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Optimization of cupcake formulation by replacement of wheat flour with different levels of eggplant fiber using response surface methodology

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Abstract

This study aimed to design and produce optimal formula of cupcakes containing eggplant fiber by surface response methodology (RSM). The wheat flour replaced with eggplant fiber in five levels, 0-40%, whole-egg and sugar were set at the same time, 55-75% and 70-90% based on (wheat-flour + eggplant-fiber) weight, respectively. Considering the most important textural properties (hardness, cohesiveness, springiness, gumminess and chewiness), density, weight, and also by mean comparisons with Duncan's test at the level of 5% significance, optimal formulas include: formula (a) (12% eggplant-fiber, 71% whole-egg, 70% sugar) and formula (b): (8% eggplant-fiber, 57% whole-egg, 70% sugar) were appropriately suggested. Chemical properties of the optimal formulas including, protein, fat, carbohydrate, moisture, insoluble ash in acid and calorie were calculated and compared with the blank. Using of the eggplant-fiber in cupcake formulation caused calorie reduction and increased its nutritional value. Formula (b), in terms of many factors, demonstrated similarity to the blank. The eggplant-fiber had an impact on all of the textural properties except springiness. The impacts of whole-egg content on springiness, chewiness and density are also remarkable. Sugar content will be shown in weight differences and is expressed as one of the most effective variables on sample weight.

Keywords: dietary cupcakes; eggplant fiber; response surface methodology; physio-chemical properties.

Practical Application: Response surface methodology suggested two optimal-formulas (a) and (b). Formula (a) (12% fiber-70% sugar-71% egg) and formula (b): (8% fiber -70% sugar - 57% egg) were appropriately suggested. Eggplant fiber decreased the cupcake calorie and carbohydrate, whereas increased its acid insoluble ash, protein, fat and moisture values. The eggplant fiber has an impact on all of the textural properties except springiness. The impacts of egg content on springiness, chewiness and density are also remarkable. Sugar content will be shown in weight differences and is expressed as one of the most effective variables on sample weight.

1 Introduction

Since increasing people's awareness about diet and health, there have been many changes that occurred in consumer dietary habits which have increased the demands for producing healthier foods. Fiber has been one of the first functional compounds since the 1980s (Crizel et al., 2013) and dietary fiber consumption not only is an effective way to prevent cardiovascular diseases, but it can also be used in a variety of foods such as muffins, soups, beverages, confectioneries and snacks. Dietary fiber is a food composition that is not digested and absorbed in the human intestine and digestive system. Hence, the production of new products with some fiber replacements, have become the strategic fields (Romero-Lopez et al., 2011). Moreover, it has a great ability to bond various components such as cholesterol, so that increased consumption of fiber-enriched foods can be part of the strategy to reduce the risk of cardiovascular diseases (Jenkins et al., 1998). Considering the high level of sugar in cakes, to enhance the product's nutritional value, and at the same time their taste, different dried additives have been used, leading to redesigning the formulations of traditional foods (Frye & Setser, 1992). Fruits such as orange, apple and peach have some by-products in the juice extraction process that are recycled as highly rich compounds. Besides, various vegetables such as carrot, potato, green pea, pepper, artichoke, onion, asparagus and eggplant contain wastes such as soluble and insoluble fiber compounds during processing that can be used in the formulation of new functional foods (Sharoba et al., 2013). Eggplant is a rich source of vitamins and minerals, holding nutritional values nearly similar to a tomato. The fresh fruit consists of 96.2% water, 1.9% fiber, 1.9% calorie and vitamins with the following ratios: 5 µg vitamin A (Retinol), 60 µg vitamin B_1 (Thiamine), 45 µg Vitamin B_2 (Riboflavin), 0.6 µg of vitamins B_3 (Niacin) and 1.2 mg of vitamin C (ascorbic acid). In the early twentieth century, it was proved that eggplants are effective in treating high cholesterol problems, thanks to the dietary fiber content of eggplants. (Osidacz & Ambrosio-Ugri, 2013). Anthocyanins are found in many grains, fruits and vegetables with red skins. nasunin, which is the anthocyanin of eggplant, prevents the peroxidation which is caused by Linoleic acid- Lipoxygenase. Based on this phenomenon, the free radicals' inhibitory activity by nasunin, which is much stronger than laboratory anthocyanins, is investigated. Inhibitory effects of nasunin against superoxide anion radicals and hydroxyl radicals have been studied by the rotational resonance electron spectroscopy (ESR). The effects of natural antioxidant in the purple skin of eggplant (nasunin)

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resulted in the prevention of fat peroxidation in rat's plasma brain (Noda et al., 2000). Partial incorporation of eggplant fiber powder in the wheat flour formulations of bakery products improves product quality and nutritional value (Uthumporn et al., 2014). In 2014, Pinto dos Santos et al. (2014) stated that powdered fruits and vegetables, such as eggplant, banana, passion fruit and grape can bring some functional features as replacing with wheat flour to produce loaves of bread, cakes and pasta products.

