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ORIGINAL ARTICLE

Effect of *Soy* protein isolate, Guar gum and *Ocimum basilicum* seed powder as replacers of fat on Porosity, Color and Texture of Muffin cake

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ABSTRACT
Increasing public awareness of health and nutrition has increased the market for low-fat, low-calorie, low-cholesterol food products. Due to the increased consumption of high amounts of oil and oil products such as muffin cakes, today, a suitable replacer seems to be essential. Therefore, in present study porosity, color and texture of muffin cake were examined in which fat was replaced with soy protein isolate, guar gum and Ocimum basilicum seed powder. The results showed that the sample containing 10% soybean and 2% basil powder had the highest porosity and least amount of hardness compared to those of other samples. Also, the content of parameters L and a* increased With the addition of guar gum, Ocimum basilicum seed powder and parameters soy protein isolate and Ocimum basilicum seed powder respectively.*
Keywords: cake, soy protein, guar gum, basil seed, porosity, color, texture

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INTRODUCTION

A consensus remains among health and nutrition professionals that most Americans should lower their dietary intake of fat, saturated fat, and cholesterol [1]. This guideline has been set to reduce the risk of diseases that have been associated with excessive intake of fat in the diet, such as coronary heart disease, obesity, hypertension, certain cancers (e.g. breast, colon, or prostate), and possibly gall bladder disease [2]. On the other hand, Bakery products are the most consumed foods in the world and among these products; cakes are the most popular products due to their deliciousness and special organoleptic characteristics [3]. Flour, sugar, oil and eggs are the four main ingredients used to make cakes and each plays an important role in the cake structure and nutritional quality [4, 5].

The first step in substituting fat in foods is to understand the functionality of fat. More specifically, understanding the functionality of fat in the particular food system that will be modified. After identifying fat's role in this system, a fat-substitute or combination of fat substitutes that will mimic these functions can be chosen. Other factors that should be considered when choosing a fat substitute system are cost, availability, safety, and quality. Hence, different fat replacements were used in the bakery products.

Garcíaa *et al* [6] used lipase enzymes, emulsifiers and inulin as fat replacers in the formulation of cake. Their findings demystify that cake samples containing emulsifiers had less density and more viscoelastic properties. Also, the samples containing lipase had the most texture softness during storage time. Furthermore, the results showed that in the presence of inulin, the microstructure of the internal part of the cake had been improved. Abozeid and *et al* [7] used microcrystalline, pectin, egg-white as fat replacers in the formulation of cakes and pastries. They found that the sample containing pectin, egg-whites had a structure similar to those of the control sample (without oil removal). Archilla L used Maltodextrin gel as a partial replacement for fat in a high-ratio white-layer cake formulation. The results showed that in batter specific gravity significantly decreased. Crust and crumb *L* and *b* values, indicated that a dark crust with a light crumb. Overall, no significant differences in water activity were found among treatments, in contrast, degree of staling significantly increased over time for all treatments.

In their study, Dilek et al [8] found that the use of poly dextrose as a fat replacer in the formulation of cake, not only reduced 22% of the final product calorie, but also it reduced the size of the air bubbles of the cake batter and distributed them homogenously in the texture of the product and the results suggested a harder texture, but with a crust similar to that of the control sample. Using tofu (cheese made from soy milk) in the formulation of low-fat cake, Power et al [9] stated that the texture hardness of the product considerably increased by replacing more than 50% of oil with tofu, and this led the panelists to reject the final product acceptability, particularly in terms of smell and taste. Moreover, Rafael et al [10] did a survey on the Chia flour (protein synthesis) as a fat replacer in cake formulations, and suggested that comparing to the control sample (without oil removal), by replacing 25% of the fat with Chia Flour, no change occurred in the color, taste, texture and overall acceptability of the produced samples. Size and porosity of the cake reduced and its texture hardness increased when we replaced more than 50 percent of the oil with this flour. Laura et al [11] examined the effects of hydroxypropyl methylcellulose and inulin on biscuit. The results revealed that only 15% of oil replacement in the formulation made the panelists to accept the sample taste. Having focused on the conducted studies in the field of fat replacements and the society growing demand for producing and introducing diverse dietetic products, researchers aimed at reducing 50 percent of the oil used in the formulation of muffin cake and reviewing its replacement with soy protein isolate (at three levels: zero, 10 and 20%), guar gum (zero, 0.15 or 0.30 percent) basil powder at three levels (zero, 1 or 2%) in a completely randomized design based on factorial porosity, color and textural properties of the product.

