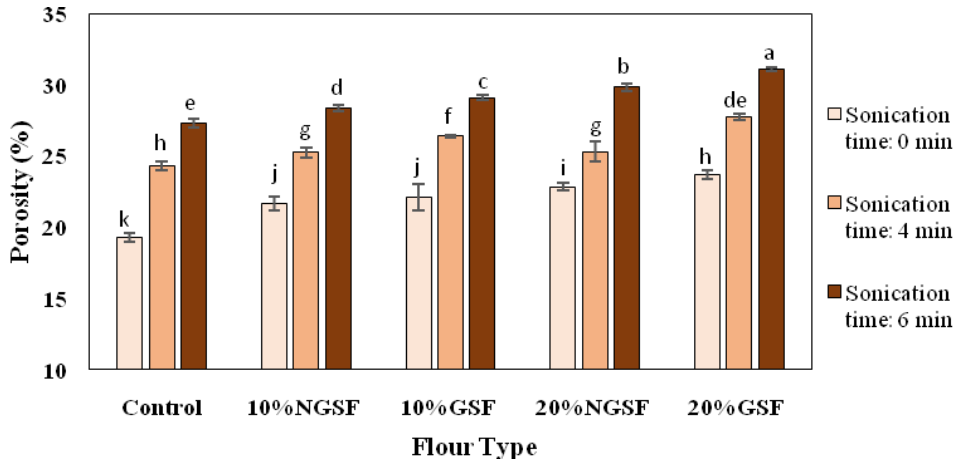

Fig 3 Effect of rice flour (Control) replacement withnon-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF) on porosity of gluten free cake. Different letters are significantly different (P<0.05).

3-3-4- tissue stiffness

According to Figure 4, the replacement of rice flour with regular and sprouted soybean flour significantly reduced the hardness of the produced cake by 20% compared to the control (p<0.05). The hardness of samples containing 10% sprouted soybean flour was significantly reduced compared to 10% sprouted soybean flour. The firmness of the samples containing 20% sprouted and sprouted soybean flour showed no statistically significant difference (p<0.05). The decrease in hardness of samples containing sprouted soybean flour can be related to the change and disintegration of starch and protein structure in sprouted soybean flour. Chavahan et al. (2015) reported that biscuits containing sprouted amaranth flour had a softer texture compared to normal amaranth flour [22].

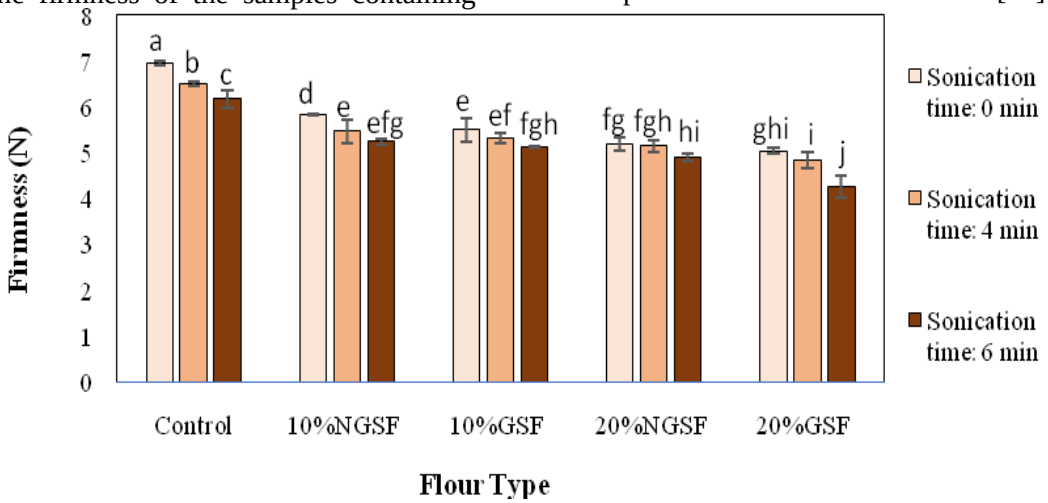

Fig 4 Effect of rice flour (Control) replacement withnon-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF) on Firmness of gluten free cake. Different letters are significantly different (P<0.05).

