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Scientific Research

Investigating the effect of Transglutaminase enzyme and Ultrasonication on the properties of Barbari bread containing soybean meal

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ABSTRACT

Soybean meal is one of the sources of vegetable protein, which together with wheat flour proteins, can provides a complete source of amino acids for the human body, so using it in bread can help to solve protein deficiencies. For this purpose, to prepare Barbari bread containing soy meal, a combined design containing a group of mixing variables, including different levels of transglutaminase enzyme (0 to 1 %), soybean meal flour (0 to 50 %), wheat flour as filler (0 to 100 %) and a process variable including ultrasonic altitude (0 to 100%) was used and physicochemical and sensory characteristics including total ash, pH, moisture, porosity and taste, texture and color scores were investigated. The results showed that transglutaminase enzyme and ultrasonication have a significant effect on physicochemical properties and porosity ($P<0.0001$). The significant increase in color score of the samples was due to the positive and significant effect ($P<0.0001$) of soybean meal on that characteristic. The porosity of the samples was significantly affected ($P<0.0001$) by the interaction of enzyme and ultrasound. Finally, in order to obtain samples with the highest porosity and color, taste and texture scores, it is suggested to use the mixing ratio of soybean meal flour 33%, enzyme 1%, wheat flour 66% and ultrasound altitude 100%.

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1- Introduction

In recent years, the improvement of the nutritional characteristics of wheat bread has received much attention, which is done by mixing wheat flour with different flours and increases the mineral compounds, vitamins, protein and dietary fibers in the final product. . Soybean meal is one of the sources of vegetable protein, which together with wheat flour proteins can provide a complete source of amino acids for the human body, so using it in bread can help to solve protein deficiencies. [1]. But the addition of enriching compounds creates many challenges in the preparation of bread, the most important of which are adverse changes in texture, color and taste [2]. Decreasing the share of wheat flour in products enriched with soy flour weakens the gluten network and as a result produces a sticky dough with a low ability to retain gas during fermentation and poor formability. Due to the decrease in the ability to retain water, this dough has a low consistency and a low tolerance coefficient, and the bread prepared from it has a small volume, a dense core, and very weak sensory properties (texture, color, aroma and taste). Therefore, adding the right amount and using texture improvers should also be considered. However, improving the taste of bread by using different ingredients and additives has now become an important activity to attract consumers [3]..

Although there is a great variety in chemical improvers such as chlorine, chlorine dioxide, potassium bromate, potassium persulfate, and azodicarbonamide, but their residues can be dangerous for human health, so searching among healthy compounds in increasing quality Such products can be useful. One of the healthy protein additives in foods is the microbial transglutaminase enzyme[1] Is. This enzyme is one of the transferase enzymes that can convert the amino acid glutamine[2] of a protein and lysine[3] create cross-links from other proteins [4]. Therefore, it can be effective in improving the texture quality of bakery products [5].. Research shows that the use of ultrasound waves increases the function of the transglutaminase enzyme and improves the texture of the resulting bread. In Haoho et al.'s (2015) research, the performance of gels catalyzed by microbial transglutaminase enzyme, soy isolate protein combined with whey protein after ultrasound treatment was observed [6].. It is also possible to use the intensification effect of aeration by ultrasound to bring more oxygen to the flour and improve its properties [7].. Also, the positive effect of some compounds such as chickpea flour, psyllium[4] and cyclodextrin glycosyltransferase[5] Along with transglutaminase, it was observed on the specific volume of bread and the firmness of gluten-free bread and the stability of starch[8]. Regarding the production of gluten-free products, the presence of sodium caseinatewith transglutaminaseIt can also be useful for the production of gluten-free corn bread bSharp[9]. Therefore, since carrying out this research with the aim of using soybean meal can be the basis for improving the nutritional conditions of the society, the production of bread containing soybean meal flour and transglutaminase enzyme, which were sonicated under certain conditions, was done.

2- Materials and methods

2-1- Required materials and tools

Berber flour (Customer Flour Factory, Golestan, Iran), soy (Soban Protein Company, Iran), salt (Golha Company, Iran), Saccharomyces Cervizia yeast (Freeman Mashhad Company, Iran), sunflower liquid oil (Ghancheh Company, Iran), transglutaminase enzyme(TG) Microbial (BDF, Spain), oven (Memmert, Germany), pH meter (Metrohm), ultrasonic device (Hielscher, German).

