Effect of Chenopodium Quinoa Wild Flour on Different Physical Properties of Baguettes

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Abstract - Chenopodium Quinoa Wild flour is considered as one of the functional products due to the high number of benefits associated with it. It has been also studied extensively as an enriching ingredient because of its high nutritional value. The present study attempts to investigate the impact of adding Chenopodium Quinoa Wild flour on different properties of baguettes. To this end, different percentages of wheat flour (%0-30) have been substituted by Quinoa flour to produce baguettes. Then, rheological tests (including Extensograph and Fariongraph) have been conducted on the dough and bread tests (texture, sensory evaluation) have been conducted afterward. The mean results have been analyzed statistically through one-way ANOVA and within a confidence interval of %95. The results suggested that concerning farinograph properties, the addition of quinoa flour resulted in higher water absorption and longer time required for dough expansion. Moreover, the addition of up to %20 quinoa flour results in higher stability of the dough. Regarding extensograph features, the addition of quinoa flour results in dough's energy and strength reduction as well as its extensibility. Besides, the addition of quinoa flour up to %10 improved the sensory features of baguettes; however, higher amounts of that, resulted in a significant reduction of the product's acceptability, fragrance, taste, and texture. In short, it can be concluded that the best experimental design for the addition of quinoa flour was a %10 increase.

Keywords: quinoa flour; extensograph; farinograph; baguette; texture-related properties

Introduction

Wheat is one of the oldest and most valuable plants in the world which is cultivated in a large volume throughout the world. It supplies calories for our body more than anything else and its protein supply in the human diet is the highest as well. Wheat is among the first agricultural products which have been cultivated by a human. The history of wheat domestication dates back to 12000-18000 years BC and perhaps its beginning has been marked by collecting the wild species of current wheat species. It has been conjectured that Southwestern Asia is the origin of wheat (Payan, 2001).

According to the review of the related literature carried on by the Food and Agricultural Organization (FAO), the middle-eastern countries' inhabitants supply nearly %70 of their required daily energy from wheat and other food products using wheat as their ingredient. According to national statistics, the annual bread consumption is 135-500 g per day and 150-200 kg per year. It's noteworthy that in rural and low-income urban families, sometimes up to %75 of an individual's calorie is supplied by bread (Rajabzadeh, 2001).

Different wheat bread, as a basic part of a human's diet, is considered vital for supplying the nutritional requirements of the body. Recently, baguette bread has received increased attention because modern dough processing and baking involved in the production of this type of bread is such that the bread waste is lowered won and it will result in preserving the vitamins and proteins existing in bread and will result in higher durability of bread (Buehler, 2006).

Chenopodium Quinoa is a high-nutrition plant, indigenous to North American regions and has been long used as food there (R.Repo-Carrasco et al., 2003). Due to its nutritional values, quinoa is highly under attention and it has attracted people's attention due to its high quality and nutritional benefits this seed is farinaceous and two-splits. Thus, it's not a grain; rather, it’s discussed as a semi-grain (Demir & Kilinc, 2017). It's rich with regards to lysine basic amino acid and makes it to be famous as a whole protein seed compared with some vegetables. Besides, it's gluten-free and it can be beneficial for those afflicted with coeliac disease or those who are allergic to wheat. The oily constituent of this seed is of high quality and very nutritious. It's rich in iron, and magnesium and supplies fiber, Vitamin E, copper, phosphor, some variants of vitamin B, potassium, and zink requirements of the body, chenopodium quinoa is rich in terms of their micronutrient content, including minerals and vitamins.

This seed is considered as really significant, such that Food and Agricultural Organization of the United Nation, entitled 2013 year as the international quinoa year and the purpose in so doing was to attract global attention to the role quinoa plays in the provision of food security, nutrition, and fighting against hunger and its significance for future generations.

Besides, quinoa is a low-requirement plant and is resistant to drought, such that it can be cultivated under limited-resources. Therefore, quinoa is a plant that is compatible with Iran's climatic conditions and can be cultivated as a good substitute for wheat and other whole grains. In the case of quinoa flour will be mixed with wheat flour, super-beneficial bread will be produced by using the high nutritional value of quinoa seed.

Ghsemizade et al. (2016) studied gluten-free bread which has been produced from the combination of multiple ingredients including quinoa, corn, and rice flour. They studied the impact of three variables of quinoa flour (%0-30), cornflour (%0-30), and Xanthan gum (0-1.5) on physical (e.g. color, texture, special volume) and chemical properties (e.g. water content, ash, fat, and seed's inflammation power) properties of the bread. Their results illustrated that the addition of quinoa and xanthan gum to the bread resulted in higher water content and ash of the bread samples and improved both bread's texture and color. Finally, the optimized formula for gluten-free bread has been obtained as %19.39 quinoa flour, %9.39 corn flour, and 0.5 xanthan gum.

Elgathy et al. (2013) studied the improvement of volume and texture of free-gluten bread using quinoa white flour. They suggested that quinoa white flour can enhance the volume of free-gluten bread as compared with those produced with corn or rice four up to %33. Besides, without bran ingredients, quinoa flour baking performance will be enhanced. The basic properties of free-gluten bread using quinoa white flour experienced a significant quality improvement compared with rice and cornbreads.

