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The effect of sugarcane bagasse and soy water-soluble polysaccharide on the image characteristics of donuts

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ARTICLE INFO	ABSTRACT
  DOI: 10.22034/FSCT.19.132.387 **DOR: 20.1001.1.20088787.1401.19.132.31.4** *Corresponding Author E-Mail: Nasehi.b@pnu.ac.ir	In recent years, the non-destructive and fast method of image processing has been successfully used for quantitative and qualitative evaluation of the characteristics of food products. In this study, the effect of sugarcane bagasse as a source of fiber enrichment (0-25%), soybean water-soluble polysaccharide (0-2%) and frying time (2-5 minutes) on the image characteristics of donuts such as color, number , density and size of bubbles, porosity, energy, homogeneity, contrast and entropy were investigated. The findings of this research showed that the increase of sugarcane bagasse fiber increases the a* index and decreases the L* and b* components of the crust and crumb and porosity. On the other hand, increasing the frying temperature increases the redness of the crust and decreases the lightness of the crust and the porosity of the texture. Meanwhile, the polysaccharide soluble in soybean water had no significant effect on the characteristics of the treatments. The optimization results also showed that if 8.58% sugarcane bagasse and 0.36% soybean soluble polysaccharide are added to the formula and the sample is fried within 5 minutes, the best quality will be obtained.

1. Introduction

Donut is a delicious cereal snack that is widely consumed in many countries such as Iran. Since it has to be fried in oil to prepare, it has a high fat and energy content, which makes its lovers worry about their health [1]. Therefore, many researches have been done to reduce the amount of oil absorption of this product during the frying stage. Among other things, we can mention the use of fibrous compounds, which, in addition to reducing the amount of oil absorption [2 and 3], improves the functioning of the digestive system, reduces blood cholesterol and the risk of heart diseases, and controls weight and blood sugar [4]. Sugarcane bagasse is one of the available and valuable residues that contains 45-40% cellulose, 25-35% hemicellulose, 14.4-30% lignin, 3.5-12.14% extract and 0.6-3.4% The percentage of ash and many amounts of phenolic compounds, wax and minerals is [5 to 7]. Polysaccharides soluble in soy water, which have a structure similar to pectin, have a relatively low viscosity and high stability in aqueous solutions, and due to their various functions, they can be used in the food and pharmaceutical industries [8].

In the image processing method, important features regarding the structure and microstructure of the sample are evaluated quickly and non-destructively using digital photos. So far, this method has been widely used in the evaluation of the cellular structure of various types of bakery products, which has an effective role on its other characteristics [9 and 10]. Therefore, the purpose of this research is to use the image processing method to investigate the characteristics of donuts enriched with bagasse and The polysaccharide was soluble in soybean water during different frying times.

2- Materials and methods
2-1- Materials

The ingredients of the formula and the percentage of each of them based on one hundred grams of wheat flour (South Ahvaz flour) including water, 37.5%; Shortening (optimum food and protein products and Zain Alborz), 18.7%; Eggs (Talawang, Tehran), 12.4%; Sugar (Kosha Nutrition Mandesh Tehran), 6.2%; Non-fat dry milk powder (Parsian Sanat Shayan Nazarabad), 6.2%;

Active dry yeast (Razavi Mashhad yeast), 2.9%; salt (Spidanfars), 1%; Vanilla (Polar Bear, China), 0.15%; baking powder (Hermin Shahriar), 1.5%; Soybean soluble polysaccharide (Fuji Oil, Japan) and special frying oil (Aftab, Margarine Sahami Am, Tehran, Iran) were used.

Sugarcane bagasse was also prepared from Dabal Khazai Plantation and Industry and after removing impurities and washing water, it was dried in the sun. In order to remove lignin, bagasse was placed in 0.25 M sodium hydroxide at a ratio of 1 gram per 20 ml of solution for 3 hours at 80 degrees Celsius in a hot water bath. Then it was washed with water to remove the remaining sodium hydroxide. After that, the bagasse was placed in an oven with a temperature of 60 °C for about 4 hours. At the end, its particles were reduced to the size of 0.475 mm using a laboratory mill.

