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Investigation on replacing egg with soy flour and Psyllium seed gum in gluten-free rice cake

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ABSTRACT

The aim of this study was to investigate the effect of egg replacing with soy flour in different proportions (0, 25, 50, 75 and 100% w/w based on the weight of egg) and incorporation psyllium gum in different proportions (0, 0.5, and 1% w/w based on the weight of rice flour) on the physicochemical and sensory properties of rice cake. A factorial experiment with a completely randomized design with three replications was used for data analysis. The substitution of egg by soy flours up to 50% significantly improved the technological characteristics (color, texture and porosity) and sensory attributes of the samples ($p<0.05$). Increasing of the proportion of egg by soy flour by more than 50% significantly decreased these properties. The addition of up to 1% psyllium gum to the batter not only increased the batter viscosity, but also improved moisture, volume, porosity and softness of the cake samples. Compared with the sample containing the whole egg and without psyllium gum, the highest and the lowest contents of moisture, volume, porosity, softness, and sensory properties were determined in the samples containing up to 50% soy flour as an egg substitute and incorporated with 1% psyllium gum and the samples containing full soy flour and without psyllium gum, respectively. A higher darkness (L value) and redness (a value) and low sensory scores of tastes and color of compared to the control, were observed in the samples containing up to 50% soy flour as an egg substitute and incorporated with 1% psyllium gum. Therefore, it was found that the egg could be substituted by the soy flour in gluten free cakes and incorporation of psyllium gum to the cake batter formulation with reduced egg can be effective for improving their physicochemical and sensory characteristics.

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1- Introduction

Nowadays, due to the change in the way of food consumption due to the awareness of the occurrence of many diseases, vegan diets (elimination of foods of animal origin) are among the most popular diets based on plants [1]. Cake is one of the most popular bakery products with wheat flour, eggs, sugar and oil components. Wheat flour causes strength and texture in the product by forming a gluten network [2]. Egg also acts as a foaming agent, emulsifier, texture, coloring and gelling agent in cake formulation [3]. Celiac is an autoimmune disease that causes inflammation in the small intestine, diarrhea, and nausea in affected people by consuming food containing gluten, while disrupting food absorption [4]. The tendency to consume eggs is also decreasing due to high cholesterol and saturated fatty acids and the negative effect on cardiovascular health and the occurrence of allergic reactions such as hives, itching, nausea and vomiting in people due to egg white proteins [3]. Choosing suitable substitutes for wheat gluten and eggs in cake formulation with the aim of producing a healthy product while maintaining its technological characteristics (texture, volume, porosity and sensory characteristics) is of particular importance [5]. Rice, corn and potato flours are suitable substitutes for wheat flour in the production of gluten-free bakery products [6]. Alghetti et al. (2014) produced gluten-free bread with soft texture and optimal volume by combining quinoa flour and rice flour [7]. The complete replacement of eggs in the formulation of all kinds of cakes with egg substitutes reduces the quality of the final product due to the inability to form a stable foam [8]. The use of egg substitutes in the production of bakery products began in 1979 with the use of bovine blood plasma serum in cake formulation [9]. Egg substitutes in bakery products include soy protein isolate, chickpea and lentil protein concentrate, barley and chickpea cooking water, whey proteins, wheat gluten, sugar beet fiber, hydrocolloids, or some emulsifiers [3]. Soybeans are used in the food industry with the two goals of increasing nutritional value and technological quality (emulsification, foaming, thickening and moisture absorption) in formulations [10 and 11]. Hydrocolloids are a wide collection of sugars and proteins soluble in water, which often produce a thick gel in low concentrations [12]. Their use in bakery products is of interest due to proper water absorption, consistency, emulsification, gelling, texture and foaming [9]. Ashwini et al. (2009) expressed the ability to cover starch granules by egg substitute gums in the formulation of egg body cakes as the reason for improving the quality of the final product [9]. Hedayati et al. (2018) considered the replacement of eggs with soy milk in the cake formulation as the reason for the soft texture of the product [13]. Agrahar Mugurkar (2016) compared chia seed flour, soy milk and banana powder as an egg substitute in cake production and stated that the cake made from chia seed flour was softer and more consistent compared to others [14]. Esferzeh is an annual plant covered with very soft hairs and with 250 plant species, two of which exist in Iran with scientific names (*Plantago ovata L.*) And (*Plantago psyllium L.*) are called esfarzeh [15]. The ovoid seeds are brownish-gray with a pink tint. The gum of the seed shell, which consists of arabinose, xylose and small amounts of other sugars, is white in color and forms a colorless gel by absorbing water up to 20 times its weight, which is chemically neutral and is not digested or absorbed in the digestive system. [16]. Beikzadeh et al. (2018) did not report a significant difference in the quality characteristics of oil cake comparing the effect of esfarzeh gum with commercial xanthan gum on the characteristics of oil cake [17]. Naqipour et al. (2015) by adding esfarze gum in the cake formulation, increased the overall acceptance of the samples compared to the control sample [18]. The removal of wheat flour and eggs in the formulation of cakes often decreases the quality of the product and reduces its customer friendliness. Because of its gelling properties, low price and favorable biodegradability, saffron seed gum and soybean flour are also used as texturizers in the food industry. Therefore, in this research, the replacement of eggs with soybean flour and saffron seed gum was investigated in improving the physicochemical and sensory characteristics of gluten-free cake.

2- Materials and methods

2-1- Raw materials

Rice flour (moisture 9.11, protein 8.19 and ash 0.78%) and soybean flour (moisture 7.55, protein 29.12, ash 0.54 and crude fiber 2.3%) were obtained from the local market. . Sugar (Golha Company), sunflower liquid oil (Laden Company), fresh eggs (Talaung Company), baking powder (Golha Company) and vanilla (Golha Company) used in the formulation of gluten-free cakes were obtained from a reputable store in the city.

2-2- Methods

2-2-1- Esfarza mucilage extraction

The extraction of Asfarza seed gum was done according to the method of Ahmadi et al. (2013) with a slight modification. First, 10 grams of saffron seed husks were distributed and spread in one liter of distilled water at 80 degrees Celsius for one hour and mixed at a speed of about 600 revolutions per minute. The insoluble part of the composition obtained after

passing through a separate filter and the soluble part (carbohydrates that give the gel) was dried and ground at 40 degrees Celsius and used as esforza gum powder [19].

2-2-2- Preparing the dough and baking the cake

Gluten-free rice cake (control sample) based on 100 grams of rice flour using rice flour (100 grams), sugar (100 grams), eggs (100 grams), water (100 grams), baking powder (4.8 grams) and vanilla (2.8 grams) was prepared. In the first step, sugar and eggs were mixed for 4 minutes, then baking powder and vanilla were added and mixed with other ingredients for 2 minutes. Then, other dry ingredients such as rice flour, soy flour, and esfarza gum powder (depending on the type of cake) were sieved and added to the formula and mixed for 4 minutes. The resulting dough was filled in paper cups (with a volume of 30 ml) and placed in steel trays for the baking stage. The cups containing the dough were transferred to an electric oven (FI5 851 P IX, Italy) preheated at 180 degrees Celsius and the cake was baked for 40 minutes. After cooling at room temperature, the necessary evaluations were done on the produced cakes [20].