The addition of soy flour in the formulation of the samples had a significant effect due to the positive effect of soy protein in the formation of a protein network similar to gluten in maintaining the air bubbles and therefore the softness of the texture. The findings of Talebi and Qiafe Dawoodi (2017) which showed that adding soy protein isolate up to 10% to gluten-free cake batter increased the volume of the final product of sponge cake samples, but with an increase in the percentage of soy protein isolate up to 20%, a significant decrease in the volume of the samples was observed. 36]. Shirini et al. (2010) showed that replacing 20% of corn flour with soybean flour in the formulation of gluten-free bread, while increasing the amount of protein, resulted in a decrease in hardness and an increase in product volume[37]. According to Figure 4, ultrasonic pretreatment for 6 minutes on the dough significantly reduced the hardness of the

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produced cakes ($p<0.05$). Increasing the replacement rate of soy flour decreased the effect of ultrasound waves on dough texture. Tan and

Colleagues (2011) reported that using 6 minutes of ultrasound on the dough resulted in the softness of the product [34]. Applying ultrasound pretreatment to the dough increased the softness of the product by increasing the quantity and quality and the uniform distribution of air holes in its texture, which was consistent with the results of Talebi and Qaifeh Dawoodi (2017) [36].

3-3-5- color feature

The average values of color components in different samples compared to the control are shown in Table 3. Increasing the ratio of replacing rice flour with different amounts of sprouted soybean flour up to 20% caused the color of the final product to darken and decrease the amount of component (L) to 47.54 compared to the control (71) ($p<0.05$).

Table3 Effect of rice flour (Control) replacement withnon-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF) on color properties of gluten free cake.

Treatment	Sonication time (min)	(L)	(a)	(b)
Control	0	$71.00^{c} \pm 1.00$	$8.50^{d} \pm 0.50$	$32.00^{a} \pm 0.1$
	4	$77.00^{b} \pm 1.00$	$6.15^{g} \pm 0.35$	$32.05^{a} \pm 0.15$
	6	$80.50^{a} \pm 0.52$	$5.10^{j} \pm 0.10$	$32.26^{a} \pm 0.4$
10% NGSF	0	$60.50^{f} \pm 0.50$	$9.25^{c} \pm 0.25$	$32.00^{a} \pm 0.05$
	4	$63.00^{It\ is} \pm 1.00$	$6.15^{g} \pm 0.05$	$32.09^{a} \pm 0.10$
	6	$66.50^{d} \pm 0.50$	$5.00^{j} \pm 0.2$	$32.55^{a} \pm 0.55$
10% GSF	0	$55.00^{h} \pm 1.00$	$10.10^{b} \pm 0.10$	$31.80^{a} \pm 0.25$
	4	$58.50^{g} \pm 0.50$	$6.50^{g} \pm 0.30$	$32.61^{a} \pm 0.40$
	6	$62.50^{It\ is} \pm 0.50$	$5.70^{i} \pm 0.23$	$32.15^{a} \pm 0.90$
20% NGSF	0	$52.50^{i} \pm 0.56$	$10.10^{b} \pm 0.10$	$32.50^{a} \pm 0.50$
	4	$55.35^{h} \pm 0.62$	$7.35^{f} \pm 0.15$	$32.38^{a} \pm 0.40$
	6	$61.00^{f} \pm 0.22$	$5.25^{j} \pm 0.05$	$32.09^{a} \pm 1.00$
20% GSF	0	$47.54^{k} \pm 0.56$	$11.75^{a} \pm 0.26$	$32.51^{a} \pm 0.50$
	4	$51.35^{j} \pm 0.12$	$7.75^{It\ is} \pm 0.22$	$32.45^{a} \pm 1.05$
	6	$56.10^{h} \pm 1.02$	$6.05^{h} \pm 0.05$	$32.76^{a} \pm 1.03$

Different letters are significantly different ($P<0.05$).

An increase in darkness and as a result a decrease in the amount of component (L) up to 46.75 in bakery products containing soy flour up to 15% is also mentioned in the reports of Tasheer et al. (2017) [38]. The increase in the amount of protein in formulations containing soybean flour as a result of the intensification of the Maillard reaction during cake baking is the main reason for their darker color[38]. The intensification of the Maillard reaction in germinated soybean flour due to the protease enzyme activity and on the other hand the limited damage of starch causes the product to become darker compared to cakes containing ordinary soybean flour[39]. Rosales-Jorales et al. (2009) confirmed the increased activity of alpha-amylase, lipase, protease and galactosidase enzymes and the decrease of lipoxygenase enzyme activity by examining sprouted soybean flour [27]. With increasing amount of soybean flour, component (a), which is related to the red color of the cake, had a significant increase, while component (b) did not show any significant change ($p<0.05$). Maleki et al. (2016) confirmed the decrease in the amount of component (L) up to 64.24 and the increase in redness (increase in the amount of component a up to 1.16) of gluten-free breads by replacing 20% of rice flour with soybean flour compared to samples without soybean flour [40].]. Salehi et al. (2019) by adding 20% soy protein isolate in sponge cake formulation determined the value of component (L) to be 21.78 and stated that adding up to 0.5% castor bean gum to sponge cake formulation while increasing the volume of the product to The reason why the internal tissue became brighter, the amount of component (L) increased [41]. According to the findings of Table 3, ultrasonic pre-treatment of the dough had a significant effect on improving the color quality of all samples of Hayik's mortar ($p<0.05$). The