2-2- Preparation of donuts

Donut samples were prepared based on the formula and recipe of Norio et al. (2017) with some changes [11]. To activate the yeast, the formula was mixed with about 70% water at a temperature of 35 degrees Celsius and kept for 5 minutes. Wheat flour, processed bagasse, soluble soybean polysaccharide and baking powder were mixed by hand. Other powdered ingredients including sugar, non-fat dry milk powder, salt, vanilla and shortening were mixed in another container for 1 minute on high speed. Then, eggs were added to this mixture and mixed on high speed for 1 minute. Then the rest of the formula water was added to this container and mixed with slow speed for 30 seconds. In the next step, part of the flour mixture was added gradually. Then the yeast suspension was added to the rest of the flour mixture and kneaded until a suitable dough was formed. The dough was left to ferment for 30 minutes at room temperature. Then the dough was molded to a thickness of 1 cm wide and with a square mold (with dimensions of 5 x 5 cm) and was placed again for 15 minutes for final fermentation. Next, the dough pieces were fried in a fryer containing frying oil at a temperature of 180 ± 2 for 2 to 5 minutes. At the end, the donuts were taken out of the fryer and placed on a napkin to be photographed after 30 minutes [12].

2-3- Image processing

In this research, shell and brain color indices, brain structure characteristics and donut surface texture descriptors were studied using an image analysis system including a Canon

digital imaging camera (PowerShot SX60 HS model) and a personal computer. The images were taken at a fixed distance of 30 cm from the samples placed in a black box (with approximate dimensions of 100x100x100 cm) and illuminated at an angle of 45 degrees by fluorescent lamps [11]. For this purpose, the characteristics of the color of donut core and shell were evaluated by evaluating three indicators of brightness (*L), redness (*a) and yellowness (*b). First, a slice of the shell and brain images with dimensions of 2 x 2 cm (142 x 142 pixels) was prepared in Photoshop software to analyze the color indices in JImage software [9]. The characteristics of the brain structure, including the number, area and density of cells, as well as the porosity, were evaluated from the color (24-bit) images of the brain of the samples [11]. To check surface texture descriptors, the gray level simultaneity matrix of each image was created and features such as contrast (local changes in the image), energy (image texture uniformity), entropy (image irregularities) and homogeneity (image smoothness) were determined.[۱۳]

2-4- Statistical design

In order to statistically evaluate the dependent variables including the image characteristics of the treatments, the response surface method with a rotating central composite design was used. The independent variables included sugarcane bagasse fiber (in the range of 0-25%) and soybean water-soluble polysaccharide (0-2%) and frying time (2-5 minutes), according to which Minitab20 software introduced the treatment. After conducting the experimental tests and regression analysis of the findings, a quadratic polynomial model was fitted for each of the responses using the following relationship.

$$Y = \beta_\circ + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} X_{ii}{}^2 + \sum_{1 \le i < j}^{k} \beta_{ij} X_i X_j$$

In this regard, Y is the estimated response and expressions$\circ\beta$, β_i, β_{ii}, β_{ij} are constants of the equation (width from origin), coefficient of linear effects, coefficient of quadratic effects and coefficient of reciprocal effects and also, x_i And x_j Levels are independent variables. Then numerical optimization was done in order to achieve the optimal levels of independent variables [12].

3. Results and Discussion
1-3- Color features

The findings of Table 1 show that sugarcane bagasse has a significant negative linear effect on the L* and b* factors of the brain and b* of the shell (p<0.05).

Table 1 Analysis of variance and regression coefficients of responses of fiber and color of peel and pith of samples enriched with sugarcane bagasse