2-2-3- 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 [21].

2-2-4- Cake physicochemical tests

2 hours after cooking, the moisture content of the samples was determined by drying in an electric oven (Parsin Tab, Iran) at a temperature of 103 degrees Celsius and using a standard method (AACC 44-15).ash using electric furnace and standard method (AACC 0801), raw fiber by standard method (AACC 3210), protein by standard method (AACC 4616), fat by standard method (AACC 3010) and their volume using the method of displacement of rape seeds (AACC 3210), was measured[22].

2-2-5- 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 software (Image J) and the amount of porosity was calculated by converting the images into gray images and then into binary images and by calculating the ratio of bright to dark points as an indicator of the porosity of the samples [23]. By activating the color space in the (Plugins) section, the active (LAB) space and color indicators (L), (a) and (b) were determined [24].

2-2-6- 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 baking, the samples were cut by a very sharp knife in the form of rectangular cube pieces with dimensions of 2 x 2.5 x 2.5 cm and then by a circular probe with a diameter of 10 cm and at a speed 50 mm/min was compressed by 40% and the force required to compress the samples was reported as the degree of stiffness in Newtons [23].

2-2-7- Sensory test

The samples were cut 2 hours after production and after coding, with the help of 10 trained people, they were evaluated for the characteristics of color, aroma, smell and taste, texture and overall acceptance using a 5-point Hedonic Scale test. they got. 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 [24].

2-3- Statistical analysis

This research is based on the factorial method and according to a completely random statistical design with two factors of replacing eggs with different levels of soybean flour (zero, 25, 50, 75 and 100% weight-by-weight) and adding gum powder (at three levels of zero, 5 0.0 and 1% of flour weight) was performed in three repetitions. Data analysis was done with statistical software (SPSS) and comparison of means was done based on Duncan's multiple range test at a significance level of 5%.

3. Results and Discussion

3-1- Paste viscosity

Changes in the viscosity of gluten-free rice cake batter by replacing eggs with different levels of soybean flour and adding different percentages of safflower gum are shown in Figure 1. The results of comparing the averages showed that replacing egg with soybean flour significantly increased the viscosity of the dough ($p<0.05$). Also, the process of increasing up to 1% of safflower seed gum in the dough formulation had a significant effect on increasing the viscosity ($p<0.05$). According to Figure 1, by increasing the level of replacing egg with soy flour by more than 50%, the process of increasing dough viscosity increased significantly ($p<0.05$). The highest dough viscosity by completely replacing eggs with soy flour

(46141.9 centipoise) was obtained in the samples containing 1% of saffron gum compared to the control sample containing whole eggs and without saffron gum (4660.54 centipoise) ($p<0.05$). Due to having proteins containing disulfide groups, soybean flour significantly increased the strength and viscosity of the samples ($p<0.05$) [24]. Salehi et al. (2018) stated that with the increase of hydrophilic compounds such as soy protein isolate powder and basil seed gum in the rice cake formulation, the dough viscosity increases [25], which was consistent with the results of this research. In general, hydrocolloids, including gums, increase the viscosity of the dough by increasing water absorption and as a result of increasing stronger hydrogen bonds in the dough, reducing molecular mobility in the formulation and increasing the amount of soluble fibers [26]. Of course, the intensity and amount of viscosity increase depends on the chemical structure of added gum [27]. Mohajer Khorasani et al. (2019) stated that the reason for the increase in viscosity of gluten-free cake batter containing 0.15% xanthan gum is the reduction of the diffusion of water molecules and the increase in the absorption capacity of air bubbles in the batter formulation [28]. Lin et al. (2017) reported that the viscosity of the dough of egg-free cakes containing soy protein isolate and xanthan gum increased significantly compared to the control due to the increase in water absorption capacity in the dough, which was consistent with the results of this study [29].

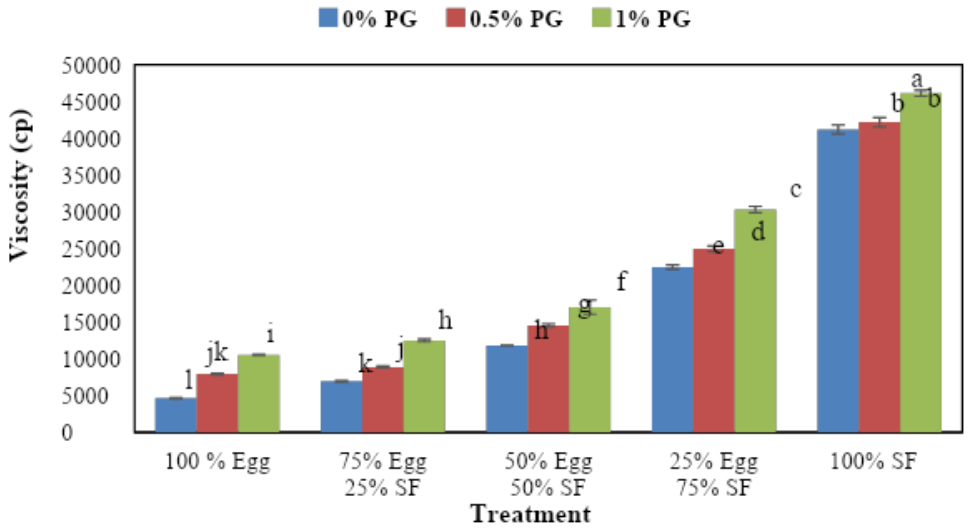

Fig 1. Effect of egg replacement with soy flour (SF) and psyllium gum (PG) on viscosity of gluten-free cake batter. Different letters are significantly different ($p<0.05$).

2-3- moisture, ash, protein, fat and fiber cake

According to Table 1, by replacing eggs with different levels of soybean flour, the amount of protein, fiber, ash and fat of the final product increased compared to the control sample, but the moisture content decreased ($p<0.05$). Addition of saffron seed gum also increased the moisture content of all treatments and the control, but it had no significant effect on their protein, fiber, ash and fat content ($p<0.05$). Increasing the level of replacing egg with soybean flour by more than 50% significantly reduced the moisture content of the product ($p<0.05$). The highest amount of moisture was measured in the sample containing 100% eggs and containing 1% saffron gum (19.72%), and the lowest in the sample containing 100% soybean flour and without saffron gum (11.54%). One of the important reasons for the difference in the moisture content of the samples was related to the higher dry matter of soybean flour compared to eggs, which was in line with the results of Farzana and Mohajan (2015) [30]. Adding saffron seed gum to the cake formulation increased the moisture content of the final product compared to samples without gum due to the increase in the hydrophilic nature of hydrocolloids. Naqipour et al. (2015) announced that by adding 1% of Asfarza gum to the combined flour of wheat and sorghum, the moisture content of the product increases to 4%, which was consistent with the results of Table 1 [18]. Regarding the increase in the amount of protein, fiber, ash and fat in products by increasing the level of replacing eggs with soybean flour, since the amount of protein, fiber, ash

and fat in soybean flour is higher compared to eggs, the increase of these components in the final product is far from expected. was not This result was in agreement with the results of Farzana and Mohajan (2015) [30] and Kuang et al. (2015) regarding the amount of egg components [31].