MATERIALS AND METHODS

Materials

Star Flour was purchased with extraction rate of 83 percent from flour Golmakan (Mashhad, Iran).The flour needed for the experiment was prepared and kept at 4 °C.

Other ingredients used in experiments were as follow:

sugar with the brand name of sweet sugar (Mashhad, Iran), invert syrup form Aryan Glucose Company (Tehran, Iran), liquid vegetable oil from Varamin Factory (Tehran, Iran), baking powder with the name of Shahsavan (Mashhad, Iran) which were purchased from a confectionery store. Tlavng (brand name) fresh eggs were prepared the day before producing the sample and were stored in the refrigerator (4 °C). Guar gum (brand MEYPROtm GUAR E412), lecithin emulsifier and vanilla (brand RHOVANILLA) from Rvdya Company (France), soy protein isolate from Soy Sun Company (Tehran, Iran) and basil seeds were purchased from the local market.

Methods

The physicochemical properties of wheat flour such as moisture, protein, ash, fat, wet gluten and Falling Number were measured based on AACC[1] standard procedures (2000). To prepare the basil powder, basil seeds were washed with water. Then, they were placed on a cabinet drying- tray and were dried at 60-55 °C and air flow of 1.5 - 2 meter per second for 5 hours. Immediately, the dried grains were converted into powder using Moulinex electric rubbing mill (AR1066Q) with high speed (220 rpm). In order to control the size of the granules, they were passed through a 100 mesh sieve.

Cake batter preparation and cake production

Cake batter basic formula (control) contains 100% wheat flour, 25% sugar, 25% oil, 36% eggs, 12% invert syrup, 2% baking powder and 0.2% vanilla and appropriate amount of water (60- 50% depending on the treatment). 50% of the oil contained in the low fat cake formulation (12.5 percent) was replaced with soy protein isolate at three levels: zero, 10 and 20%, guar gum at three levels: zero, 0.15 and 0.30 and basil powder at three levels: zero 1 and 2% (on the basis of wheat flour weight). It should be noted that in order to maintain the fatty acids in basil seeds, 1% Lecithin emulsifier was added to all cake samples. Generally, to prepare a cake, oil, sugar and eggs were mixed using an electric mixer (Electra EK-230M, Japan) at a speed of 128 rpm for 6 minutes to produce a cream containing air bubbles. Then, water, invert syrup, guar gum and basil powder were added into the cream and we mixed them for 4 minutes. Next, soy protein isolate, baking powder and vanilla were added into the flour and the obtained mixture was added into the cream gradually. Then, using funnel pitchers, 55 grams of the produced cake batter was poured into paper cases placed in the cake special molds. Then, baking process was performed using Karl Welkerkg electric oven (Germany) at 170 °C for 20 minutes. Following cooling process, each sample was packaged in polyethylene bags and stored at room temperature to evaluate its quantity and quality [12].

Physico-chemical tests on muffin cake

Evaluation of porosity

[1] American Association of Cereal Chemists

To assess the porosity rates, the images were processed using Image J software. By activating the 8-bit, gray level images were created. To convert gray images to binary images, the binary section of the software was activated. These images are combination of light and dark areas and calculation of the light to dark spots was considered as an index of the porosity of the samples. Obviously, there is direct correlation between this ratio and the rate of porosity. Finally, activating the Analysis section of the software, this ratio and porosity of the samples were measured [13, 14].