Source	Crust			Crumb		
	L*	a*	b*	L*	a*	b*
0b	50.39	2.912-	60.605	74.662	4.174-	4.464
A	-0.161 [ns]	0.043 [***]	0.685- [***]	1.298- [***]	0.026 [***]	0.012 [ns] -
B	0.175 [ns]	6.896 [**]	-4.064 [**]	1.327 [ns] -	0.800 [ns] -	6.467 [ns]
C	-4.700 [ns]	2.923 [ns]	2.852 [ns] -	5.527 [ns]	0.062 [ns]	5.508 [ns]
AB	0.0416 [**]	-0.018 [ns]	0.034 [*]	0.014 [ns]	0.007 [***]	0.018 [ns] -
AC	-0.159 [ns]	0.467 [ns] -	0.234 [ns]	0.220 [ns]	0.072 [ns]	0.766 [ns] -
BC	1.347 [ns]	2.299 [ns] -	0.288 [ns]	1.135 [ns] -	0.207 [ns] -	1.857 [ns] -
A^2	0.129 [ns] -	5.055 [ns] -	0.183 [ns] -	0.044 [ns]	0.001 [ns]	0.099 [ns]
B^2	0.936 [ns] -	0.201 [ns]	0.155 [ns] -	0.005 [ns]	0.034 [ns] -	0.185 [ns]
C^2	1.669 [ns]	0.400 [ns]	1.469 [ns]	1.042 [ns] -	0.156 [ns]	0.808 [ns] -
Model	0.155 [ns]	0.002 [**]	0.007 [**]	0.000 [***]	0.000 [***]	0.563 [ns]
Lack of fit	0.871 [ns]	0.334 [ns]	0.995 [ns]	0.160 [ns]	0.100 [ns]	0.026 [ns]
R^2	63.79	87.94	83.32	96.21	97.34	44.53
Adj-R^2	31.19	66.08	68.31	92.81	94.94	0.000
CV (%)	6.98	33.68	13.90	8.21	28.45-	13.90
PRESS	224.528	163.803	181.306	111.303	4.729	587.738

A(Bagasse),B(Frying time),C(Gum) -[ns]not significant,[*] P <0.05,[**] P <0.01,[***] P <0.001

Frying time has a positive and significant linear effect on the a* factor of the crust and a significant negative linear effect on the b* factor of the crust (p<0.05). The quadratic effect of sugarcane bagasse fiber on L* and b* parameters of shell and a* brain was positive and significant (p<0.05). Also, the quadratic effects of frying time and polysaccharide soluble in soybean water and the mutual effects of all three independent factors were insignificant.