2 Materials and methods

To formulate a cupcake, raw materials such as pastry flour, oil, sugar, full-fat milk, whole egg, vanilla, Tiara brand baking powder (contains sodium bicarbonate, sodium pyrophosphate and mono-calcium phosphate) and greenhouse eggplant (bought from a local market) need to be provided. The original formulation includes 100 grams of wheat flour, 65 grams whole-egg, 90 grams of sugar, 50 grams of oil, 65 grams milk, 1.11 grams of sodium bicarbonate, 0.2-gram vanilla, 1.35 grams sodium pyrophosphate and 0.2 grams of mono-calcium phosphate (Mirani & Goli, 2021).

2.1 Cupcake preparation

At first, oil and sugar were poured into a mixer and blended for 10 minutes at a speed of 4 (180 rounds per minute) to reach a creamy state. Secondly, eggs (whole-egg) were added to the mixture and stirred for six minutes at a speed of 4. Next, vanilla was added and mixed at a rate of 4 for about one minute. Milk and mixed wheat flour (with fiber source) were added and mixed at a speed of 2 for four minutes. 50 g of cake batter was poured into aluminum molds (height of 45 mm and a diameter of 55 mm). Cooking was done at 180 °C in an experimental batch with air circulation for 30 minutes. After baking, cakes were removed from the molds and cooled at room temperature for one hour and were kept in containers with plastic lids until the experiments were carried out (approximately 12 to 24 hours before performing tests) (Lebesi & Tzia, 2011). It should be noted that in all treatments, which also covered the blank, the percentage of the raw materials including milk, oil or shortening, vanilla and baking powder was kept constant and changes were made only to whole-egg, sugar and wheat flour percentages.

2.2 Eggplant fiber preparation

These steps were carried out according to Uthumporn et al. method in 2015. First, greenhouse eggplants were sourced from a local store. Fresh eggplants were rinsed to exclude undesirable dirt and contaminant if any. Then eggplants with their skin were cut into thin slices and submerged in brine (15% for 10 to 20 minutes) to remove bitterness. The thin slices were dried in an oven at 40 °C for 72 hours and then milled. The milled eggplants were passed through a sieve with meshes of 250 and 500 micrometers and were packed into propylene plastic air-impermeable bags. Samples were kept in a refrigerator at 4 °C till they were used (Mirani & Goli, 2021).

2.3 Experimental design and statistical analysis

RSM is a series of statistical techniques used to optimize processes. Results are affected by several variables (Table 1). This statistical design helps reduce the number of experiments and estimate all quadratic regression model coefficients and the interactional effects of the factors. The most important aim of this research is to study the main and mutual effects of factors, necessitating, therefore, the use of, the response surface method (Jalalizand & Goli, 2020; Bing et al., 2019; Atkinson & Donev, 1992).

This plan includes a set of statistical and mathematical techniques making it possible to achieve an optimal condition in complicated systems. By using the regression analysis function, indicators measured in the form of a second-order polynomial are modeled according to Equation 1 and Table 1:

$$Y = \beta_0 + \beta_1 A + \beta_2 B + \beta_3 C + \beta_{11} A_2 + \beta_{22} B_2 + \beta_{33} C_2 + \beta_{12} AB + \beta_{13} AC + \beta_{23} BC \quad (1)$$

In this equation, Y is the predicted response, β_0 is the constant-coefficient and β_1, β_2 and β_3 are linear effects. β_{11}, β_{22} and β_{33} are the squares. β_{13}, β_{12} and β_{23} are factor interactions. (A) is the amount of eggplant fiber, (B) equals whole-egg content and (C) is the sugar content based on the wheat flour weight. Mean properties values of the cake such as density, weight and texture are considered as dependent variables or responses (Y). To obtain experimental models for predicting responses, linear relationships and a quadratic polynomial were written based on data obtained from experiments. Subsequently, these models were analyzed statistically to select an appropriate model. From the statistical point of view, a good model is one that has the highest value of R^2 (Maghamian et al., 2021; Sazesh & Goli, 2020; Zaghian & Goli, 2020). After formulation and production of treatments, as it is shown in Table 1 based on three factors (A: the percentage of replacing wheat flour with eggplant fiber; from 0 to 40%) (B: whole-egg content based on wheat flour weight + eggplant fiber; from 55 to 75 grams) and (C: sugar content based on wheat flour weight + eggplant fiber; from 70 to 90 grams), and by performing texture analyzing and density tests and comparing these properties with the blank (Table 2), optimal formulas were determined by using Design-Expert software is based on RSM statistical design. Their chemical properties include protein, fat, carbohydrate and insoluble ash in acid; besides moisture and caloric contents are also calculated. Mean comparison results with Duncan's test, at a significant level of 5% were done and finally, two optimal formulas (formula (a) contain: 12% eggplant fiber, 71% whole-egg - 70% sugar and formula (b): 8% eggplant fiber - 57% whole-egg - 70% sugar) were determined. Designed treatments are listed in Table 1.