Evaluation of the color of the crust

Analysis of cake crust color was performed by determining the parameters L*, a*, b* and ΔE. L* is the luminance or lightness component, which ranges from 0 to 100, and parameters a* (from green to red) and b* (from blue to yellow) are the two chromatic components, which range from –120 to 120 [15, 16, 17]. Index ΔE shows rates of the color change in the sample in comparison with control which is obtained from equation 1 [19].

$$\Delta E=\sqrt{(L.-L)^2+(a.-a)^2+(b.-b)^2} \qquad \text{Equation 1}$$

To measure these indices, the prepared photographs were processed using Image J software. By activating the LAB space in Plug-ins, these components were calculated [18].

Texture evaluation

Cake texture was evaluated based on Ronda and colleagues [20] method using a texture meter at intervals of 2 hours and one week after baking. The maximum force required for a cylindrical probe to penetrate from the center of the cake with a flat end (2 cm diameter and 3.2 cm in height) at a speed of 30 millimetre (mm) per minute, was considered as the hardness index. It is worth noting that in order to achieve accurate internal texture hardness of the cake; the top part of it was removed with a knife. The trigger and the target points were 0.05 Newton and 30 mm, respectively. In fact, the hardness value was obtained in terms of force-deformation curve. In this case; the hardness was equal to the force-deformation curve maximum value, which was expressed based on the Newton (N).

Statistical Design and Results Analysis

The results of this research were examined using Mstat-c software, version 1.42 and also the factorial design with completely randomized three-factor arrangement. For this purpose, half of the oil in the muffin cake formulation (12.5 percent) was replaced with the three factors i.e. soy protein isolate (at levels of zero, 10 and 20%), guar gum (at three levels: zero, 0.15 and 0.30%) and basil powder (at three levels: zero, 1 or 2 percent). Each cake sample was prepared in three replicates. Means were compared by Using Duncan's test at a significance level of 0.95 percent (p<%05).

RESULTS AND DISCUSSION

Qualitative characteristics of wheat flour

Flour characteristics are shown in table 1.

Table 1. Qualitative characteristics of wheat flour

Qualitative characteristics	value
Moisture (percent)	13.6
Protein (percent)	10.3
Ash (percent)	0.64
Fat (percent)	3.25
Wet gluten (percent)	26.7
Falling number (s)	402

Porosity evaluation

According to the Table 2 results, the addition of soy protein isolate, guar gum and basil seeds powder into the formulation of low-fat muffin cake, it's porosity significantly increased at p <0.05. Overall, porosity is directly related to the number of gas cells and their homogenous distribution in the product texture [21]. As the results in Table 2 show, if simultaneous large amount of isolate soy protein, guar gum and basil seed powder be added into low-fat muffin cake formulation, it's porosity will be significantly reduced. Possibly, the reduction of the porosity in this case was due to the excessive increase of wall thickness of the gas cells preventing their expansion during the baking process. It is highly probable that distribution of more homogeneous of the gas bubbles in the batter containing basil seed powder is caused by the presence of fatty acids in the basil seeds. However, as the results show, the use of basil seed powder with 10% soy protein isolate is more suitable to increase the porosity. It seems that basil seed powder alone is not sufficient to replace the fat and 10% soy protein isolate played more significant role in gas retention. In this regard, Doxastakisa [22], Fleming and Sosulski [23] in their studies found that soybean increase retention of gas in the batter and its homogenous distribution in the final product and of course, too much

of it has negative effects on texture characteristics, especially in terms of stiffness, the volume and porosity. The results of this study indicated the above mentioned fact.