2-2- Preparation of dough

To prepare the dough in the first stepsoy flour, some wheat flour, Water and appropriate amounts of enzyme according to table 1 are mixed together and the paste is dilutedand under the influence of ultrasound treatment with the desired amplitude. In the next step, the rest of the flour was added, and in order to bake the bread, the ingredients were mixed in a mixer for 15 minutes, and then the dough was left for 10 minutes at 30 degrees Celsius for fermentation.The starter was placed, and in the next

[1]-MTG

[2]- Glutamine

[3]-Lysine

[4]- psyllium

[5]-Cyclodextrin Glycosyltransferase

step, the dough was divided into pieces of 80 grams and rested inside a specially greased mold for 10 minutes (intermediate fermentation stage). Then the molds were placed in an incubator for 60 minutes with a temperature of 45 degrees Celsius and a relative humidity of 80% (final fermentation stage). Finally, baking was done in a laboratory rotary oven with a temperature of 230 degrees Celsius for 10 minutes [10]..

2-3- How to conduct tests

2-3-1- Measurement of physicochemical properties

pH measurement, according to Iran's national standard method No. 37 [11] ،total ash according to Iran's national standard method No. 2706 [12] ، Moisture from Iran's National Standard No. 2705 [13], Gluten from Iran's National Standard No. 9639 [14], Acidity from Iran's National Standard No. 103 [15] ،Maltose from the national standard of Iran No. 3104 [16] ،Falling of Iran's national standard number was 4175 [17].

2-3-2- Sensory evaluation

Sensory evaluation of the samples was done by 10 trained judges. The place where the test was conducted was conducted in suitable conditions of temperature (20 degrees Celsius), humidity (80 percent) and light (300 lux), and the method was based on the 9-point hedonic test method, score one; very bad and score 9; It was so good. The average scores of appearance, color, smell, taste, texture and mouth feel and texture were recorded and subjected to analysis of variance [18]..

2-3-3- Evaluation of the porosity of the bread core

Image processing technique was used to evaluate the porosity of the bread core. For this purpose, a cut with dimensions of 4 x 4 cm

It was obtained from the brains and scanned using a scanner with a resolution of 300Pixel (G3010 Scanjet HP) was photographed And the amount of porosity was measured with Image J software. **2-3-4- Statistical method**

In this research, the combined design (combination of mixing components and process variable) was used to select different levels of variables in the preparation of Berber bread treatments. This design includes 3 mixing components of transglutaminase enzyme (0 to 1 percent), soybean meal flour (0 to 50 percent), wheat flour as a filler (0 to 100 percent) so that the sum of the three components is 100 percent, and a process variable includes the range Ultrasound (0 to 100%) was used (Table 1). The minimum number of treatments for the implementation of the mentioned plan was 23 treatments, which were presented along with the levels of variables, by the Stat-Ease Design Expert 10 software, and the physicochemical properties were measured during total ash, pH, moisture, porosity, taste scores, texture and color tests. became. Then the variance analysis of the obtained data was done and the significance of the variables and their effectiveness according to the explanatory coefficients.[6] They (Table 2) were obtained. Also, identifying the appropriate model according to the amount of R values[2] corrected[7] ،R^2 prophesied[8] and sufficient accuracy[9] The significance of the F test ($p>0.01$) was selected and finally Predictive models were presented. All these calculations were done by the mentioned software.

3. Results and Discussion

Due to the necessity of knowing the composition and characteristics of the raw materials used, their measurement was done before preparing the treatments. In this way, the moisture content of soybean flour used was 7%, ash 3%, protein 38% and fat 18%, and the characteristics of wheat flour used were moisture 14%, pH 6.12, gluten 31%, gluten The index was 81%, acidity was 1.2%, protein was 13.5%, maltose number was 512 mg per ten grams, Falling number was 370 seconds and ash was 0.721%.