Table1. Effect of egg replacement with soy flour (SF) and psyllium gum (PG) on physicochemical properties of gluten free cake.

Treatment	PG (%)	(Moisture%)	(Ash%)	(Protein%)	(Fat%)	(Fiber%)
100% Egg	0	$17.90^{c} \pm 0.17$	$1.01^{It\ is} \pm 0.01$	$7.43^{It\ is} \pm 0.05$	$20.90^{It\ is} \pm 0.32$	$0.33^{c} \pm 0.02$
	0.5	$18.80^{b} \pm 0.09$	$1.00^{It\ is} \pm 0.01$	$7.40^{It\ is} \pm 0.04$	$21.19^{It\ is} \pm 0.57$	$0.33^{c} \pm 0.02$
	1	$19.72^{a} \pm 0.08$	$1.00^{It\ is} \pm 0.05$	$7.45^{It\ is} \pm 0.03$	$20.96^{It\ is} \pm 0.39$	$0.34^{c} \pm 0.01$
75% Egg 25% SF	0	$17.30^{d} \pm 0.15$	$1.06^{d} \pm 0.01$	$7.76^{d} \pm 0.07$	$22.57^{d} \pm 0.33$	$0.58^{b} \pm 0.05$
	0.5	$17.91^{c} \pm 0.12$	$1.07^{d} \pm 0.02$	$7.75^{d} \pm 0.01$	$22.58^{d} \pm 0.30$	$0.56^{b} \pm 0.04$
	1	$19.03^{b} \pm 0.08$	$1.07^{d} \pm 0.02$	$7.77^{d} \pm 0.02$	$22.68^{d} \pm 0.36$	$0.58^{b} \pm 0.02$
50% Egg 50% SF	0	$17.08^{d} \pm 0.12$	$1.11^{c} \pm 0.03$	$8.15^{c} \pm 0.15$	$23.77^{c} \pm 0.47$	$0.80^{b} \pm 0.09$
	0.5	$17.86^{c} \pm 0.19$	$1.11^{c} \pm 0.02$	$8.19^{c} \pm 0.12$	$23.79^{c} \pm 0.26$	$0.84^{b} \pm 0.02$
	1	$18.85^{b} \pm 0.06$	$1.12^{c} \pm 0.02$	$8.20^{c} \pm 0.05$	$23.74^{c} \pm 0.32$	$0.83^{b} \pm 0.04$
25% Egg 75% SF	0	$14.58^{g} \pm 0.05$	$1.17^{b} \pm 0.04$	$8.47^{b} \pm 0.14$	$24.92^{b} \pm 0.08$	$1.02^{a} \pm 0.14$
	0.5	$15.05^{f} \pm 0.02$	$1.17^{b} \pm 0.01$	$8.46^{b} \pm 0.10$	$24.98^{b} \pm 0.16$	$1.06^{a} \pm 0.09$
	1	$15.52^{It\ is} \pm 0.04$	$1.18^{b} \pm 0.02$	$8.53^{b} \pm 0.09$	$24.96^{b} \pm 0.05$	$1.04^{a} \pm 0.08$
100% SF	0	$11.54^{i} \pm 0.13$	$1.25^{a} \pm 0.03$	$9.07^{a} \pm 0.02$	$26.13^{a} \pm 0.48$	$1.35^{a} \pm 0.13$
	0.5	$11.91^{h} \pm 0.04$	$1.26^{a} \pm 0.02$	$9.19^{a} \pm 0.01$	$26.03^{a} \pm 0.01$	$1.34^{a} \pm 0.02$
	1	$12.16^{h} \pm 0.01$	$1.25^{a} \pm 0.01$	$9.35^{a} \pm 0.16$	$26.22^{a} \pm 0.15$	$1.40^{a} \pm 0.11$

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

3-3- The volume of the cake

The results of Figure 2 showed that replacing eggs with soy flour in the formulation of cakes (up to 50%), increased their volume significantly ($p<0.05$). But by increasing the level of replacing egg with soybean flour by more than 50%, a significant decrease in the volume of samples was observed ($p<0.05$). By increasing the amount of safflower seed gum in the dough formulation up to 1%, the volume of samples in which up to 50% of eggs were replaced with soy flour increased compared to samples without safflower gum. Addition of saffron seed gum in the volume of samples with more than 50% soybean flour did not create a statistically significant difference ($p>0.05$). Replacing up to 50% of eggs with soy flour and adding 1% of saffron seed gum produces samples with the largest volume (47.12 cubic centimeters) compared to other samples and the control sample (36.73 cubic centimeters) containing whole eggs and without seed gum. It was estimated ($p<0.05$). The higher protein content of soy flour compared to whole eggs was effective in increasing the cake volume by increasing the dough strength and increasing the gelatinized temperature of starch during baking [32, 33]. Ributa et al. (2004) reported that the addition of soy flour improves the mechanical properties of the dough and thus increases the volume of the final product in gluten-free bread, but it is not desirable in amounts greater than 20%, which is in line with the results of this study [34]. Dehghan Taneh and Karimi (2016) reported that saffron seed gum in donut formulation increased the specific volume of production samples by strengthening and uniformly increasing air bubbles in the dough [35].