Table 2. Interaction of adding soy protein isolate, guar gum and basil powder at different levels on the texture hardness of the low-fat muffin cake within two hours and one week after baking

soy protein isolate (percent)	guar gum (percent)	basil powder (percent)	hardness(N)		porosity (percent)
			2 hours after baking	a week after baking	
0	0	0	10.87 ± 0.15 c	18.53 ± 0.15 a	14.37 ± 0.23 n
		1	10.33 ± 0.15 d	16.13 ± 0.21 c	14.77 ± 0.12 m
		2	9.20 ± 0.10 g	15.80 ± 0.10 d	15.54 ± 0.25 l
	0.15	0	9.50 ± 0.10 f	14.63 ± 0.15 f	16.47 ± 0.10 k
		1	8.73 ± 0.15 h	14.47 ± 0.21 f	16.50 ± 0.15 k
		2	7.70 ± 0.10 j	13.57 ± 0.15 h	17.53 ± 0.15 j
	0.30	0	7.63 ± 0.12 jk	12.60 ± 0.17 j	16.55 ± 0.15 k
		1	7.43 ± 0.06 k	12.10 ± 0.10 k	20.33 ± 0.21 g
		2	6.37 ± 0.12 m	11.27 ± 0.21 l	22.33 ± 0.21 f
10	0	0	6.97 ± 0.06 l	12.70 ± 0.20 j	23.67 ± 0.15 e
		1	5.07 ± 0.15 o	7.93 ± 0.15 o	26.57 ± 0.31 b
		2	4.45 ± 0.15 p	6.37 ± 0.15 q	28.33 ± 0.15 a
	0.15	0	5.03 ± 0.06 o	6.40 ± 0.17 q	26.20 ± 0.06 c
		1	5.63 ± 0.12 n	7.20 ± 0.10 p	26.37 ± 0.10 c
		2	6.40 ± 0.10 m	7.33 ± 0.15 p	24.77 ± 0.25 d
	0.30	0	6.30 ± 0.10 m	8.80 ± 0.10 n	24.77 ± 0.06 d
		1	7.17 ± 0.06 l	10.37 ± 0.15 m	22.40 ± 0.20 f
		2	8.13 ± 0.12 i	11.07 ± 0.15 l	19.10 ± 0.10 i
20	0	0	8.27 ± 0.12 i	13.07 ± 0.15 i	19.80 ± 0.15 h
		1	9.60 ± 0.10 f	13.30 ± 0.20 hi	16.50 ± 0.21 k
		2	10.37 ± 0.15 d	13.93 ± 0.15 g	15.57 ± 0.21 l
	0.15	0	9.90 ± 0.10 e	14.03 ± 0.21 g	15.51 ± 0.15 l
		1	10.83 ± 0.15 c	15.50 ± 0.10 e	14.33 ± 0.15 n
		2	12.27 ± 0.21 b	15.60 ± 0.17 de	13.43 ± 0.15 o
	0.30	0	10.90 ± 0.10 c	15.87 ± 0.15 cd	11.90 ± 0.10 p
		1	12.37 ± 0.15 b	17.37 ± 0.15 b	11.87 ± 0.25 p
		2	13.67 ± 0.15 a	17.50 ± 0.25 b	10.10 ± 0.12 q

Statistically, similar letters has no significant difference at P <0.05

Table 3, The Interaction of adding soy protein isolate, guar gum and basil seeds powder at different levels (as a substitute half of the oil in the formulation) on the color components and color changes of the low-fat muffin cake crust