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use of ultrasonic waves did not significantly change component (b). Jamal Abadi and Saremnejad (2016) investigated the effect of ultrasound on the characteristics of wheat starch and announced that the dough of sonicated starches was more transparent due to the breakdown of starch granules compared to starches without ultrasound, which can increase the brightness of the dough and ultimately the products. be effective [42].

3-3-6- sensory characteristics

The sensory evaluation results in Table 4 showed that the cakes containing ordinary soybean flour received a lower score from the evaluators in terms of color, aroma, flavor, texture, and general acceptability compared to the control, and this score was increased by increasing the ratio of replacing rice flour with soybean flour to 20%. had a decrease ($p<0.05$). Cakes produced with dough pretreated with ultrasound had a higher score in sensory indicators. Cakes containing 10% sprouted soybean flour received higher sensory scores compared to 10% normal soybean flour and the control ($p<0.05$). Although increasing the replacement ratio of sprouted soybean flour up to 20% did not have a favorable effect on the sensory characteristics of the produced cakes, but by applying ultrasound treatment to their dough for 6 minutes, their overall acceptance score increased compared to the control without ultrasound ($p<0.05$).). Samples containing 10% sprouted soybean flour and 6 minutes before ultrasonic treatment of the dough had the highest sensory acceptance score ($p<0.05$). Mashaikh et al. (2008) found a decrease in the sensory score of color and taste (due to the inherent taste of soybeans) in breads enriched with soybean flour by 12% as the two main reasons for the decrease in the overall acceptance score to 5.7 compared to the control sample. Score 6) such products from the consumer's point of view [43] stated that it is consistent with the results of reducing the overall acceptance score of products containing soy flour compared to the witness of this research in Table 4. Applying ultrasound to gluten-free rice cakes dough made it possible to use higher amounts of soybean flour in combination with rice flour by reducing the soybean taste.

Table 4 Effect of rice flour (Control) replacement withnon-Germinated soybean flour (NGSF) and Germinated Soybeanflour (GSF) on sensory properties of gluten free cake.

Treatment	Sonication time (min)	(Color)	(Taste/Odor)	(Texture)	(Overall)
Control	0	$4.03^{c} \pm 0.05$	$3.40^{c} \pm 0.02$	$3.25^{of} \pm 0.03$	$3.55^{d} \pm 0.05$
	4	$4.45^{b} \pm 0.08$	$3.62^{b} \pm 0.01$	$3.48^{b} \pm 0.05$	$3.77^{b} \pm 0.06$
	6	$4.65^{a} \pm 0.09$	$3.83^{a} \pm 0.03$	$3.68^{a} \pm 0.03$	$3.94^{a} \pm 0.06$
10% NGSF	0	$3.37^{of} \pm 0.12$	$2.85^{fg} \pm 0.05$	$3.10^{fg} \pm 0.10$	$2.98^{f} \pm 0.05$
	4	$3.30^{if} \pm 0.17$	$2.90^{f} \pm 0.10$	$3.15^{if} \pm 0.05$	$3.08^{f} \pm 0.05$
	6	$3.50^{d} \pm 0.19$	$2.95^{if} \pm 0.05$	$3.35^{cd} \pm 0.05$	$3.22^{It\ is} \pm 0.07$
10% GSF	0	$3.00^{h} \pm 0.00$	$3.05^{It\ is} \pm 0.05$	$3.05^{fg} \pm 0.05$	$3.61^{cd} \pm 0.16$
	4	$3.15^{fgh} \pm 0.05$	$3.32^{d} \pm 0.10$	$3.25^{of} \pm 0.05$	$3.71^{bc} \pm 0.02$
	6	$3.17^{fg} \pm 0.15$	$3.35^{c} \pm 0.05$	$3.45^{bc} \pm 0.07$	$3.82^{ab} \pm 0.06$
20% NGSF	0	$3.12^{gh} \pm 0.12$	$2.62^{h} \pm 0.03$	$2.78^{i} \pm 0.02$	$2.50^{h} \pm 0.10$
	4	$3.10^{gh} \pm 0.10$	$2.75^{g} \pm 0.02$	$3.01^{g} \pm 0.07$	$2.70^{g} \pm 0.10$
	6	$3.35^{It\ is} \pm 0.05$	$2.85^{fg} \pm 0.04$	$3.44^{bc} \pm 0.04$	$3.05^{f} \pm 0.05$
20% GSF	0	$3.00^{h} \pm 0.00$	$2.85^{fg} \pm 0.15$	$2.90^{h} \pm 0.1$	$3.23^{It\ is} \pm 0.05$
	4	$3.05^{gh} \pm 0.05$	$2.85^{fg} \pm 0.05$	$3.03^{g} \pm 0.06$	$3.51^{d} \pm 0.10$
	6	$3.20^{fg} \pm 0.11$	$2.90^{f} \pm 0.10$	$3.26^{of} \pm 0.11$	$3.69^{bc} \pm 0.09$