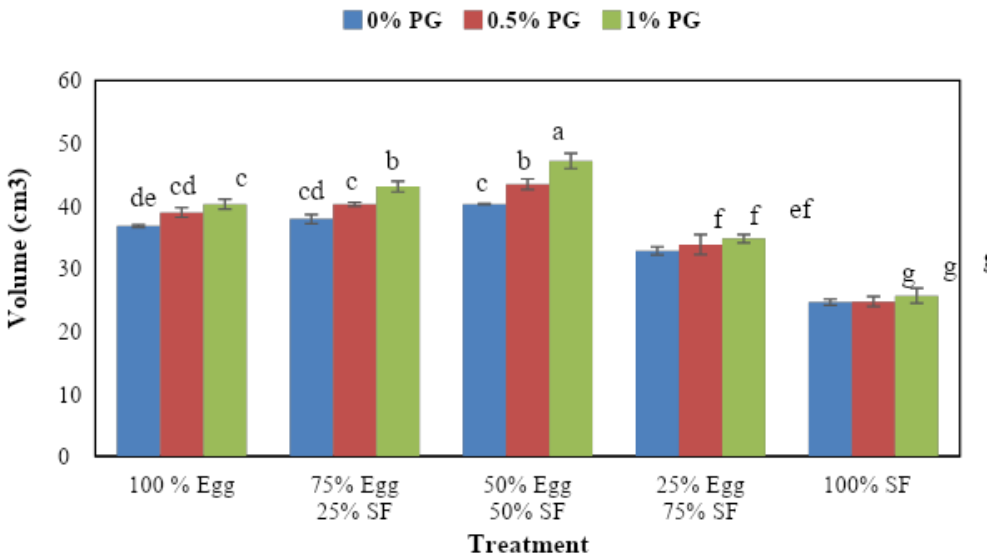

Fig 2. Effect of egg replacement with soy flour (SF) and psyllium gum (PG) on volume of gluten free cake. Different letters are significantly different ($p<0.05$).

4-3- Cake porosity

The results of Figure 3 showed that by replacing up to 50% of eggs with soybean flour in the formulation, the percentage of porosity of the produced cakes increased significantly, but with the increase of the replacement percentage to more than 50%, the porosity of the samples decreased ($p<0.05$). On the other hand, the percentage of porosity of the samples in which up to 50% of egg was replaced with soy flour showed a significant increasing trend, in line with the increase in the proportion of safflower gum from zero to 1% in the dough formulation. Addition of saffron seed gum did not create a statistically significant difference in the porosity of samples in which more than 50% of eggs were replaced with soybean flour ($p<0.05$). The highest porosity was measured in the samples in which up to 50% of the egg was replaced with soy flour (34.32%) compared to other samples and the control sample (25.36%) containing whole eggs and without safflower seed gum. Soderberg (2013) investigated the replacement of soybean protein with eggs in the production of egg-free food formulations and reported that soy protein is similar to egg proteins in terms of solubility, water absorption, and emulsifying power, but it has weaker foaming and gelling properties. The increase in the porosity of cakes containing soy flour can be related to the increase in protein and lecithin content of soy flour compared to eggs, which increases the foaming of the dough and forms a resistant protein layer at the interface between the air cells, which keeps air bubbles in it [36]. This result was consistent with the results of P. Carli et al. (2021) [37]. The reduction of porosity by increasing the ratio of egg replacement with soy flour to more than 50% in gluten-free cake formulation was related to the reduction of the structuring and gelling power of soy protein compared to egg protein [14]. Rwanda et al. (2011) stated that with the increase in dough viscosity, the possibility of air entering the dough texture decreases, which results in a decrease in the volume and porosity of the final product, which is consistent with the results of this research regarding the increase in dough viscosity by removing more than 50% of eggs. was [38]. Ashwini et al. (2009) reported that the presence of hydrocolloids in the dough formulation of egg-free bakery products covered with starch granules makes the protein network uniform and also increases the thickness and uniform distribution of air cells in the cake texture [9]. Beikzadeh et al. (2018) stated that increasing the viscosity of the dough containing gums increases the volume of the cake by slowing down the gas release rate and maintaining it in the initial stages of cooking [17].

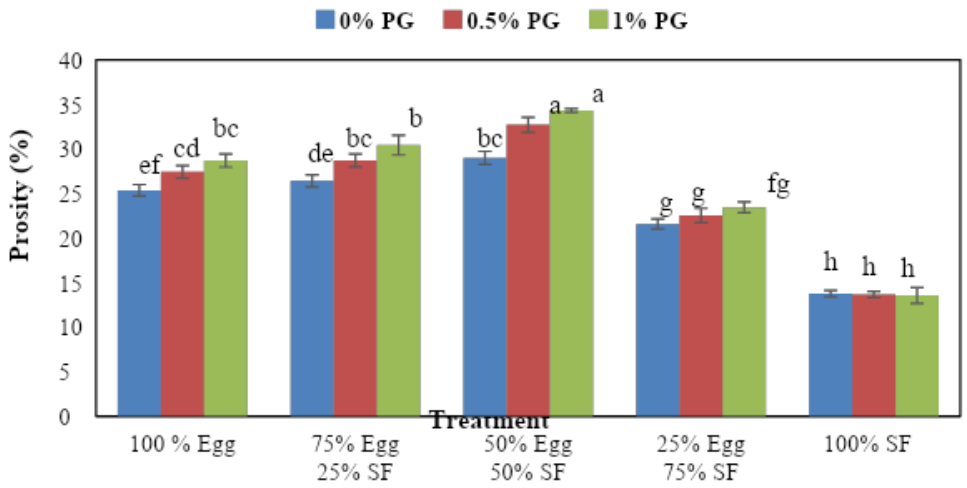

Fig 3. Effect of egg replacement with soy flour (SF) and psyllium gum (PG) on porosity of gluten free cake. Different letters are significantly different ($p<0.05$).

5-3- The firmness of the cake texture

Replacing eggs with soy flour significantly ($p<0.05$) increased the firmness of the produced samples compared to the control (Figure 4). Addition of saffron gum in the control sample and other samples that contained soy flour as an egg substitute reduced the stiffness of the texture. By increasing the level of replacing egg with soy flour by more than 50%, a significant increase in the hardness of the samples was observed ($p<0.05$). By increasing the amount of safflower seed gum in the dough formulation to 1%, the hardness of the samples in which up to 50% of eggs were replaced with soybean flour decreased compared to the samples without safflower gum ($p<0.05$). The increase in the texture of the samples containing soy flour as an egg substitute can be related to the increase in the amount of fiber and protein in the dough formulation and as a result, the increase in their texture. Lin et al. (2017) reported that by replacing eggs with soy protein isolate, the firmness of the product increased [29], which was consistent with the results of this study. The complete removal of eggs in the formulation causes the removal of the gelling proteins necessary to maintain the incoming air bubbles during the mixing process of the dough and the final product. If the egg is not replaced with suitable ingredients, the capacity to maintain air bubbles in the dough texture (during the mixing and baking process) decreases, which leads to the compaction of the texture and ultimately the product's stiffness [18]. Esfarza gum is effective in the softness of the cake texture by maintaining and preventing the destruction of air bubbles entering the dough texture and creating a suitable thickness in their wall during the baking process. The hygroscopicity of gums also prevents the migration of moisture from the core to the shell by maintaining more moisture after baking and plays a role in increasing the softness of the product texture [39]. Torabi et al. (2008) [27] published reports on the role of various gums and emulsifiers as a softening and anti-staling agent in bread and cake, which was consistent with the results of this research.