2.4 Physicochemical properties of the cupcake with eggplant fiber

Density measurement of cupcakes

To determine the density of cupcakes, the rapeseed movement method according to the American Association of Cereal Chemists (1995) standard was applied (Parsaei et al., 2018; Sazesh & Goli, 2020).

Table 1. Un-coded and coded level of the independent variables in flour, whole-egg and sugar levels, and physical and textural properties of cupcakes with regression equations between textural properties, density, weight and coded factors.

Range	-1	0	+1
Replacing flour with eggplant fiber (%)	0	20	40
Whole-egg (% based on wheat flour + eggplant fiber weight)	55	65	75
Sugar (% based on wheat flour + eggplant fiber weight)	70	80	90

Treatment	Replicate	Replacing eggplant fiber (% based on wheat flour weight)	Whole-gg (% based on wheat flour weight)	Sugar (% based on wheat flour weight)	Hardness (N)	Cohesiveness	Springiness	Gumminess (N)	Chewiness (N)	Density (g/cm^3)	Weight (g)
1	2	0	75	70	1.90 ± 0.06	0.79 ± 0.00	0.91 ± 0.00	1.51 ± 0.19	1.37 ± 0.18	0.37 ± 0.01	23.46 ± 0.11
2	2	0	65	80	4.95 ± 0.12	0.54 ± 0.00	0.88 ± 0.00	2.70 ± 0.01	2.40 ± 0.01	0.42 ± 0.00	30.51 ± 3.86
3	2	0	55	70	2.10 ± 0.25	0.69 ± 0.00	0.80 ± 0.00	1.42 ± 0.03	1.15 ± 0.21	0.34 ± 0.00	23.44 ± 0.41
4	2	0	75	90	4.00 ± 0.49	0.67 ± 0.00	0.89 ± 0.00	2.66 ± 0.12	2.36 ± 0.06	0.20 ± 0.00	25.34 ± 0.00
5	2	0	55	90	4.35 ± 0.06	0.69 ± 0.00	0.81 ± 0.00	3.04 ± 0.10	2.47 ± 0.05	0.36 ± 0.00	24.35± 0.58
*6	*4	*20	*65	*80	3.75 ± 0.07	0.67 ± 0.00	0.85 ± 0.00	2.53 ± 0.05	2.18 ± 0.05	0.51 ± 0.00	31.10 ± 8.62
7	2	20	55	80	5.30 ± 0.25	0.63 ± 0.00	0.81 ± 0.00	3.37 ± 0.04	2.75 ± 0.01	0.48 ± 0.00	31.1 ± 0.19
8	2	20	65	90	2.90 ± 0.01	0.75 ± 0.00	0.90 ± 0.00	2.19 ± 0.04	1.98 ± 0.59	0.76 ± 0.00	33.36 ± 0.04
9	2	20	65	70	2.65 ± 0.12	0.71 ± 0.00	0.87 ± 0.00	1.90 ± 0.08	1.67 ± 0.06	0.43 ± 0.00	33.19 ± 0.17
10	2	20	75	80	4.00 ± 0. 40	0.61 ± 0.00	0.85 ± 0.00	2.64 ± 0.03	2.10 ± 0.02	0.46 ± 0.00	32.02 ± 4.30
11	2	40	65	80	6.25 ± 0.00	0.67 ± 0.00	0.96 ± 0.00	4.23 ± 0.00	4.08 ± 0.10	0.40 ± 0.00	30.98 ± 2.90
12	2	40	55	90	9.70 ± 0.16	0.54 ± 0.00	0.96 ± 0.00	5.32 ± 0.03	4.08 ± 0.06	0.58 ± 0.00	34.72 ± 1.40
13	2	40	55	70	12.10 ± 0.04	0.58 ± 0.00	0.79 ± 0.00	7.12 ± 0.09	5.68 ± 0.09	0.58 ± 0.00	30.34 ± 0.05
14	2	40	75	90	11.55 ± 0.02	0.65 ± 0.00	0.83 ± 0.00	7.51 ± 0.01	6.26 ± 0.03	0.57 ± 0.00	36.55 ± 13.32
15	2	40	75	70	28.70 ± 0.04	0.42 ± 0.00	0.77 ± 0.00	12.17 ± 0.00	9.48 ± 0.00	1.38 ± 0.05	30.10 ± 3.66