[6]- Coefficient determination
[7]- Adjusted R2
[8]- Predicted R2
[9]- Adequate precision

3-1- Examining the results of total ash test

In examining the selected models, both for the mixing plan (components of soybean meal and transglutaminase enzyme) and for the process plan (ultrasound domain), the linear model was a better model in fitting the data obtained from total ash than other proposed models (<0.0004). p, Table 2). As can be seen in Table 2, the linear variables of transglutaminase enzyme and soybean meal had a significant effect on the amount of ash in the production samples. The results showed that by increasing the amount of enzyme in the formulation of manufactured breads, the total amount of ash in the samples increased (Figure 1). Due to the presence of calcium ion in transglutaminase enzyme**[19]** It seems that increasing its concentration increases the ash of the samples. With the increase in the amount of soybean meal, the amount of total ash also increased significantly, which is due to the greater amount of ash in soybean meal (3%) compared to wheat flour (around 2%), and with the increase of its replacement with wheat flour, the amount of total ash increased. increase.By comparing the amount of wheat flour and soybean meal, during the use of the mixtures used in bread, it has been determined that the addition of soybean flour increases the amount of protein, fiber, ash, amino acid lysine and threonine.20]. The result of this test was similar to the research of Mashaikh et al. who produced bread samples with 3-12% soy flour.21].

Equation 1 shows the prediction model for the amount of total ash. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is more than 0.2 and both of them are higher than 0.5 and also the sufficient accuracy index is higher than 4 (7.551), so the predictive model can be used to an average extent and the output of the model will not be very accurate.

relationship (1)

Total ash =+0.153TG +0.0329 soybean meal +0.02364* wheat flour – 0.00120* TG* ultrasound -0.003277 * soybean meal* ultrasound +0.001276* wheat flour * ultrasound.

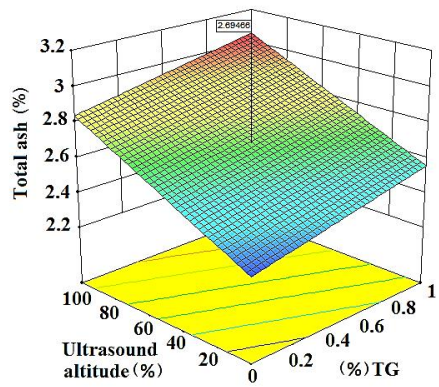

Figure 1- Changes of total ash in different amounts of TG enzyme and ultrasound

3-2- Checking the results of the pH test

Among the models calculated with pH data, the linear model was the better model for both the mixing component variables and the process component variable (ultrasonic range) (p<0.0001, Table 2). The significant effect of linear variables of transglutaminase enzyme and ultrasound on production samples is shown in Table 2. So that by increasing the amount of enzymepH Bread production increased (Figure 2). This phenomenon was also observed in the research of Ababaf et al., and its cause is the decrease in biological absorption of mineral salts by bread yeast due to the formation of new bonds in the protein network, and as a result, it causes a decrease inAcid is produced during fermentation [22]. Increasing the intensity of ultrasound increased the pH in the samples, which was similar to the research of Namenko et al[23]. The interaction of ultrasound with soybean meal also had a significant effect on pH. According to the explanatory coefficients (Table 2), the linear parameter of the transglutaminase enzyme had the greatest effect on this characteristic.

relationship (2)

pH= +71.68TG +5.19 * soybean meal+5.64 * wheat flour - 0.1672* TG * ultrasound +0.0169* soybean meal * ultrasound +0.0122* wheat flour * ultrasound

Table 1- Treatments produced at different levels of enzyme, soybean flour and ultrasound and raw data from the tests