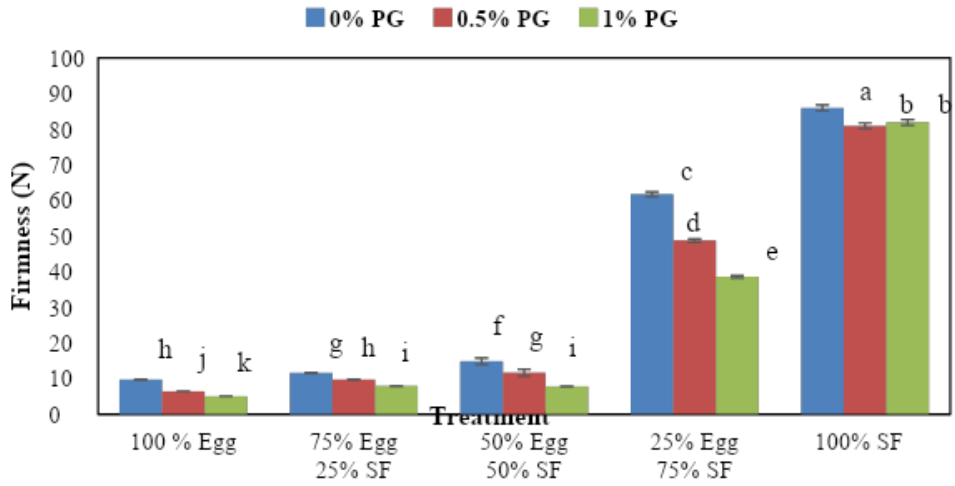

Fig 4. Effect of egg replacement with soy flour (SF) and psyllium gum (PG) on firmness of gluten free cake. Different letters are significantly different ($p<0.05$).

3-6- The color of the cake

The average values of color components in different samples compared to the control are shown in Table 2. Increasing the level of egg replacement with different amounts of soybean flour caused the color of the final product to darken and the amount of component (L) to decrease to 37.04 in the sample without eggs and without saffron gum compared to the control (54.71) ($p<0.05$). . The reduction of the amount of component (L) up to 46/75 in bakery products containing soy flour up to 15% is also found in the reports of Tasheer et al. (2017) [40]. 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 the darker color [40]. Increasing the proportion of safflower gum from zero to 1% in the dough formulation significantly brightened the color of the samples ($p<0.05$). Salehi et al. (2018) stated the increase in the volume of the final product containing balango seed gum in gluten-free cake batter formulation as the reason for the lighter color of the product [21]. Naqipour et al. (2015) reported that the addition of 0.75% safflower seed gum in the formulation of oil cake dough makes the color of the core and the surface of the product lighter. They stated that the clear reason for the color is the retention of moisture in the texture of the cake by the esfarza gum during the baking process and as a result preventing the creation of non-uniform surfaces and more and better reflection of light from the surface of the product [18]. With the increase in the level of egg replacement with soybean flour, component (a) which is related to the red color of the cake, had a significant increase. By removing up to 50% of eggs in component (b), no significant change in color was observed ($p<0.05$), but by increasing the proportion of soybean flour compared to eggs to 100%, component (b) showed a significant decrease ($p<0.05$).). 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 soy flour [41]. The addition of saffron seed gum in the cake batter formulation reduced component (a) in all samples, and component (b) decreased in samples in which more than 50% of eggs were removed. Awad Soufian et al. (2014) reported the reduction of free water in the formulation and thus the reduction of the

intensity of browning reactions due to the reduction of component (a) in gluten body cakes containing xanthan gum [42].

Table2. Effect of egg replacement with soy flour (SF) and psyllium gum (PG) on color of gluten free cake

Treatment	PG (%)	(L)	(a)	(b)
100% Egg	0	$54.71^{def} \pm 1.35$	$8.82^{f} \pm 0.22$	$41.02^{a} \pm 0.95$
	0.5	$63.19^{b} \pm 1.54$	$6.41^{h} \pm 0.16$	$40.99^{a} \pm 0.99$
	1	$70.16^{a} \pm 1.71$	$4.60^{i} \pm 0.12$	$40.13^{a} \pm 0.06$
75% Egg 25% SF	0	$51.09^{fg} \pm 1.24$	$10.02^{It\ is} \pm 0.26$	$39.12^{a} \pm 0.07$
	0.5	$56.59^{cde} \pm 1.38$	$7.60^{g} \pm 0.19$	$40.25^{a} \pm 0.11$
	1	$60.32^{bc} \pm 3.52$	$5.35^{i} \pm 0.13$	$41.45^{a} \pm 1.05$
50% Egg 50% SF	0	$47.29^{gh} \pm 1.15$	$12.25^{d} \pm 0.31$	$39.67^{a} \pm 0.54$
	0.5	$53.57^{if} \pm 1.30$	$9.37^{if} \pm 0.24$	$40.05^{a} \pm 1.33$
	1	$58.59^{bcd} \pm 1.43$	$7.57^{g} \pm 0.19$	$39.31^{a} \pm 0.59$
25% Egg 75% SF	0	$42.27^{ij} \pm 1.03$	$14.91^{b} \pm 0.38$	$30.45^{bc} \pm 1.70$
	0.5	$46.32^{hi} \pm 1.13$	$14.56^{b} \pm 0.25$	$33.90^{b} \pm 0.70$
	1	$50.34^{fgh} \pm 1.23$	$13.50^{c} \pm 0.35$	$32.42^{bc} \pm 2.16$
100% SF	0	$37.02^{k} \pm 0.96$	$17.86^{a} \pm 0.46$	$28.22^{c} \pm 1.17$
	0.5	$39.09^{jk} \pm 1.13$	$17.13^{a} \pm 0.44$	$29.58^{bc} \pm 0.90$
	1	$40.75^{jk} \pm 0.99$	$16.96^{a} \pm 0.31$	$28.76^{c} \pm 1.66$

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

3-7- Sensory characteristics of the cake

The evaluators did not observe a significant difference ($p<0.05$) in the sensory characteristics of color, flavor, texture, and overall acceptance of the samples that had up to 50% egg replaced with soy flour (Table 3). Also, increasing the level of replacing eggs with soy flour to more than 50% significantly reduced the sensory characteristics score of the produced cakes ($p<0.05$). Increasing the amount of saffron gum in the dough formulation up to 1% increased the sensory characteristics of the samples in which up to 50% of eggs were replaced with soybean flour compared to the samples without saffron gum, but increased the sensory characteristics of the samples in which more than 50% of eggs were added. It was replaced with soy flour, it did not cause significant change ($p<0.05$). The highest overall acceptance score (4.83) was observed in the samples containing up to 50% soybean flour and 1% saffron gum compared to the control sample (4.40) which contained whole eggs and no saffron gum ($p<0.05$). . The decrease in the sensory scores of the samples containing more than 50% soybean flour can be related to the decrease in the moisture content of the product and on the other hand, the decrease in its texture and color characteristics. Prophet Dost et al. (2016) reported that the

increase in sensory acceptance of cakes containing basil mucilage is related to the role of the mentioned gum in maintaining moisture and softness and the aroma of the product; So that the decrease in humidity and the increase in the stiffness of the texture had a significant effect on the decrease in the sensory score of the cakes, which was in good agreement with the results of this research. According to Table 3, by replacing egg with soy flour, the lowest sensory score was related to the sensory attribute of color and aroma compared to other sensory attributes, which had a negative effect on the sensory score of overall acceptance. Zanganeh et al. (2023) declared the decrease in the sensory score of color and taste (due to the inherent taste of soybeans) in gluten-free cakes containing soybean flour as the two main reasons for the decrease in the overall acceptance score compared to the control sample [24], which is consistent with the results The decrease in the overall acceptance score of products containing soy flour compared to the control of this study was consistent in Table 4.