isolated Soy Protein (percent)	guar gum (percent)	basil powder (percent)	color of surface			
			L*	a*	b*^{ns}	ΔE
0	0	0	44.44 ± 1.05 e	5.18 ± 0.06 i	23.59 ± 0.14	0 p
		1	46.60 ± 0.39 d	5.57 ± 0.05 h	23.60 ± 0.36	2.19 ± 0.04 f
		2	48.63 ± 0.54 c	5.89 ± 0.03 g	23.60 ± 0.41	4.25 ± 0.07 h
	0.15	0	49.61 ± 1.01 c	5.19 ± 0.01 i	23.60 ± 0.54	5.18 ± 0.06 a
		1	51.04 ± 0.09 b	5.54 ± 0.07 h	23.71 ± 0.12	6.61 ± 0.03 b
		2	53.06 ± 0.16 a	5.92 ± 0.03 g	23.59 ± 0.51	8.65 ± 0.04 c
	0.30	0	49.74 ± 0.72 c	5.18 ± 0.04 i	23.63 ± 0.95	5.30 ± 0.08 ail
		1	51.08 ± 0.04 b	5.55 ± 0.04 h	23.59 ± 0.05	6.65 ± 0.03 b
		2	53.12 ± 0.09 a	5.92 ± 0.05 g	23.62 ± 0.55	8.71 ± 0.01 c
10	0	0	44.46 ± 0.39 e	6.19 ± 0.06 f	23.58 ± 0.63	1.01 ± 0.07 d
		1	46.55 ± 0.41 d	6.51 ± 0.03 e	23.60 ± 0.73	2.49 ± 0.09 e
		2	48.64 ± 0.59 c	6.69 ± 0.04 d	23.65 ± 0.53	4.46 ± 0.06 g
	0.15	0	49.63 ± 1.20 c	6.19 ± 0.01 f	23.67 ± 0.70	5.29 ± 0.03 ail
		1	50.98 ± 0.08 b	6.54 ± 0.04 e	23.62 ± 0.84	6.68 ± 0.04 b
		2	53.02 ± 0.10 a	6.95 ± 0.04 d	23.54 ± 0.84	8.76 ± 0.08 c
	0.30	0	49.75 ± 0.57 c	6.18 ± 0.02 f	23.47 ± 0.15	5.40 ± 0.02 i
		1	51.11 ± 0.28 b	6.53 ± 0.04 e	23.68 ± 0.42	6.81 ± 0.04 bm
		2	53.13 ± 0.16 a	6.96 ± 0.06 d	23.63 ± 0.57	8.87 ± 0.03 c
20	0	0	44.36 ± 1.17 e	7.11 ± 0.03 c	23.57 ± 0.87	1.93 ± 0.06 j
		1	46.53 ± 0.44 d	7.61 ± 0.04 b	23.68 ± 0.69	3.21 ± 0.05 k
		2	48.71 ± 0.58 c	7.99 ± 0.07 a	23.67 ± 0.39	5.11 ± 0.04 al
	0.15	0	49.66 ± 1.13 c	7.12 ± 0.06 c	23.58 ± 0.63	5.57 ± 0.07 i
		1	50.98 ± 0.12 b	7.60 ± 0.04 b	23.61 ± 1.22	6.97 ± 0.02 m
		2	53.03 ± 0.02 a	8.01 ± 0.01 a	23.63 ± 0.89	9.04 ± 0.09 n
	0.30	0	49.75 ± 0.54 c	7.08 ± 0.03 c	23.68 ± 0.49	5.64 ± 0.08 i
		1	51.12 ± 0.08 b	7.62 ± 0.04 b	23.41 ± 0.44	7.11 ± 0.06 o
		2	53.12 ± 0.23 a	7.99 ± 0.02 a	23.64 ± 0.79	9.20 ± 0.07 n

(Similar letters differences in each column are not statistically significant at p <0.05)

Crust Color (L*, a*, b* and ΔE)