The final equation based on coded factors	R^2
Hardness (N) = $3.19 + 0.65(A) - 0.065(B) + 0.5(AB) - 1.11(AC) + 2.57(A^2) + 1.62(B^2) + 1.01(A^2B) + 3.69(AB^2)$	0.98
Cohesiveness = $0.67 + 0.065(A) + 0.029(AC) - 0.055(A^2) - 0.04(B^2) + 0.069(C^2) + 0.039(ABC) - 0.14(AB^2)$	0.72
Springiness = $1.43 - 0.22(B) + 0.3(B^2)$	0.60
Gumminess (N) = $2.19 + 0.76(A) - 0.46(B) + 0.53(AB) - 0.74(AC) + 1.5(A^2) + 0.95(B^2) + 0.91(A^2B) + 1.76(AB^2)$	0.97
Chewiness (N) = $2.15 + 0.84(A) + 0.56(BC) + 1.15(A^2) + 0.64(ABC) + 0.49(A^2C) + 0.63(AB^2)$	0.95
Density (g/cm^3) = $0.5 - 0.06(A^2) + 0.13(AB^2)$	0.65
Weight (g) = $31.99 + 3.71(A) + 1.23(C) - 2.85(A^2)$	0.64

Results are reported as mean ± standard deviation, *Means the central point with 4 replications. A: Replacing flour with eggplant fiber (0 to 40%), B: Whole-egg (55 to 75% based on wheat flour + eggplant fiber weight) and C: Sugar (70 to 90% based on wheat flour + eggplant fiber weight).

Table 2. The limitations utilized for optimization, data validation (actual and predicted) and chemical properties measurements of optimal formulas and blank.

Name	Upper Goal	Lower Limit	Upper Limit	Weight	Importance
Replacing wheat flour with eggplant fiber (%)	is in range	0	40	1	3
Whole-egg (% based on wheat flour + eggplant fiber weight)	is in range	55	75	1	3
sugar (% based on wheat flour + eggplant fiber weight)	is in range	70	90	1	3
Hardness (N)	is target = 1.6	1.6	12.3	1	3
Cohesiveness	is target = 0.652	0.507	0.801	1	3
Springiness	is target = 0.813	0.746	1.036	1	3
Gumminess (N)	minimize	1.228	7.631	1	3
Chewiness (N)	minimize	1.006	6.443	1	3
Density (g: cm3)	is target = 0.288	0.2	0.678	1	3
weight (g)	is target = 30.38	22.8	40.2	1	3

Means in the same block with different letters chemical properties are significantly different according to ANOVA at a significance level of 0.05, Each property was calculated at three repetition.

Textural properties of the cupcake

To examine the cake texture, the STM-20 texture profile analyzer device from the SANTAM machine manufacturer was utilized. Tests were carried out twelve hours after baking. Samples were cut into a cylindrical shape (diameter of 2.5 cm and a height of 4.5 cm) using a metal cylindrical mold and compressed twice in a cycle by using a texture analyzer instrument to the half of their initial heights (up to 50% almost 15 mm). The measurements were carried out during two cycles between flat plates by a probe with a diameter of 40 mm, 1256 mm surface area and speed of 1 mm/s. The main textural properties were hardness, cohesiveness, springiness, gumminess and chewiness. Hardness defines as the maximum force required to compress the samples, represented by p_1 (maximum height in the first cycle of the graph), and cohesiveness calculated from the ratio of the underneath area of the first compression graph relative to the second one. Springiness is the ability of samples to return to their initial shape after the elimination of applied force. Gumminess resulted from the multiplication of hardness and cohesiveness, and the amount of chewiness is also expressed as gumminess multiplied by springiness (Mirani & Goli, 2021; Zonoubi & Goli, 2020).

Chemical analysis

The cakes prepared from different mixtures of wheat flour and eggplant fiber were analyzed for moisture (method 14.004), total ash (method 14.006), crude protein—N x 6.25 (method 2.057), and crude fat (method 7.062) according to Association of Official Analytical Chemists (1984) procedures. Total titratable acidity (TTA) and pH were determined according to Association of Official Analytical Chemists (1990). Carbohydrate was determined using the method reported by Osborne & Voogt (1978). In fifteen initial treatments, parameters such as density, weight, and textural properties (hardness, cohesiveness, springiness, gumminess, chewiness) were measured, and results were reported in Table 1.

3 Results and discussion

3.1 Effects of eggplant fiber, whole-egg, and sugar on the textural properties and density of cupcakes

According to Figure 1A and 1B, it can be seen that the amount of sugar does not have much effect on the hardness as its increase caused no significant changes in observations. Nonetheless, an increase in sugar and fiber content simultaneously, led to a linear increase in hardness so the hardest sample was observed in the highest fiber and sugar content. Sugar is one of the main ingredients in the cake that helps to a better combination of air bubbles during the cake batter creaming and creates a desirable granule texture and final flavor and texture in the product. Sugar also helps retain moisture and a desirable cake crust color, prolongs the shelf life and preserves its freshness, so a reduction in the levels of sugar may affect the sensory and textural properties (Manisha et al., 2012).