Color score	Texture score	Taste score	porosity	moisture	pH	Total ash	Ultrasonic range(%)	I am protein	Enzyme	treatment
7	6	5	36.87	34.9	6.3	2.59	50	40	0	1
3	6	8	36.55	34.5	6.24	2.56	0	0	1	2
5	8	6	38.22	37.5	6.7	2.78	50	18.3	0.46	3
4	5	6	31.88	31.9	5.79	2.4	25	9.5	0	4
7	5	5	36.22	33.3	6	2.47	0	36.5	1	5
5	9	6	52.78	40.8	7.3	3.03	100	18.5	1	6
4	8	6	39.21	38.3	6.9	2.84	100	6.9	0	7
7	5	5	31.08	31.2	5.3	2.31	0	37.4	1	8
3	5	8	31.23	31.8	5.8	2.37	0	0	1	9
9	8	8	38.85	37.8	6.8	2.81	98	50	0	10
7	8	8	46.69	38.4	6.9	2.85	74	43.5	1	11
4	7	8	36.8	34.7	6.27	2.58	75	7.9	0	12
8	9	8	51.46	40.5	7.3	3.01	100	49.1	0.91	13
3	9	9	47.17	40.2	7.2	2.99	100	0	0.65	14
6	6	5	37.23	36.6	6.6	2.72	50	34	1	15
3	8	5	42.59	38.8	7	2.88	75	25.5	1	16
6	8	5	45.13	40.1	7.2	2.98	100	29.4	0.4	17
3	8	9	44.66	39	7	2.9	51	0	1	18
5	5	6	33.2	32	5.8	2.38	0	18.2	0.48	19
3	7	9	36.9	35.4	6.3	2.63	50	0	0	20
8	7	4	37.8	36.8	6.6	2.73	50	49.4	0.59	21
7	5	4	33.2	32	5.85	2.48	0	49.5	0.5	22
7	8	5	38.15	37.2	6.6	2.76	24	43.1	1	23

Table 2 - Variance analysis of data obtained from bread samples prepared with different amounts of transglutaminase (TG) enzyme and soybean meal flour, processed at different ultrasound levels

Model	Total ash		pH		Moisture		porosity		Taste score		Texture score		color score	
Source	Estimate the coefficient	p-value	Estimate the coefficient	p-value	Estimate the coefficient	p-value	Estimate the coefficient	p-value	Estimate the coefficient	p-value	Estimate the coefficient	p-value	Estimate the coefficient	p-value
Model	-	< 0.0004	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	< 0.0001	-	<0.0001
Linear Mixture	-	<0.0003	-	<0.0001	-	<0.0001	-	<0.0001	-	<0.0001	-	0125/0	-	<0.0001
A-TG	12.02	<0.0187	34.79	<0.0001	187.57	<0.0001	289.71	<0.0001	0.21	0.244	58.69	0.0035	-7.51	0.083
B-soybean meal	2.78	<0.0006	6.15	0.237	34.37	0.412	34.61	0.518	-0.200	<0.0001	6.22	0.385	7.90	<0.0001
C-Ultrasound	0.038	0.3772	0.63	<0.0001	3.46	<0.0001	6.08	<0.0001	-0.12	0.501	1.62	<0.0001	0.053	0.767
AC	-0.050	< 0.545	-3.87	0.9848	-4.22	0.4605	188.98	0.0053	0.265	0.665	2.41	0.9146	-617.18	0.0001
BC	0.060	< 0.4874	0.73	<0.0001	3.64	<0.0001	4.44	0.0007	0.402	0.599	1.59	0.0009	14.43	0.0003
AC^2	-	-	-	-	-	-	220.41	0.0399	-	-	-	-	9.71	0.6391
BC^2	-	-	-	-	-	-	0.45	0.8073	-	-	-	-	-0.016	0.9665
R-Squared	0.6342		0.9424		0.9306		0.9499		0.9642		0.8397		0.9835	
Adj R-Squared	0.5266		0.9254		0.9102		0.9212		0.9395		0.7925		0.9671	
Pred R Squared	0.3071		0.8992		0.8955		0.8655		0.8001		0.7598		0.9181	
Adeq Precision	7.551		23.819		21.258		20.094		19.684		12.928		24.881	

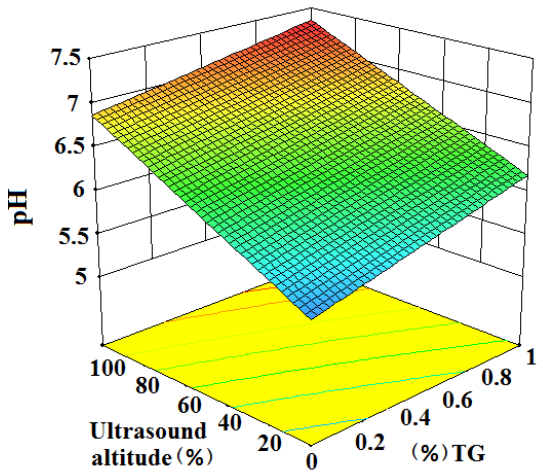

Figure 2- pH changes in different amounts of TG enzyme and ultrasound

Equation 2 shows the prediction model for pH. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is less than 0.2 and both of them are higher than 0.9 and also the sufficient accuracy index is higher than 4 (23.819), so the predictor model can be used.