Table 3. Effect of egg replacement with soy flour (SF) and psyllium gum (PG) on sensory properties of gluten free cake

Treatment	PG (%)	(Color)	(Taste/Odor)	(Texture)	(Overall)
100% Egg	0	$4.30^{ab} \pm 0.21$	$4.66^{bc} \pm 0.07$	$4.29^{c} \pm 0.11$	$4.40^{bc} \pm 0.21$
	0.5	$4.53^{a} \pm 0.34$	$4.87^{ab} \pm 0.02$	$4.56^{abc} \pm 0.07$	$4.59^{abc} \pm 0.12$
	1	$4.60^{a} \pm 0.25$	$4.92^{a} \pm 0.09$	$4.67^{ab} \pm 0.04$	$4.82^{ab} \pm 0.14$
75% Egg 25% SF	0	$4.14^{ab} \pm 0.08$	$4.58^{cd} \pm 0.03$	$4.48^{bc} \pm 0.11$	$4.29^{c} \pm 0.22$
	0.5	$4.18^{ab} \pm 0.05$	$4.61^{cd} \pm 0.11$	$4.74^{ab} \pm 0.07$	$4.51^{abc} \pm 0.15$
	1	$4.35^{ab} \pm 0.11$	$4.63^{c} \pm 0.07$	$4.86^{ab} \pm 0.07$	$4.83^{ab} \pm 0.12$
50% Egg 50% SF	0	$3.92^{b} \pm 0.01$	$4.38^{d} \pm 0.07$	$4.56^{abc} \pm 0.09$	$4.33^{c} \pm 0.23$
	0.5	$4.15^{ab} \pm 0.03$	$4.48^{cd} \pm 0.01$	$4.71^{ab} \pm 0.07$	$4.52^{abc} \pm 0.14$
	1	$4.37^{ab} \pm 0.12$	$4.63^{if} \pm 0.04$	$4.89^{a} \pm 0.03$	$4.91^{a} \pm 0.06$
25% Egg 75% SF	0	$3.07^{c} \pm 0.04$	$3.14^{lt\ is} \pm 0.08$	$3.21^{d} \pm 0.20$	$2.96^{if} \pm 0.10$
	0.5	$3.05^{c} \pm 0.05$	$3.35^{lt\ is} \pm 0.05$	$3.44^{d} \pm 0.24$	$3.28^{of} \pm 0.14$
	1	$3.10^{c} \pm 0.03$	$3.36^{lt\ is} \pm 0.10$	$3.58^{d} \pm 0.18$	$3.48^{d} \pm 0.03$
100% SF	0	$2.27^{d} \pm 0.07$	$2.01^{fg} \pm 0.10$	$2.53^{lt\ is} \pm 0.06$	$2.11^{h} \pm 0.06$
	0.5	$2.56^{d} \pm 0.09$	$2.11^{f} \pm 0.12$	$2.51^{lt\ is} \pm 0.04$	$2.34^{g} \pm 0.07$
	1	$2.70^{cd} \pm 0.13$	$2.23^{f} \pm 0.11$	$2.57^{lt\ is} \pm 0.02$	$2.58^{fg} \pm 0.11$

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

4 - Conclusion

In this research, soybean flour and esfarzeh gum powder were used as egg substitutes in the production of gluten-free rice cakes with the aim of improving the physicochemical and sensory characteristics of the final

product. Replacing eggs with soybean flour in gluten-free rice cakes increased water absorption and dough viscosity, but this effect was favorable up to the ratio of replacing 50% of eggs with soybean flour, and more than that significantly caused a decrease in the technological characteristics of the cakes (volume, porosity, and softness).) and also reduced the sensory characteristics of the final product. The evaluators stated the loss of bean color and taste as the reasons for reducing the score of sensory characteristics. On the other hand, the decrease in the moisture content of the formula due to the presence of soy flour, which ultimately led to the creation of a product with a hard and dry texture, was another reason for not accepting cakes with the complete removal of eggs. The addition of esfarza seed gum to egg-free gluten-free rice cakes improved the moisture, volume, porosity, and softness of the samples, and on the other hand, by improving the color and brightness of the product, it had a significant effect on increasing the sensory acceptance and customer-friendliness of the egg-free gluten-free product; Therefore, it can be concluded that replacing eggs with soybean flour up to 50% will be acceptable in terms of technological and sensory characteristics, and adding gums such as esfarze in the formulation by improving the physicochemical and sensory characteristics of the final product will play a decisive role in increasing the customer's friendliness of the product.

5- Resources

[1] Noguerol , A.T. , Larrea , V. & Pagan , M.J. . (2022). The effect of psyllium (*Plantago ovata* Forsk) fibres on the mechanical and physicochemical characteristics of plant-based sausages. *European Food Research and Technology*, 248, 2483–2496.

[2] Poursafar, L., Peighambardoust, S. H., Alizadeh Shalchi, L., Shakuoie Bonab, E., & Rafat, S. A. (2012). Effect of the temperature and time of flour heat treatment on the quality characteristics of sponge cake. *Food Processing and Preservation Journal*, 2 (4): 87-104[in Persian].

[3] Yazici, G. N., & Özer, M. S. (2021). A review of egg replacement in cake production: Effects on batter and cake properties. *Trends in Food Science & Technology*, 111, 346-359.

[4] Egea, M.B., De Sousa, T.L., Dos Santos, D.C. et al. (2023). Application of Soy, Corn, and Bean By-products in the Gluten-free Baking Process: A Review. *Food and Bioprocess Technology*, 16, 1429–1450.

[5] Gularte, M. A., Gómez, M. & Rosell, C. M. (2012). Impact of legume flours on quality and in vitro digestibility of starch and protein from gluten-free cakes. *Food and Bioprocess and Technology*, 5, 3142–3150.

[6] Yanpi, M., Aalami, M., Mohammadzadeh, J., Sadeghi, A. R., & Kashiri, M. (2018). Effects of the addition of white maize flour and xanthan gum on physical and sensory properties of gluten-

free rice cake. *Journal of Food Science and Technology (Iran)*, 14(73), 319-330 [in Persian].