In addition, sugar can limit the available water for starch granules and reduce water activity, or raise the temperature during the protein denaturation process, which generates a harder inner texture in the cakes. Generally, sugar reacts with gluten and contributes to the brittleness of the cake texture. It is worth mentioning that the effects of sugar levels on starch gelatinization are more considerable than egg denaturation. By increasing the amount of fiber, hardness significantly increases due to the loss of fiber ability in absorbing water at high levels and also reducing the number of gaseous cells in the cake texture. Therefore, it can be concluded that a rise in the amount of fiber more than a specific level, instead of reduction, causes an increase in the cake hardness. Eggplant fiber samples were harder than blank as higher levels of eggplant fiber, influenced cohesion and air bubbles holding the ability of gluten, led to a reduction of air bubbles volume inside the cake, and made its texture harder. Based on the results, at a lower fiber content and a higher level of whole-egg, at first, hardness increased, then decreased. Hardness reduction in more egg quantities is attributed to the fact that because of the high moisture in egg, the cake texture would be kept moist. According to Sharoba et al.

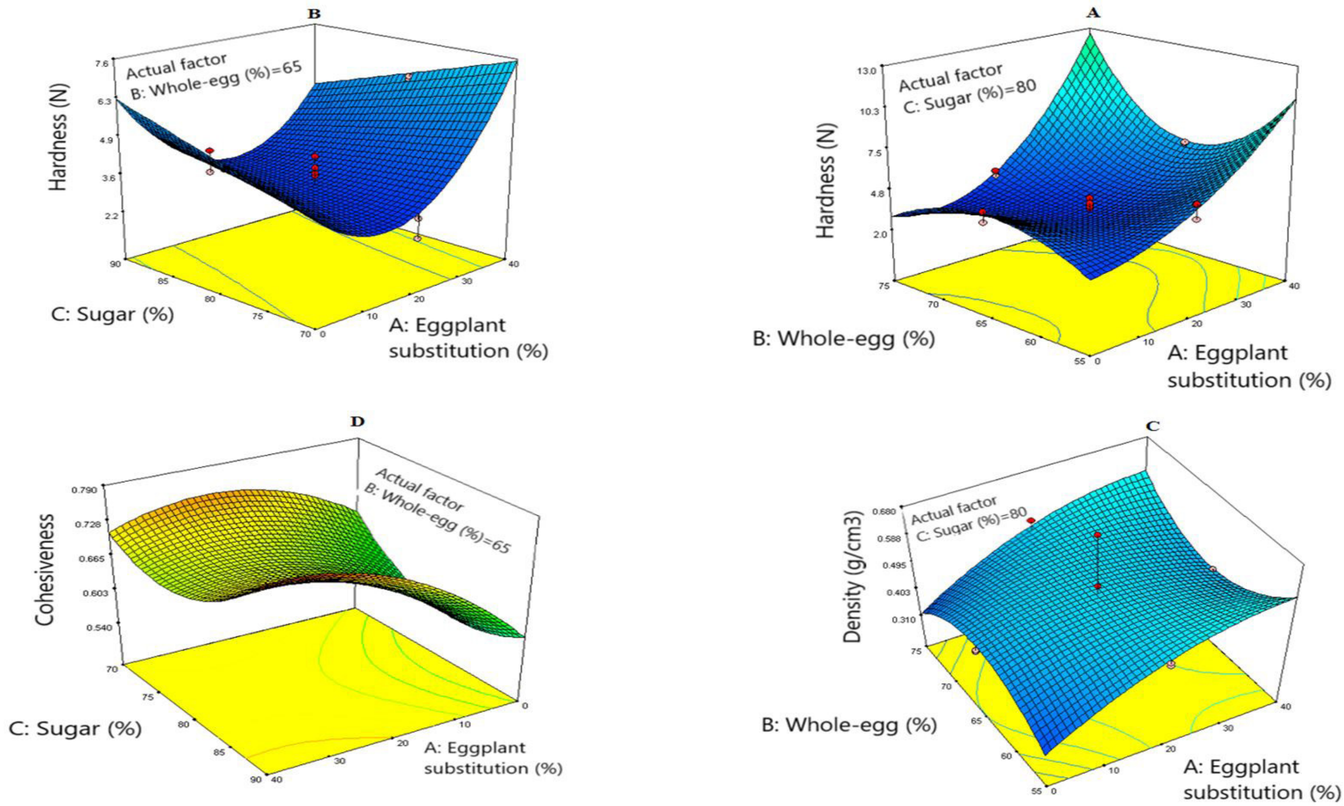

Figure 1. Effects of the replacement of wheat flour with eggplant fiber (%), whole-egg (%), and sugar (%) on hardness (N) [A & B], density (g/cm^3) [C], and cohesiveness [D].

(2013), chemical reactions between fiber, starch, oil, and protein affect starch retrogradation. The reaction between fiber, starch swollen granules and protein networks, causes texture hardness. Therefore, the hardest sample is the one with the highest fiber and whole-egg content.