389

| b	a
d	c
f	It is
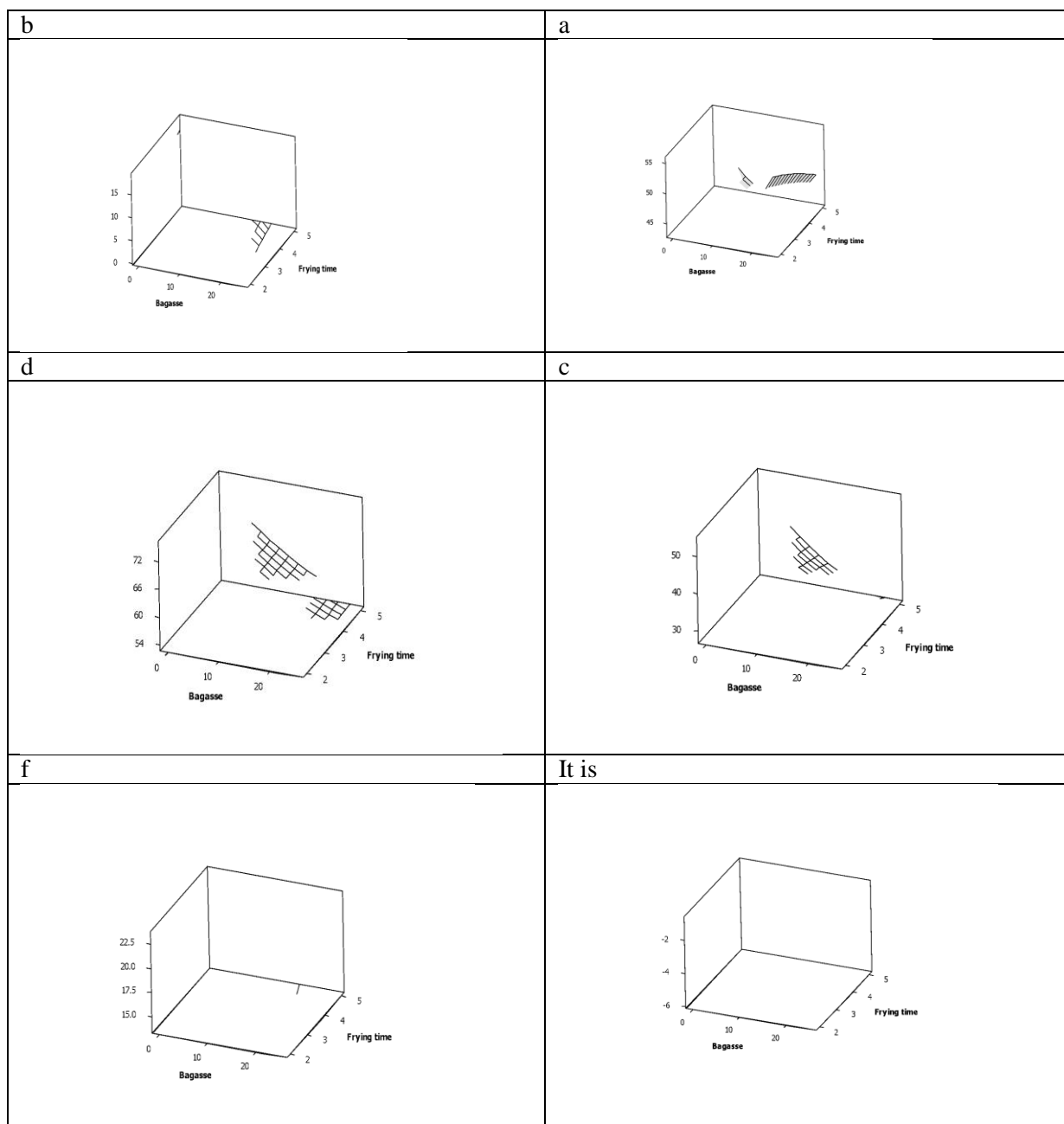
Fig 1 Response surface diagram of the variables of frying time and bagasse in on the color of donut (a) L crust, (b) a crust, (c) b crust, (d) L crumb, (e) a crumb, (f) b crumb..

The skin color is influenced by Maillard and caramelization reactions. With the presence of fibers, less flour is used in the formula. Also, changes in pH (fibers as a buffer) and changes in the amount of water provide the basis for color changes. Adding levels of more than 15% of jojoba fiber to sponge cake caused a decrease in L* and a* factors and an increase in b* factor [14]. Color changes during frying of carrots coated with guar and xanthan gums showed that these gums significantly prevent moisture evaporation and Maillard reaction due to their high ability to connect with water [15]. The results of investigating the effect of duration and power of microwave and duration

of frying on donuts enriched with carrot fiber showed that increasing the duration of frying decreases the brightness of the shell and core, increases the redness index and decreases the yellowness index, which is consistent with the results obtained from this The research about the index a* and b* of the shell was consistent [11]. Also, the addition of orange pulp powder to the fermented donut formula caused a decrease in the brightness index and an increase in the amount of yellowness and redness of the donut shell and core. On the other hand, in the frying process, the use of high temperature actually provides the basis for non-enzymatic browning and

caramelization reactions [16]. In addition, the difference in color treatments is also related to the degree of moisture loss and fat absorption. However, since moisture content is the key effective factor in Maillard and caramelization reactions, its loss during frying accelerates these reactions [17].

3-2- Features of the brain

Analysis of variance of the results of donut brain characteristics in Table 2 shows that the model proposed in this research for the number of cells, average area of cells, density of cells and porosity of donut tissue was significant (p<0.05) and their lack of fit test was non-significant. Also, the linear effect of sugarcane bagasse and the linear and quadratic effects of frying time had a significant negative and positive effect on brain tissue porosity, respectively (p<0.05).