3-3- Checking the results of humidity test

The analysis of the data obtained in this test showed that the moisture content of the samples was significantly influenced ($p<0.0001$) by the linear variables of transglutaminase enzyme and ultrasound (Table 2). As the amount of enzyme increased, the amount of moisture increased (Figure 3). The interaction of ultrasound with soybean meal also had a significant effect ($p<0.0001$) on moisture. According to the explanatory coefficients (Table 2), the linear parameter of the transglutaminase enzyme had the greatest effect on this characteristic. Similar to this phenomenon, it happened in the research of Gharib Zahedi et al. (2017) in connection with the absorption of more moisture in noodle samples containing transglutaminase enzyme. Maintaining more moisture in the samples is due to the increase in the water holding capacity in the dough tissue, which is caused by the increase in the emulsifying property that is created as a result of the activity of the transglutaminase enzyme. The novel extra- and intramolecular covalent cross-links between the amino acids glutamine and lysine lead to the formation of high molecular weight proteins and can effectively produce a product with higher water holding capacity, improved thermal stability and elasticity.[24]. In the review of the selected models, for both the mixing plan and the process, a linear model was suggested by the software in fitting the humidity data compared to other models ($p<0.0001$, Table 2). Equation 3 shows the prediction model of humidity. Given that the difference in the values of two parameters R^2 Modified and R^2 Predicted (Table 2) is less than 0.2 and both of them are higher than 0.9 and also the sufficient accuracy index is higher than 4 (21/258). Therefore, the use of predictive model is suggested.

relationship (3)

Moisture= +352.217* TG+30.100* soybean meal +31.367* wheat flour-0.23748* TG * ultrasound +0.0767* soybean meal * ultrasound+0.0686* wheat flour * ultrasound.

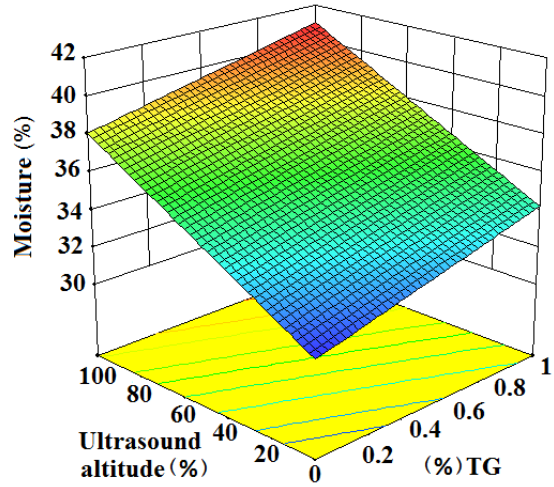

Figure 3- Moisture changes in different amounts of TG enzyme and ultrasound

3-4- Examining the results of the porosity test

The porosity of the samples has a significant effect ($p<0.0001$, Table 2) Enzyme TG was placed and with the increase in its concentration, the porosity of the samples also increased (Figure 4). Also, the higher the coefficient of explanation (71/289) compared to other variables, it also shows the significant contribution of the enzyme in increasing the porosity of the samples(Table 2). This effect was also seen in the research of Servali et al. (2011). This is due to its effect on the glutenin protein of the doughAs a result of the crosslinking of lysine and glutamine, a wider and stronger network is formed.25]. Applying ultrasonic waves increases the number of air bubbles in the dough and increases the porosity due to better aeration of the dough (Figure 4). Similar to this research, in the research of Meibodi et al., it was found that ultrasound causes more porosity in bread[26]. The interaction effect of enzyme with ultrasound and soybean meal with ultrasound showed a high significance (Table 2) and caused an increase in porosity. By increasing the percentage of soybean flour with ultrasoundIt provides more substrate for the operation of transglutaminase enzyme and creates a wide network by connecting cross links. The

findings of Sheikh al-Islami and colleagues (2009) also showed that the use of ultrasonic waves increases the amount of aeration and as a result causes more porosity in bread. In choosing the combined model, for the mixing plan (components of soybean flour and transglutaminase enzyme) the linear model and for the process plan (ultrasound domain) the quadratic model was the better model in fitting the data obtained from the porosity compared to other proposed models (0.0001) >p, Table 2).