As shown in Figure 1C, in the constant amounts of sugar, similar effects in sample densities were observed, as the amounts of whole-egg and fiber changed. The egg can hold air bubbles during stirring, which increases volume and decreases density. Besides, according to Guarda et al. (2004), the presence of fiber resources in the formulation also improves the aqueous and gaseous distribution of the molecules that eventually increases the number of gaseous bubbles and volume, and make the cake to be less dens. As seen in Figure 1C, the highest density is related to the sample which has higher levels of fiber and whole-egg. Higher densities in eggplant fiber-enriched cakes are due to the partial dilution of gluten in the cake batter and its negative effect on the gluten network cohesiveness. This phenomenon causes a loss in cake dough air bubbles, ultimately, reduces the cake's final volume and increases its density. Besides, the presence of fiber causes faster absorption of water and starch, and starch does not have enough water to gelatinize so a reduction in product volume happens.

According to Figure 1D in higher levels of sugar, by a decrease in the fiber of formulation, cohesiveness rose. The reaction occurred between fiber and some components such as starch or protein, caused an improvement in cohesiveness and fiber-enriched foods' sensory properties. Thus, it can be stated that the most effective factor in cake cohesiveness, is the amount of fiber. In this study, no significant difference was observed in the cohesiveness of fiber-enriched samples compared to the blank ones. This means that due to a complex system that existed in the cake texture, all three variables can interact with each other and have their impacts on the cake cohesiveness. According to Figure 2A and 2B, the gummiest cake is one with the highest amounts of fiber and whole-egg. In lower levels of fiber, by a gradual rise in the whole-egg content, the gumminess parameter experienced a fluctuation of increase and decrease, respectively. As the replacement's percentage of wheat flour with eggplant fiber rises, the relative proportion of gluten in wheat flour that is responsible for the cake starch retrogradation, decreases which subsequently, might affect both hardness and gumminess parameters. It can be observed that, when a cake had lower fiber and higher sugar or experienced an increase in both sugar and fiber levels, gumminess increased. Therefore, it can be concluded that the only effective variable that has an impact on gumminess, as well as hardness, is the amount of formulation fiber, and the level of sugar, appears to not affect the gumminess parameter.

As shown in Figure 2C, 2D and 2F, the chewiest cake is that sample with the highest fiber and lowest whole-egg levels, however, in 90% of sugar, the trend is quite different and the highest chewiness is assigned to the sample containing the higher amounts of both fiber and whole-egg. Similar results were observed, during the evaluation of fiber-sugar interactions. According to the results, as mentioned beforehand, because of

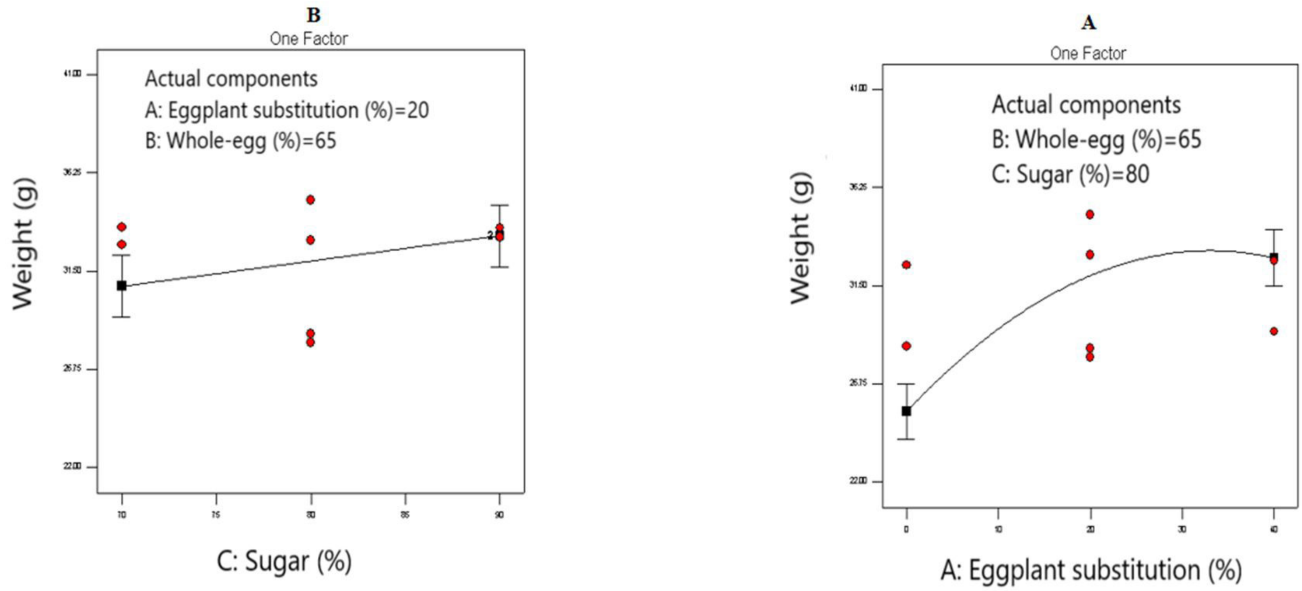

Figure 2. Effects of the replacement of wheat flour with eggplant fiber (%), whole-egg (%), and sugar (%) on gumminess (N) [A & B], chewiness (N) [C, D, F], and springiness [E].

the cake's complicated texture, it cannot be found which factor has more impact on the chewiness parameter. Both gumminess and chewiness changes, are followed by some changes occurred in hardness and cohesiveness parameters. It is worth to be mentioned that the amount of fiber as a hardening and gumming factor along with whole-egg as a springing factor affect the chewiness more significantly than the sugar amounts in the cake formulation do.