b	a
d	c
f	It is
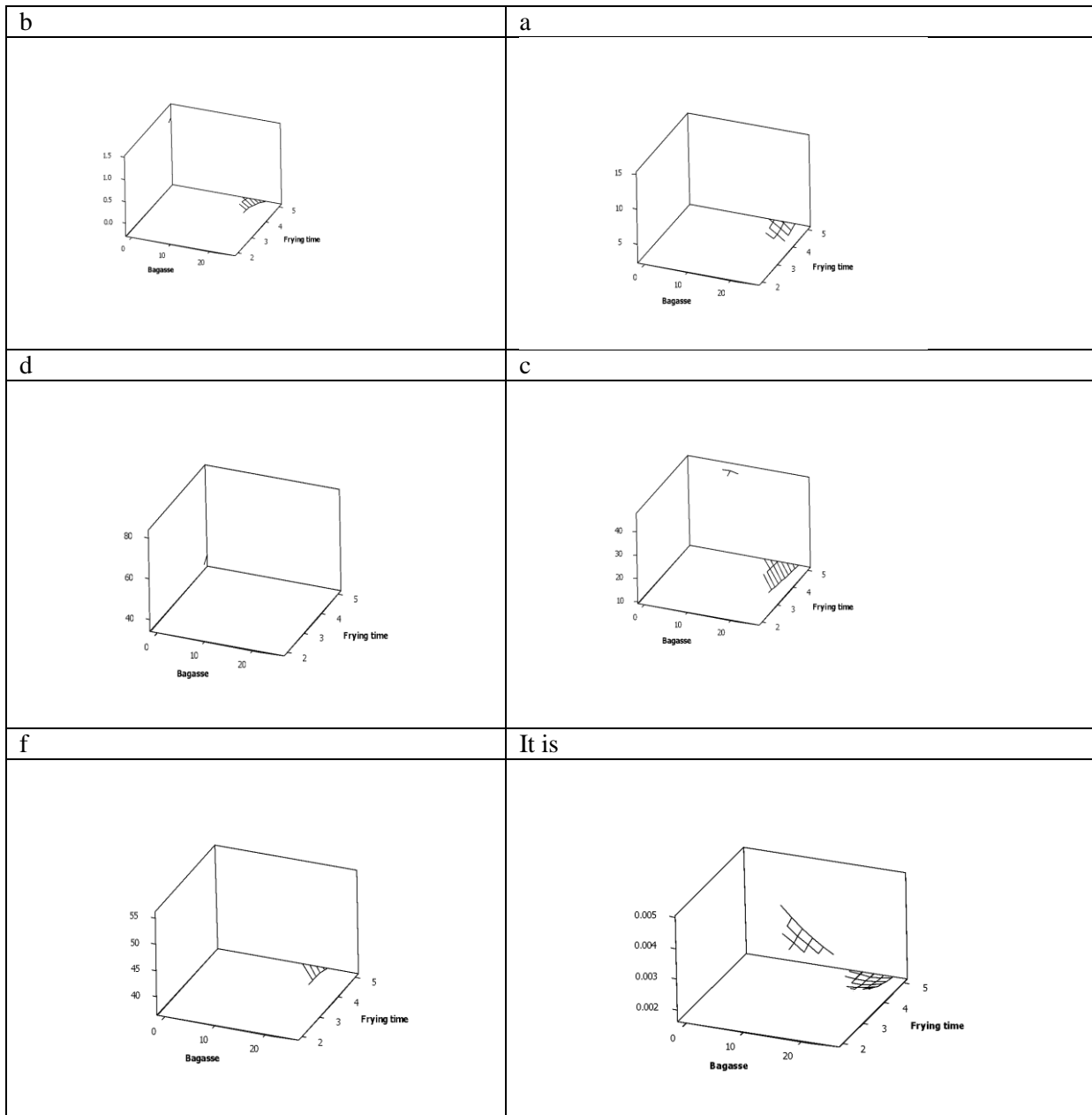
Fig 2 Response surface diagram of the variables of frying time and bagasse fiber on the characteristics of donut core (a) porosity (b) cell density (c) number of cells (d) area of cell, (e) Energy, (f) Contrast.