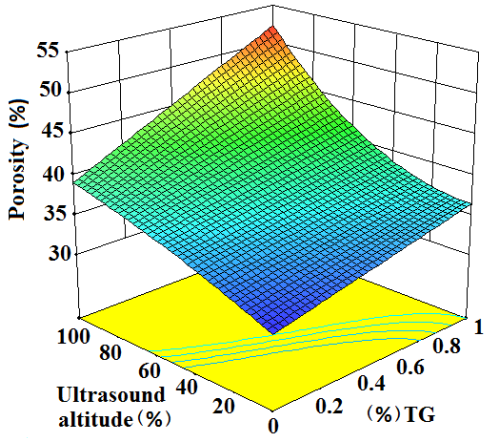

Figure 4- Porosity changes in different amounts of TG enzyme and ultrasound

Relationship 4 shows the prediction model provided by the software that is related to the amount of porosity. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is less than 0.2 and both of them are higher than 0.9 Also, the index of sufficient accuracy is higher than 4 (20/094), so the predictive model can be used.

Relationship (4)

Porosity = +611.501 * TG+30.455* soybean meal +30.771* wheat flour 10.224* TG * ultrasound -8.838* soybean meal * ultrasound +0.150* wheat flour ultrasound +0.177* TG * ultrasound altitude^2 +1.061 * soybean meal * ultrasound altitude^2 -7.029 * wheat flour * ultrasound^2

3-5- Examining the results of the taste test

In this feature, only soy flour has a significant negative effect (0001/0>p, Table 2) on the taste score of the produced samples and the taste score decreased with the increase of its amount (Figure 5). This negative effect is caused by the bean flavor of soy flour.The result of this research is consistent with the result of Ali et al. (2022) who used modified cheese and soy enzymes in bread.[27].

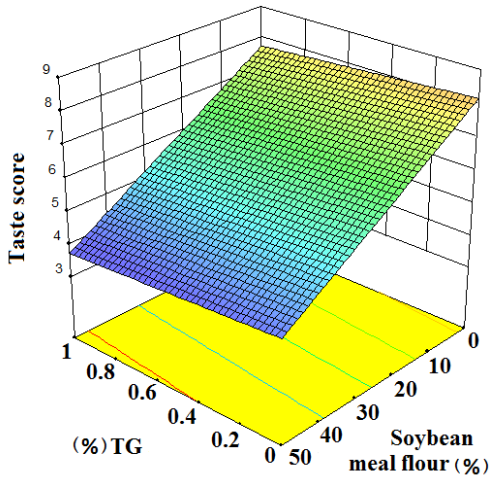

Figure 5- Changes in taste score in different amounts of TG enzyme and soy flour

In the review of the selected models, both for the mixing design (components of soybean flour and transglutaminase enzyme) and for the process design (ultrasound domain), the linear model is a better model in fitting the data obtained from the taste score than other proposed models. was (p>0.0001, Table 2). The prediction model in relation 5 shows the amount of taste score. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is less than 0.2 and both of them are higher than 0.9 and also the sufficient accuracy index is higher than 4684/19) is therefore the predictive model can be used.

Relationship (5)

Taste score=+3.572* TG-33.546* soybean meal +8.309* wheat flour -5.359* TG * soybean meal-5.40* TG * wheat flour+67.18* soybean meal * wheat flour+3.619* TG* soybean meal * wheat flour -1.787* TG * soybean meal -1.831* TG * wheat flour+ 60.095* soybean meal *wheat flour

3-6- Examining the results of the texture test

The data obtained in this test showed thatThe highest texture score related to There were samples that contained the highest amount of enzyme