According to Figure 2E, by a gradual increase in whole-egg content and at 70 percent and above, initially, cake springiness increased then decreased. It is proven that eggs have some specific abilities such as gelatinizing, foaming, emulsifying, and coagulating, hence the only effective factor on springiness parameter, can be the amount of whole-egg. Large quantities of coagulated egg white proteins produce foam and air bubbles during the batter preparation, which bring a well-structured and stable sponge cake after baking. Besides, considerable amounts of moisture in the egg, lead to a cake softness retention during its shelf life.

3.2 Effect of eggplant fiber, whole-egg, and sugar on the weight of cupcakes

According to Figure 3A and 3B, it is observed that, at higher levels of fiber in constant amounts of sugar and whole-egg, sample weights at first, gradually increased, secondly, relatively remained unchanged and finally slightly decreased. Based on this observation, it has been proven that, by an increase in the amounts of fiber, a decrease in the number of gaseous cells would occur which reduces the cake overall volume and increases its weight. As figures shown, when the amounts of fiber and whole-egg were at a certain level, by increasing sugar content, weight increased linearly. In total, it can be said that the amounts of fiber and sugar have a greater effect on weight than the whole-egg level variable.

3.3 Chemical analysis of optimal formulas in comparison with the blank

Chemical analysis of optimal formulas and blank are given in Table 3. According to the results, the optimal formulas significantly had higher moisture and fat than the blank, which could be due to the fiber ability in holding water and oil. The presence of free hydroxyl groups of cellulose in fiber, make it capable of creating a hydrogen bonding with free water molecules, leading to better water holding capacity. According to Uthumporn et al. (2014), optimal formulas contained fewer carbohydrates than blank because of fiber ability in energy reduction. It was also found that the percentages of protein and insoluble ash in acid in optimal formulas, were higher than blank that might be attributed to the presence of various minerals such as calcium, magnesium, phosphorus, sodium, and potassium in ashes contained eggplant fiber, which might have similar components with fresh eggplant fruit. In addition, based on Kim et al. (2012) findings, when the wheat flour was replaced with 0 - 9 grams of fig powder in the sponge cake formulation for enrichment purposes, the calorie content and the crumb color of the cake (L and a parameters) decreased as well.

4 Conclusion

This study aimed to optimize the cupcake formulation by replacing the wheat flour with eggplant fiber (in five levels from 0 to 40%), which enhanced the cake nutritional value. Meanwhile, after the determination of optimal formulas, calorie, and cholesterol (whole-egg amounts in the formulation) values were reduced. In this research, apart from the substitution of wheat flour with eggplant fiber, whole-egg and sugar levels of the formulation were changed in five levels based on the (wheat flour + eggplant fiber) weight, and finally, fifteen formula (each at two repetition) with one central point (with four repetition) were designed using response surface methodology (RSM).