[7] Elgeti, D., Nordlohne, S.D., Föste, M., Besl, M., Linden, M., Heinz, V., Jekle, M., & Becker, T. (2014). "Volume and texture improvement of gluten-free bread using quinoa white flour. *Journal of Cereal Science*, 59(1),41–47.

[8]Karazhiyan, H., & Keyhani, V. (2015). The effect of Chubak extract on sponge cake as an egg white substitute. *Iranian Food Science and Technology Research Journal*, *11*(1), 63-76.

[9] Ashwini, A., Jyotsna, R., Indrani, D. (2009). Effect of hydrocolloids and emulsifiers on the rheological, microstructural and quality characteristics of eggless cake.*Food Hydrocolloids*, 23, 3, 700-707.

[10] Zinia, S. A., Nupur, A. H., Karmoker, P., Hossain, A., Jubayer, A. F., Akhter, D., & Mazumder, M. A. R. (2022). Effects of sprouting of soybean on the anti-nutritional, nutritional, textural and sensory quality of tofu,*Hellion*, 8(10), e10878.

[11] Naghipour, F., Sahraiyan, B., Habibi Najafi, M. B., Karimi, M., Hadad Khodaparast, M. H., & Sheikholeslami, Z. (2017). Effect of soy milk powder as a natural additive to improve the technological and sensory properties of sorghum flour-based gluten-free oil cake. *Journal of Food Science and Technology (Iran)*, 61(13), 77-86 [in Persian].

[12] Yademellat, M. , Jooyandeh, H., & Hojjati, M. (2018). Comparison of some physiochemical and sensory properties of low-fat stirred yogurt containing Persian and Balangu-Shirazi gums.*Journal of Food Science and Technology (Iran)*, 72(14), 313-326 [in Persian].

[13] Hedayati, S., & Mazaheri Tehrani, M. (2018). Effect of total replacement of egg bysoymilk and lecithin on physical properties of batter and cake. *Food Sciences andNutrition*, 6(4), 1154–1161.

[14] Agrahar-Murugkar, D., Zaidi, A., & Dwivedi, S. (2018). Development of gluten free eggless cake using gluten free composite flours made from sprouted and malted ingredients and its physical, nutritional, textural, rheological and sensory properties evaluation. *Journal of Food Science & Technology*, 55(7), 2621–2630.

[15] Naghdi Badi , H. , Dastpak , A. , & Ziai , S. A. (2004). A review of psyllium plant.*Journal of Medical Plants*, 3(9), 5-14.

[16] Askari , H. , Farahnaky , A. , Aminlari , M. , Majzoobi , M. , & Mesbahi , G. (2008). Extraction of mucilage gum (Plantago ovata L.) and its rheological properties.*18th National Congress of Food Technology*, 1-13. [in Persian].

[17] Beikzadeh, S., Peighambardoust, S. H., Azizi, A., Beikzadeh, M., Asghari Jafar-abadi, M., & Homayouni-Rad, A. (2018). Effect of psyllium seed and xanthan gums on physical, sensory and staling properties of sponge cake. *Journal of Food Science and Technology (Iran)*, 76(15): 142-152 [in Persian].

[18] Naqipour, F., Sahraian, B., Habibi Najafi, M. B., & Haddad Khodaparast, M. H. (2015). Investigating the effect of esfarzeh gum on the durability and quality of mixed oil cake (wheat-sorghum). *Journal of Innovation in Food Since and Technology*, 7, 3, 1-9. [in Persian].

[19] Ahmadi , R. , Kalbasi-Ashtari , A. , Oromiehie , A. , Yarmand , M. S. , & Jahandideh , F. (2012). Development and characterization of a novel biodegradable edible film obtained from psyllium seed (Plantago ovata Forsk).*Journal of Food Engineering*, 109, 4, 745-751.

[20] Emamifar, A., Zanganeh, Z., Latifian, M., & Arbab, Z. (2020). Physicochemical, textural and sensory properties of containing jujube cake. *Journal of Food Science and Technology (Iran)*, 17 (103), 33-46 [in Persian].

[21] Salehi, F., Amin Ekhlas, S., Pavee, S., & Zandi, F. (2018). Effect of balangu seed gum on rheological, physical and sensory properties of gluten free rice cake. *Journal of Food Technology and Nutrition*,15 (4), 61-68 [in Persian].

[22] AACC (1999). American Association of Cereal Chemists. Approved Methods of Analysis, 11th Ed. St. Paul, MN, U.S.A.: AACC International.

[23] Naghipour, F., Karimi, M., Habibi Najafi, M. B., Hadad Khodaparast, M. H., Sheikholeslami, Z., Ghiafeh Davoodi, M., & Sahraiyan, B. (2013). Investigation on production of gluten free cake utilizing sorghum flour, guar and xanthan gums. *Journal of Food Science and Technology (Iran),* 10 (41), 127-139 [in Persian].

[24] Zanganeh, Z., Emamifar, A., & Karami, M. (2023). Effect of germinated soybean flour and ultrasonic wave on physicochemical and sensory properties of gluten-free rice cake. *Journal of Food Science and Technology (Iran*), 19 133, 211-224 [in Persian].

[25] Salehi, F., Amin Ekhlas, S, & Souri, F. (2018). Investigation of the batter characteristic and sponge cake properties containing soy protein isolate and basil seed gum. *Journal of Food Science and Technology (Iran),* 14 (70), 323-315 [in Persian].

[26] Amirabadi, A., Koocheki, M., & Mohebbi. M. (2015). Effect of Xanthan and Lepidium perfoliatum seed gums on quality and shelf-life of chiffon cake. *Iranian Food Science and Technology Research Journal*, 10, 4, 375-386 [in Persian].

[27] Turabi, E., Sumnu, G., & Sahin, S. (2008). Rheological properties and quality of rice cakes formulated with different gums and an emulsifier blend. *Food Hydrocolloids*, 22, 2, 305-312.

[28] Mohajer Khorasani, S. Alami, M. Kashaninejad, M., Shahiri Tabarestani, H. (2021). Effect of adding millet flour and Xanthan gum on the physicochemical and sensorial properties of gluten-free cake. *Food Processing and Preservation Journal*, 13, 1, 57-70 [in Persian].

[29] Lin, M., Tay, S. H., Yang, H., Yang, B. & Li, H. (2017). Replacement of eggs with soybean protein isolates and polysaccharides to prepare yellow cakes suitable for vegetarians. *Food Chemistry*, 229, 663-673.

[30] Farzana, T., & Mohajan, S. (2015). Effect of incorporation of soy flour to wheat flour on nutritional and sensory quality of biscuits fortified with mushroom. *Food science & nutrition*, 3(5), 363–369.