Transglutaminase and the lowest amount of soybean meal were affected by the highest intensity of ultrasound (Figure 6). Analyzing the variance of the data, the linear variables of transglutaminase enzyme ($p<0.01$) and ultrasound ($p<0.0001$) were significant (Table 2). So that by increasing the amount of enzyme and ultrasoundTexture score Increased. Increasing the intensity of ultrasound provides more substrate for the enzyme, as a result of which more lysine and glutamine can connect with each other and create a wider and stronger network. The interaction of soybean meal with ultrasound has a significant effect ($p<0.0001$) onTexture score had According to the explanatory coefficients (58/69), the linear parameter of transglutaminase enzyme had the greatest effect on this characteristic (Table 2).In confirming the results of this research, the results of the researchRomiet al showed that the enzyme Transglutaminase had a positive effect on the texture of the samples[28]. Also, in another research, the results showed that the use of ultrasound in breads containing soy flour improves the gelatinization characteristics of the texture [29].

Equation 6 shows the prediction model of texture score. Given that the difference in the values of two parameters R^2 Modified and R^2 predicted is less than 0.2, and both of them are higher than 0.9, and the index of sufficient accuracy is higher than 4 (928/12) is therefore the predictive model can be used. In the review of the selected models, for the mixing plan (components of soybean flour and transglutaminase enzyme) the linear model and for the process plan (ultrasound domain) the quadratic model was a better model in fitting the data obtained from the tissue than the other proposed models (0.0001) >p, Table 2).

relationship (6)

Texture score= +107.638* TG+4.331* soybean meal +4.918* wheat flour +0.0638 * TG * ultrasound +0.0313* soybean meal * ultrasound +0.0324 * wheat flour * ultrasound.

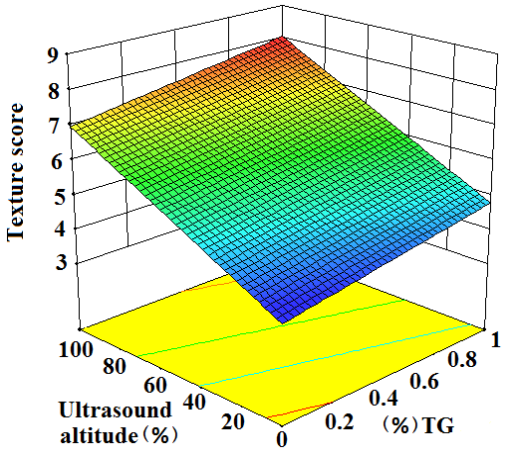

Figure 6-Changes in texture score in different amounts of TG enzyme, soybean flour and ultrasound

3-7- Check the results of the color test

Contrary to the examined characteristics, which the linear effects of enzyme and ultrasound were significant on them, none of endo had a significant effect on the two characteristics of color and taste. An interesting point is the significant effect of enzyme interaction with ultrasound. Also, the linear effect of soybean meal on the color of the samples was very effective(0001/0>p, Table 2). The reason for that was the light brown color of soybean flour, which increased the color score by increasing its share. Due to the fact that during the extraction of oil from soybeans, the heat used causes its lipoxygenase enzyme to coagulate, so it does not have color removal properties.Also, in the research of Mashaikh et al., it was found that in bread samples produced with amounts of 3-12% defatted soybean flour, the samples containing 3 and 7% soybean flour had the same appearance as the control samples [21]. Figure 7 shows the positive changes in the color score of the samples during the increase of soybean meal flour.The prediction model in relation 7 shows the color score. Given that the difference in the values of two parameters R^2 Modified and R^2 It was predicted to be less than 0.2 And both of them are higher than 0.9, and also the sufficient accuracy index is higher than 4 (24.881), so the predictive model can be used.

Relationship (7)

Color score =+4.206* TG+12.31* soybean meal +3.162* wheat flour+ 48.301 * TG *ultrasound -1.254 * soybean meal * ultrasound +0.118* wheat flour * ultrasound -1.466 * TG * ultrasound^2 +0.037 * soybean meal * ultrasound^2 -3.473* wheat flour * ultrasound^2