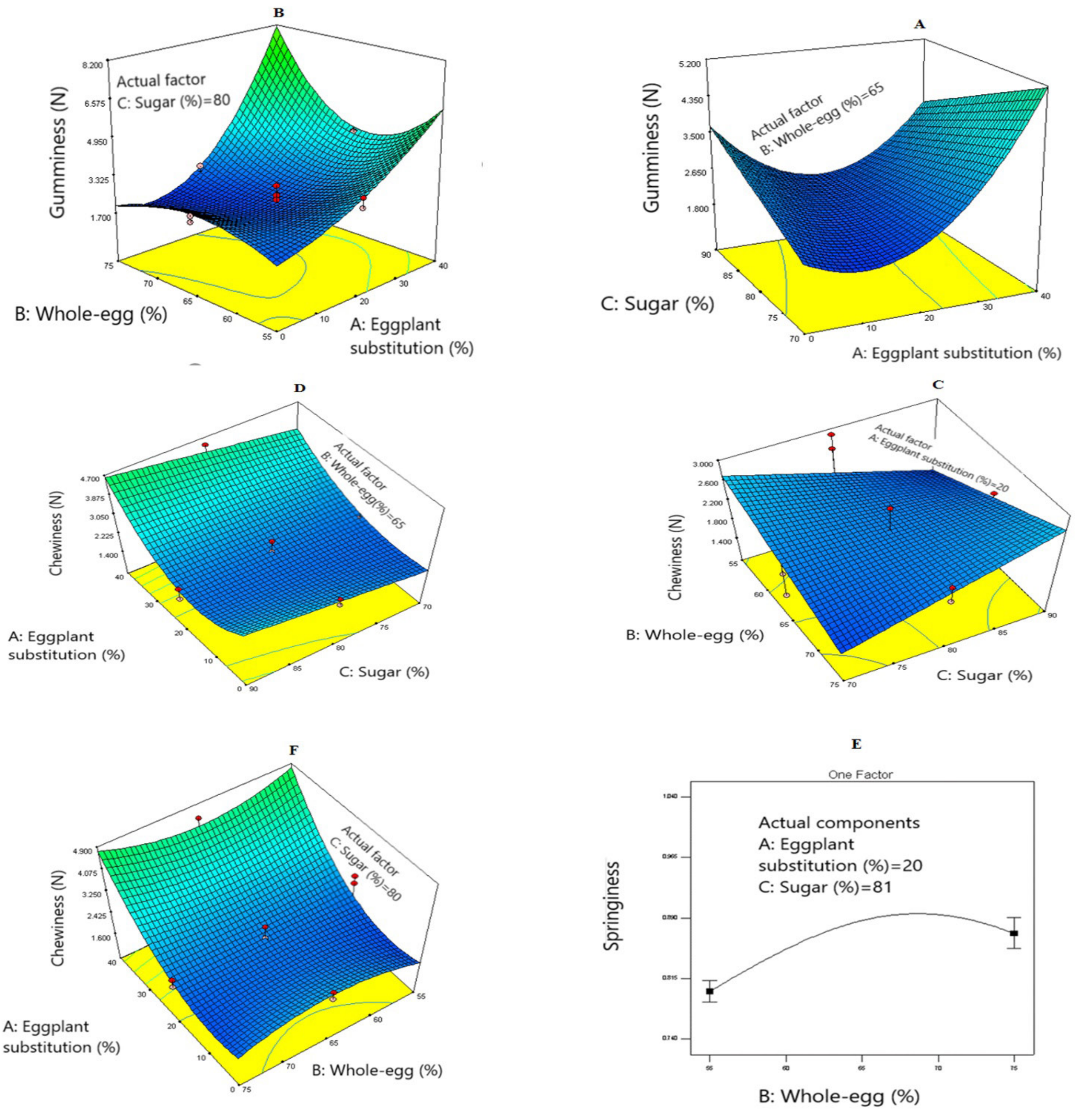

Figure 3. Effects of the replacement of wheat flour with eggplant fiber (%), whole-egg (%), and sugar (%) on weight (g) [A & B].

Table 3. Chemical properties of optimal formulas and blank in the first day after production.

Formula	Protein (%)*	Fat (%)*	Moisture (% weight percentage)	Acid insoluble ash (%)*	Carbohydrate (%)*	Calorie (calories/gr)
Formula a	23.84 ± 1.69 [a]	23.18 ± 0.60 [a]	17.03 ± 0.64 [a]	0.07 ± 0.02 [a]	35.86 ± 1.75 [b]	5882.60 ± 94.29 [b]
Formula b	15.57 ± 3.43 [b]	26.62 ± 7.79 [a]	18.08 ± 2.05 [a]	0.04 ± 0.00 [ab]	39.67 ± 2.74 [b]	5993.80 ± 28.93 [ab]
blank	13.79 ± 3.46 [b]	19.76 ± 1.12 [a]	12.30 ± 0.68 [b]	0.04 ± 0.00 [b]	54.10 ± 3.39 [a]	6095.60 ± 82.10 [a]

Means in the same block with different letters chemical properties are significantly different according to ANOVA at a significance level of 0.05, Each property was calculated at three repetition. *represents based on dry matter.

Considering the most important textural properties, weight, and density, two optimal formulas were designed. Then, their chemical properties along with the blank were calculated. Results showed that the use of eggplant fiber in cupcake formulation reduces cake calorie, and increases its nutritional value. Among optimal formulas, the formula with 8% fiber (formula b) in terms of many factors showed similarity to the blank. Effects of sugar, whole-egg, and mixed flour with eggplant fiber on the textural properties were also investigated. It was demonstrated that all of the textural properties except springiness, affected by fiber. The effect of whole-egg on three parameters: springiness, chewiness, and density were considerable and sugar content remarked as one of the most effective variables on the sample weight. As a result, a sufficient daily intake of fiber in people's diets is highly recommended and unfortunately, at the present, inadequate attention is assigned to the section of food enrichment with dietary fiber in the food industry. Therefore, it is proposed that other fruit and grain fibers that are found frequently, are practically utilized to formulate various processed foods such as bakery products for reaching a consumers' healthy diet. These products will have a higher nutritional value and better antioxidant activity due to the presence of natural antioxidants. In conclusion, efforts should be undertaken to find natural antioxidant sources and replace them in the industry with synthetic antioxidants. Nonetheless, fiber can change the sensory and physicochemical properties of foods that may not be desirable for all consumers. Therefore, the use of fiber as an ingredient in products can prompt several challenges, demanding more research in this field of work.

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