[31] Kuang, H., Yang, F., Zhang, Y., Wang, T., & Chen, G. (2018). The Impact of Egg Nutrient Composition and Its Consumption on Cholesterol Homeostasis. *Cholesterol*, 2018, 6303810.

[32] Dhen, N., Roman, L., Rejeb, I. B., Martínez, M. M., Garogouri, M., & Gomez,

M. (2016). Particle size distribution of soy flour affecting the quality of enriched gluten-free cakes. *LWT - Food Science and Technology*, 66, 179-185.

[33] Mizukoshi, M., Maeda, H., & Amano, H. (1980). Model studies of cake baking. 2. Expansion and heat set of cake batter during baking. *Cereal Chemistry*, 57(5), 352–355.

[34] Ribotta, P. D., Ausar, S. F., Morcillo, M. H., Pérez, G. T., Beltramo, D. M. & León, A. E. (2004), Production of gluten-free bread using soybean flour. *Journal of the Science of Food and Agriculture*, 84, 1969-1974.

[35] Dehghan Tanha, L., & Karimi, M. (2016). Application of plantago gum and fungal α-amylase enzyme onphysicochemical and organoleptic properties of doughnut. *Journal of Food Science and Technology (Iran)*, 52 (13), 101-110 [in Persian].

[36] Mohammad zadeh Milani, J., Sedighi, N. & Mirzaei, H. (2018). Effect of germinated and nongerminated soybean flour on quality of Barbari bread. *Electronic Journal of Food Processing and Preservation.* 10(1), 73-84[in Persian].

[36] Söderberg, J. (2013). Functional properties of legume proteins compared to egg proteins and their potential as egg replacers in vegan food. Uppsala: *Swedish University of Agricultural Sciences*, Body ID: 82118666.

[37] Pycarelle, S. S., Bosmans, G. M., Pareyt, B., Brijs, K., & Delcour, J. A. (2021). Free wheat flour lipids decrease air-liquid interface stability in sponge cake batter. *Food Research International, 140*, 110007.

[38] Ronda, F., Oliete, B., Gomez, M., Caballero, P. A., & Pando, V. (2011). Rheological study of layer cake batter made with soybean protein isolate and different starch sources. *Journal of Food Engineering*, 102, 272–277.

[39] Naghipour, F., Mazaheri Tehrani, M., Sahraiyan, B., Sheikholeslami, Z,, & Soleimani, M. (2013). Replacing eggs with soy flour and mixing with wheat flour with wheat germ for oil cake production. *Iranian Journal of Nutrition Sciences & Food Technology*, 8, 2, 211-220.

[40] Taghdir, M., Mazloomi, S. M., Honar, N., Sepandi, M., Ashourpour, M., & Saleh, M. (2017). Effect of soy flour on nutritional, physicochemical, and sensory characteristics of gluten-free bread. *Food Science & Nutrition*, 5,439–445.

[41] Maleki, G., Mazaheri Tehrani, M. and Shokrollahi, F. (2016). Effect of different concentration of soy flour on the quality of gluten-free bread containing rice flour. *Journal of Food Science and Technology,* 13(54), 51-62[in Persian].

[42] Avazsufiyan , A. , Aalami , M. , Sadeghimahoonak , A. , Ghorbani , M. , & Ziaiifar , A. M. (2014). Application of sweet almond meal and xanthan gum in the production of gluten-free cake.*Research and Innovation in Food Science and Technology*, 3(2), 185-196.

[43] Peighambardoust, S. H., Homayouni Rad, A., Beikzadeh, S., & Asghari Jafar-abadi, M. (2016). Effect of basil seed mucilage on physical, sensory and staling properties of sponge cake. *Iranian Journal of Biosystems Engineering*, 47(1), 1-9.

[44] Mashayekh, M., Mahmoodi, M. R., & Entezari, M. H. (2008). Effect of

fortification of defatted soy flour on sensory and rheological properties of wheat bread. *International Journal of Food Science and Technology*, 43, 1693–1698.

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بررسی جایگزینی تخم‌مرغ با آرد سویا و صمغ دانه اسفرزه در کیک برنجی بدون گلوتن

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چکیده

هدف این مطالعه بررسی تأثیر سطوح مختلف (صفر، ۲۵، ۵۰، ۷۵ و ۱۰۰ درصد وزنی–وزنی) تخم‌مرغ در جایگزینی با آرد سویا و افزودن صمغ دانه اسفرزه (صفر، ۰/۵ و ۱ درصد وزن آرد برنج) بر ویژگی‌های فیزیکوشیمیایی و حسی کیک برنجی بود. تجزیه و تحلیل داده‌ها بر اساس آزمایش فاکتوریل در قالب طرح آماری کاملاً تصادفی و در سه تکرار انجام شد. جایگزینی تا ۵۰ درصد تخم‌مرغ با آرد سویا در فرمولاسیون خمیر، ویژگی‌های فناورانه (رنگ، بافت و تخلخل) و حسی کیک-های تولیدی را به شکل معنی‌داری بهبود بخشید ($p<۰/۰۵$). با افزایش درصد جایگزینی به بیش از ۵۰ درصد کاهش معنی‌داری در ویژگی‌های مذکور کیک‌ها مشاهده شد ($p<۰/۰۵$). روند افزایشی تا ۱ درصد صمغ دانه اسفرزه در فرمولاسیون علاوه بر افزایش ویسکوزیته خمیر، سبب افزایش رطوبت، حجم، تخلخل و نرمی کیک‌های تولیدی شد ($p<۰/۰۵$). در مقایسه با نمونه‌های حاوی تخم‌مرغ کامل و بدون صمغ اسفرزه، به ترتیب بیشترین مقدار رطوبت، تخلخل، حجم و نرمی و امتیاز حسی، در نمونه‌هایی که ۵۰ درصد تخم‌مرغ آن‌ها با آرد سویا جایگزین شده بود و حاوی ۱ درصد صمغ اسفرزه بودند و کمترین آن‌ها در نمونه حاوی ۱۰۰ درصد آرد سویا و بدون صمغ اسفرزه مشاهده گردید. کاهش کیفیت رنگ (کاهش مؤلفه L و افزایش مؤلفه a) و همچنین افت ویژگی‌های حسی طعم و رنگ این نمونه‌ها، کاهش معنی‌داری در مقایسه با نمونه شاهد (حاوی ۱۰۰ درصد تخم‌مرغ) نشان داد ($p<۰/۰۵$). بنابراین می‌توان نتیجه گرفت که آرد سویا قابلیت جایگزینی با تخم‌مرغ در کیک‌های بدون گلوتن را دارد و افزودن صمغ دانه اسفرزه به فرمولاسیون خمیر کیک‌های بدون گلوتن با میزان تخم‌مرغ کاهش یافته در بهبود ویژگی‌های فیزیکوشیمیایی و حسی آن‌ها تأثیرگذار است.