Table 3 shows the effect of soy protein isolate, guar gum and basil seed powder on the content of L*, a*, b* and ΔE of the produced samples. As the results show, the addition of soy protein isolate into the low-fat cake formulation, no significant differences was observed at the level of $p < 0.05$ between the components of L* of the produced samples. On the other hand, the addition of guar gum and basil seed powder into low-fat cake formulation increased the content of this component significantly. It seems that ability of guar gum and mucilage produced from basil seed powder in keeping moisture helps a smooth surface being made on the product and the surface itself has influenced on the light reflection and brightness increase positively. In this regard Purlis and Salvadori [24] stated that the changes in nutrient levels are responsible for its brightness and smooth surfaces are more capable in reflecting light and an increase in L* component than wrinkled ones. Also, with the addition of gum into the formulations of bread containing rice flour and corn starch, Lazaridou et al [25] found that using gum into pasty products increased brightness of the crust. According to Table 3, with the addition of soy protein isolate and basil seed powder into the formulations of low-fat muffin cake, the content of component a* significantly increases at $p < 0.05$. The results also showed that the addition of guar gum into the formulation produced no significant difference at level $p < 0.05$. It is more likely that the increase in the amount of the component a* in samples containing soy protein isolate is due to better implementation of the Millard Reaction. In this regard, Ronda et al [25] stated that the use of soy protein isolate in the cake batter made the color of the final product darker. On the other hand, it seems that an increase in this component in the presence of the basil seed powder, originates from the seed coat color. Also according to Table 3, with the addition of soy protein isolate, guar gum and basil seed powder into the formulation, no significant differences were observed in the component b* of these produced samples. According to Table 3, with the addition of soy protein isolate, guar gum basil seed powder into the low-fat muffin cake formulation, the content of component ΔE significantly increased. Since, based upon the equation 1, the ΔE is an outcome of each three components L*, a*, b*, so it is natural that even with the increase of any of the above mentioned components, the content of the ΔE will increase, too.

Texture hardness within two hours and one week after baking

Results of the interaction of the soy protein isolate, guar gum and basil powder on the hardness of the cake texture within two hours and one week after baking in Table 3, clearly indicated that the sample containing 20% soy protein isolate,3% guar gum,2% basil powder and the sample containing 10% soy protein isolate, 2% basil powder had the most and the least texture hardness, respectively.

By looking at the texture hardness within one week after baking, it seems that 20% soy protein isolate and 3% guar gum contents weren't as effective as 10% soy protein isolate and 15% guar gum contents in decreasing texture hardness, although, independently they produced less hard texture than the control sample. It is most likely affected by the complete formation of the gluten network and texture hardening of the final product after baking. This means the lack of fat in the control formulation (the sample with 50% less oil than the basic formulations) was replaced with a portion of the soy protein isolate or guar gum and then the remaining protein and gum helped strengthening the gluten network. Consequently, it played an important role in thickening of the air bubbles of the cake batter and the texture compression. It was expected that the sample contains 20% protein, 0.30% guar gum and 2% basil powder, due to the highest strength of the gluten network, has the highest degree of texture hardness, even more than the control sample (sample where there is no fat replacer). On the other hand, besides using a suitable fat replacer in low-fat muffin cake formulation, we should adopt appropriate measures to prevent the loss of moisture in bakery products because the fat contained in these types of food plays important role in retaining moisture and preventing it from going out during the baking time [26]. As it was observed, compared to the control sample, the compounds used in this study (soy protein isolate, guar gum and basil powder), as fat replacers, all retained the water absorption nature of the cake batter and the ability to increase moisture. Surely, it can be said that, in the present study, all the produced samples had a better texture than the control sample within one week after baking. In fact, the selected fat replacers in low fat muffin cake played a positive and effective role in reducing the staling process. Finally, it should be noted that Bent et al [27] and Ashwini et al [28] made similar reports regarding the role of hydrocolloids as an emollient and anti-staling factors in cake

CONCLUSION

The results showed that among produced samples, the sample containing 10% soy protein isolate and 2% basil powder had the least texture hardness within two hours and one week after baking and the most porosity among the produced samples. As well, The results showed that the content of the component L* will increase with the addition of guar gum and basil seed powder and the amount of component a* will

rise with the addition of soy protein isolate and basil seed powder into the formulation of the muffin cake. Also, with the addition of the soy protein isolate, guar gum and basil seed powder, the content of the component ΔE increases.

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