In addition, the linear effect of bagasse on the number of cells was positive and its quadratic effect was negative and significant (p<0.05). The quadratic effect of polysaccharide soluble in soybean water on the number of cells was negative and significant, and the interaction effect of frying time and polysaccharide soluble in soybean water was also positive and

significant (p<0.05). According to the results, the linear effect of sugarcane bagasse on the average area of cells was negative and significant, and its interaction with soy water-soluble polysaccharide was positive and significant, as well as the interaction effect of frying time and soy water-soluble polysaccharide was negative and significant (p<0.05). The results of this table also show that the linear effect of sugarcane bagasse and the interaction effect of frying time and soybean water-soluble polysaccharide on cell density were significant (p<0.05). Also, by increasing the frying time, the porosity and volume of the samples is less and a thicker crust is created. The reason can be attributed to excessive drying of the samples during high frying time, which is consistent with the results of Naghipour et al., when the breads were baked at 150 and 180 degrees Celsius for 30 and 25 minutes [18]. Adding wheat bran to white wheat flour caused the formation of smaller and more spherical cells and as a result increased cell density [19]. It seems that the addition of sugarcane bagasse fiber causes the wall of the gas cells to become thicker and the air trapped in the dough to decrease, and subsequently to decrease the volume and increase the hardness of the pulp. Also, soluble soybean polysaccharide, similar to hydrocolloids such as capacarrageenan, hydroxymethyl cellulose and xanthan, due to the presence of hydroxyl groups in its structure, increases the specific volume and water holding capacity and reduces stiffness [12].

3-3-surface features

Analyzing the results of analysis of variance in Table 2 shows that the quadratic models fitted for texture descriptors were insignificant (p>0.05). Also, their misfit index was also non-significant (p>0.05). In this research, sugarcane bagasse fiber had a significant negative linear effect (p<0.05) on the energy index and a significant positive effect (p<0.05) on image homogeneity. Also, polysaccharide soluble in soybean water had a significant positive quadratic effect (p0.05 <) was based on the homogeneity of the samples. Meanwhile, the effect of frying time on textural descriptors became non-significant (p>0.05). By increasing the percentage of sugarcane bagasse fiber, the energy decreased and on the contrary, the balance and entropy increased, which had the same effect as the addition of orange pulp powder to the fermented donut [16]. The increase in contrast occurs due to the hardening of the tissue due to the presence of fibers, and these changes indicated the effect of adding this variable on the roughening of the surface of the samples. However, replacing wheat flour with soybean flour did not have a significant effect on the contrast, energy and homogeneity of the image of breads [20]. The decrease in dough viscosity that occurs after the increase in its moisture content can facilitate the release of air bubbles during the baking process. Therefore, by increasing the water content in the formula, the moisture content of the dough increases and its viscosity decreases, which subsequently causes more air bubbles to escape from the surface of the material during cooking [21]. Therefore, the roughening of the surface of the samples can be considered as the result of more air bubbles coming out of the surface of the samples. Adding non-soluble fibers reduces the concentration of gluten proteins and weakens the gluten-starch network, and by weakening the structure of the dough, it facilitates the exit of air through the surface [22].

Table 2 Analysis of variance and regression coefficients of the responses of crumb and surface tissue characteristics of samples enriched with sugarcane bagasse