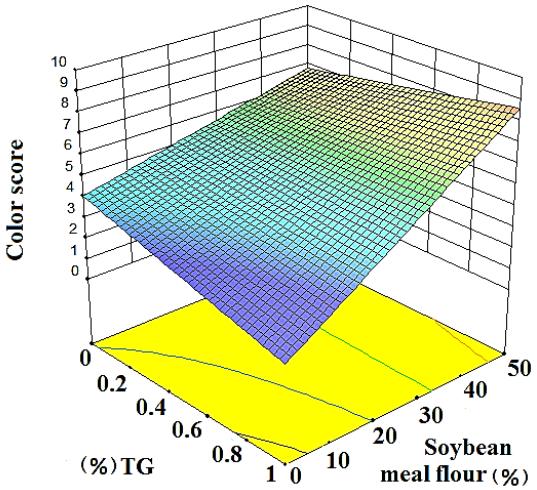

Figure 7- Changes in color score in different amounts of TG enzyme and soybean meal flour

8-3- Determining the optimal values of the variables

In order to determine the optimal values of variables by Design Expert software, First, indicators and criteria should be considered and selected for it, which were: the highest amount of soybean meal flour, the highest amount of porosity, the highest amount of color, texture and taste scores. The output results of the software showed that in order to produce bread samples with the defined criteria, the formulation should be33% soybean flour, 1% enzyme, 66% wheat flour and 100% ultrasonic rangeused Based on predictive models used in the formulation of components and ultrasound, the amount porosity, color, taste and texture scores respectively; 52%, 6.05, 5.27, 8.55 were calculated.

4 - Conclusion

In this studyWith the aim of increasing the nutritional value of bread، Samples of bread with soybean flour It was enriched and at the same time transglutaminase enzyme and ultrasound were used to improve the bread texture. The results showed that, in general, with the increase of soybean flour, the taste score decreases, and there is a maximum of 33% possibility of replacing wheat flour with soybean flour, which creates a relatively good taste score (6 out of 9). Achieving maximum porosity is provided by using 1% enzyme and 100% ultrasound range in the samples. In this research, the role and importance of transglutaminase enzyme and ultrasound in creating porosity in the samples were determined, which led to an increase in the texture score and color of the samples, and therefore they can be used as substitutes for chemical improvers of the texture of bakery products. In the end, it is suggested that the possibility of using other cereal flours along with transglutaminase enzyme and ultrasound should be investigated in the future researches in order to provide the possibility of producing and diversifying breads with higher nutritional value.

5- Resources

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چکیده

کنجاله سویا یکی از منابع پروتئینی گیاهی است که به همراه پروتئینهای آرد گندم می‌تواند منبع کاملی از اسیدهای آمینه را برای بدن انسان فراهم می کند لذا بکارگیری آن در نان می‌تواند به رفع کمبودهای پروتئینی کمک شایانی بنماید. بدین منظور برای تهیه نان بربری حاوی کنجاله سویا، طرح ترکیب شده دارای یک دسته متغیرهای اختلاطی، شامل سطوح مختلف آنزیم ترانس گلوتامیناز (۰ تا ۱ درصد)، کنجاله سویا (۰تا ۵۰ درصد)، آرد گندم به عنوان پرکننده (۰ تا ۱۰۰درصد) و یک متغیر فرآیندی شامل دامنه فراصوت (۰تا ۱۰۰ درصد) استفاده گردید و خصوصیات فیزیکوشیمیایی و حسی شامل خاکستر کل، pH، رطوبت، تخلخل و امتیازات طعمی، بافت و رنگ مورد بررسی قرار گرفت. نتایج نشان داد که آنزیم ترانس گلوتامیناز و فراصودت دهی روی خصوصیات فیزیکوشیمیایی و تخلخل تاثیر معنی داری (P<۰/۰۰۰۱) دارند. بالا رفتن قابل توجه امتیاز رنگ نمونه ها ناشی از تاثیر مثبت و معنی دار (P<۰/۰۰۰۱) کنجاله سویا روی آن ویژگی بود. ویژگی تخلخل نمونه ها نیز بسیار تحت تاثیر معنی دار (P<۰/۰۰۰۱) برهمکنش آنزیم و فراصوت قرار گرفت. در نهایت به منظور دست یابی به نمونه های داری بیشترین میزان تخلخل و امتیازات رنگ، طعم و بافت پیشنهاد می‌گردد که از نسبت اختلاط آرد کنجاله سویا ۳۳ درصد، آنزیم ۱درصد، آرد گندم ۶۶ درصد، فراصوت۱۰۰ درصد استفاده گردد.