Different letters are significantly different ($P<0.05$).

4 - Conclusion

In this research, sprouted soybean flour was used in comparison with regular soybean flour in the production of gluten-free rice cake with the aim of improving the physical, chemical and sensory characteristics of the final product. Ultrasonic pretreatment of gluten-free cake dough was also used in order to provide proper aeration, create uniformity in the texture and increase the volume and softness of the final product. Although increasing the replacement rate of rice flour with sprouted soybean flour up to 20% led to the

production of a technologically desirable product, consumers recognized the limit of using sprouted soybean flour up to 10% in dough formulation. The evaluators expressed the loss of color and taste of beans as the reasons for reducing the score of sensory characteristics. Therefore, it can be concluded that the use of sprouted soybean flour in combination with ultrasonic pretreatment on the dough as an auxiliary process had the ability to produce gluten-free rice cakes with favorable physicochemical characteristics, but with the aim of increasing customer satisfaction and reducing the bean taste of the product. , the need to use flavor-improving compounds in such products is felt.

5-Resources

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چکیده

هدف از این مطالعه بررسی تأثیر جایگزینی نسبت های متفاوت (۰، ۱۰ و ۲۰ درصد وزنی-وزنی) آرد برنج با آرد سویای جوانه‌زده و جوانه‌نزده و پیش تیمار فراصوت خمیر (۰، ٤ و ٦ دقیقه) بر ویژگی‌های فیزیکوشیمیایی و حسی کیک برنجی بود. تجزیه و تحلیل داده ها بر اساس آزمایش فاکتوریل در قالب طرح آماری کاملاً تصادفی و در سه تکرار انجام شد. استفاده از آرد سویای جوانه زده در فرمولاسیون کیک‌ها و اعمال پیش تیمار فراصوت بر خمیر آن‌ها، ویژگی‌های فناورانه و حسیکیک‌های تولیدی را به شکل معنی داری بهبود بخشید ($p<۰/۰۵$). نمونه‌های حاوی آرد سویای جوانه زده در مقایسه با آرد سویای جوانه نزده، محتوی رطوبت، پروتئین و فیبر بالاتر و همچنین حجم، تخلخل و نرمی بیشتری داشتند. بیشترین میزان حجم و تخلخل، کمترین میزان سفتی و بیشترین امتیاز حسی بافت و پذیرش‌کلی در نمونه‌های حاوی ۲۰ درصد آرد سویا جوانه‌زده با ٦ دقیقه پیش تیمار فراصوت، مشاهده گردید. متأسفانه کیفیت رنگ (کاهش مولفه L و افزایش مولفه a) و ویژگی‌های حسی طعم و رنگ این نمونه‌ها، کاهش معنی داری در مقایسه با سایر نمونه‌ها و نمونه شاهد نشان داد ($p<۰/۰۵$). کیک‌های حاوی ۱۰ درصد آرد سویا جوانه زده با ٦ دقیقه پیش تیمار فراصوت به دلیل افزایش معنی دار حجم، تخلخل و کاهش سفتی و افزایش امتیاز شاخص‌های حسی در مقایسه با سایر نمونه‌ها به عنوان بهترین نمونه انتخاب شدند($p<۰/۰۵$). این نتایج راه را برای استفاده از فناوری‌های ترکیبی شامل تیمار جوانه‌زنی و پیش تیمار فراصوت برای بهبود ویژگی‌های فیزیکوشیمیایی و حسی کیک‌های تولید شده با مخلوط آردهای بدون گلوتن هموار خواهد ساخت.