Source	Count	Average size	Density	Porosity	Energy	Contrast	Homogeneity	Entropy
0b	35.430	95.398	0.291-	15.646	0.004	30.938	0.501	5.977
A	***3.213	*2.004-	**0.123	***0.116-	*1.593-	1.514 ns	*0.002	0.017 ns
B	5.590 ns -	31.682 ns -	0.388 ns	**3.684-	9.380 ns -	9.782 ns	ns0.075-	0.067 ns
C	7.281 ns -	32.722 ns	0.641 ns -	0.269 ns -	6.176 ns -	4.691 ns -	0.126 ns -	0.207 ns
AB	***0.120-	0.018 ns	0.001 ns -	0.003 ns -	5.815 ns	0.056 ns -	3.921 ns	0.001 ns -
AC	0.265 ns	6.955 ns	0.071 ns -	**0.688	0.000 ns	1.499 ns -	0.008 ns	0.013 ns -
BC	***14.903-	6.815 ns	0.331 ns -	0.098 ns	0.000 ns	4.314 ns -	*0.055	0.231 ns -
A^2	0.282 ns -	0.119 ns	0.022 ns -	0.042 ns -	3.771 ns -	0.148 ns -	0.001 ns -	0.008 ns -
B^2	0.197 ns	*2.223	-0.035 ns	0.004 ns	5.656 ns -	0.238 ns -	0.003 ns -	0.014 ns -
C^2	**9.192	*20.590-	*0.510	0.087 ns	2.372 ns -	0.177 ns	0.020 ns	0.005 ns
Model	***0.000	*0.034	*0.025	***0.000	0.149 ns	3.195 ns	0.093 ns	0.246 ns
Lack of fit	0.386 ns	0.321 ns	0.102 ns	0.755 ns	0.069 ns	0.896 ns	0.152 ns	0.349 ns
R^2	94.68	75.55	77.16	96.46	64.18	46.61	68.44	58.53
Adj-R^2	98.90	53.55	56.80	93.28	31.95	0.000	40.04	21.21
CV (%)	28.55	27.59	55.83	29.03	29.68	10.68	12.10	3.37
PRESS	451.495	5851.04	4.358	12.612	0.000	862.900	0.052	1.954

A(Bagas),B(Frying time),C(Gum) - ns not significant, *P <0.05, ** P <0.01, *** P <0.001

4 - Conclusion

The general review of the results of this research shows that the increase of sugarcane bagasse fiber causes an increase in the a* index of the shell and pith and a decrease in the L* and b* components of the shell and pith and porosity. Increasing the frying temperature causes an increase in the index a* of the shell and the component L* of the shell and porosity. Meanwhile, polysaccharide soluble in soybean water had no significant effect on these parameters. Most of the proposed models in this research from R^2 and (Adj)R^2 They were relevant and meaningful. Also, the goodness of fit test was meaningless for most of the answers and their coefficient of variation was also appropriate. Optimization was done based on the brain brightness indices, skin redness, cell number and average cell area, density and porosity. Based on this, the treatment with 8.58% sugarcane bagasse, 0.36% soybean soluble polysaccharide, which was fried for 5 minutes, had the best quality with desirability (D=0.84). In these conditions, the brightness of the brain was 65.34, skin redness 17.15, cell number 33.35, average cell area 82.47, density 0.36 and porosity 11.49.

5- Resources

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مجله علوم و صنایع غذایی ایران

مقاله علمی_پژوهشی

ارزیابی اثر باگاس و پلی‌ساکارید محلول سویا بر ویژگی‌های تصویری دونات

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چکیده	اطلاعات مقاله

در سال‌های اخیر از روش غیر مخرب و سریع پردازش تصویر، برای ارزیابی کمی و کیفی ویژگی‌های فراورده‌های غذایی با موفقیت استفاده شده است. در این پژوهش نیز اثر فیبر باگاس نیشکر به عنوان یک منبع غنی‌کننده فیبر(۲۵-۰ درصد)، پلی‌ساکارید محلول در آب سویا (۲-۰ درصد) و زمان سرخ کردن (۵-۲ دقیقه) بر ویژگی‌های تصویری دونات مانند تعداد، دانسیته و اندازه حباب‌ها، رنگ، تخلخل، همگنی، انرژی، تباین و آنتروپی مورد بررسی قرار گرفت. یافته‌های حاصل از این پژوهش نشان داد که افزایش فیبر باگاس نیشکر سبب افزایش شاخص*a وکاهش مؤلفه *L و *b پوسته و مغز و تخلخل می‌شود. از سوی دیگر افزایش دمای سرخ‌کردن، سبب افزایش قرمزی رنگ پوسته و کاهش میزان روشنی رنگ پوسته و تخلخل بافت می‌شود. این در حالی است که پلی‌ساکارید محلول در آب سویا،اثر معنی‌داری بر ویژگی‌های تیمارها نداشت. نتایج بهینه‌یابی هم نشان داد که اگر نمونه حاوی ۸/۵۸ درصد باگاس نیشکر و ۰/۳۶ درصد پلی ساکارید محلول سویا، طی ۵ دقیقه سرخ شود، بهترین کیفیت حاصل خواهد شد.