Brito et al. (2013) studied the nutritional and sensory properties of quinoa-based free-gluten cookies. They showed that quinoa flour had a negative influence on the special volume of the cookies and will result in the production of cookies with a lower volume. Meanwhile, it will contribute to higher softness of the cookies their results illustrated that the optimal formula for free-gluten cookie includes %30 of quinoa flour, %25 quinoa fin, and %45 of corn starch. Therefore, besides being gluten-free, the resultant cookies are of a high nutritional value in terms of necessary amino-acids.

Salazar et al. (2017) produced enriched bread containing quinoa flour and whey protein. Their results suggest that the use of quinoa and whey protein results in improvement of bread's texture and will result in higher durability of the bread and its sensory features compared with the bread produced from wheat flour. Thus, their results confirm the potential of quinoa flour and whey protein as ingredients to improve the qualitative properties of bakery products. Besides, the highest favorable percentage of quinoa flour has been declared as %15 and higher percentages of that will result in the reduction of its general acceptability as well as some of its sensory features.

Considering the review of the related literature, the objective of the present study is to study the impact of quinoa chenopodium quinoa wild flour on different physical properties of baguettes.

Materials and Methods

Materials

The first material used in this study was premium Setareh wheat flour with a bran percentage of %21. Quinoa seed has been purchased from the local marketplace and xanthan has been supplied from Avizhe Farjood Parsi Company. All the chemicals used in this study were of an analytical grade.

Dough preparation

The baguette dough has been prepared by adding %95 of Setareh flour, %2 of salt, required amount of water to reach a favorable dough formidability %2 of dry baking yeast, %1 of flour treatment agent, and finally adding quinoa seed flour according to pre-specified percentages in study treatments. Then, the relevant tests have been carried on the paste.

Treatments

The treatments used in this study are displayed in Table 1. The numbers included in Table 1 are in the form of weight percentage (%wt.). The above-mentioned treatments have been prepared and then, other steps have been taken, bread was baked and relevant tests have been carried on.

Baking bread

After conducting dough tests, it will be put for 40 minutes under a temperature of 35-38℃ until fermentation would occur. Then, the baguettes have been baked. The baking process has been done under a temperature of 250 ℃ for 15 minutes. Then, bread has been cooled down and packed in polyethylene bags to prevent drying and the emergence of unfavorable changes until testing time. Finally, other tests have been done on the baked baguette.

Table 1: the formulation of the treatments used in the testing phase (the numbers are expressed in %wt)

Treatment	Quinoa flour	Xanthan gum	Salt	Flour treatment agent	Dry baking yeast	Setareh Flour
T_0	0	0	2	1	2	95
T_1	10	0.1	2	1	2	84.9
T_2	20	0.1	2	1	2	74.9
T_3	30	0.1	2	1	2	64.9

Tests

Farinograph

The impacts of adding different study treatments on some dough properties (including dough developing time, dough stability, and the water absorption rate of the flour compound) have been determined using farinograph (Youjeh bash, Turkey) and under the standard procedure of ACC54-21.

In this procedure, at first, the device's water tank's thermostat has been turned on, until the water in it reaches a temperature of 30°C. Ten device's bort has been filled with water. The flour has been sieved such that any impurity would be separated from that and uniform aeration occur. Then 300 g of flour has been weighed using a scale and 5g of salt and the relevant amounts for other additive treatments have been poured into the device's pot. Then, it has been turned on. After one minute, mixing has been finished and a uniform mixture has been obtained. Then, using the device's bort section, water has been gradually added to the flour and the water absorption plot has been plotted then.

Water addition continued until the plot reached FU 500 line. It's necessary to maintain the plot on this line for at least three minutes which is only possible by adding more water. After 5 minutes, the device has been turned off and the amount of water added can be read from the bort. This test has been conducted to define the water absorption rate and the resultant dough has been used to test the extensograph.

To plot the farinograph curve, 300 g of flour has been weighed once again and has been poured into the device without adding salt. This test has been conducted once again and the amount of water obtained from the previous stage has been added at once and the relevant curve has been plotted for 20 minutes by the device. The resultant plot in this stage of the study has been used to interpret farinograph test results.

Extensograph

Extensograph has been used to analyze the texture and resistance-related features, developing duration, and dough's energy. The test has been conducted at three different times of 45, 90, and 135 minutes (ICC standard method, No. 140).

The dough obtained in Farinograph stage has been used to carry on extesograph test. To this end, the obtained dough has been divided into two 150 g parts. Each part has been put in the device's dough piece-forming for 20 seconds. The device forms dough pieces through 20 rpm motion around an oval center. Then, it has been rolled in the roller part of the extensor device and put in the hothouse such that the dough would take a rest under a temperature of 25 °C. After this time (e.g. 30, 90, and 130 minutes), the dough has been take out and put in a holder-equipped section. Then, through pressing the intended bottom, the device's anchor has been lowered down and through pulling the dough downward, extensograph plot has been depicted. Finally, the plotting has been stopped when the dough tore apart, the anchor stopped at the end of the line and moved upward next. The plot obtained in this stage has been used to interpret extnsograph results.

Bread Tests

Bread Texture Analysis

To study the bread texture's toughness, testometreic texture-analysis device, made in the UK has been used. A probe with a diameter of 1 mm penetrates the dough under a velocity of 3 mm/s and will compress it until it tears apart. The force required to drill the dough and length of dough until being torn apart has been recoded as dough's toughness and extensibility respectively.

The bread samples have been cut in dimensions of 525mm and the plunger moving under a 3 mm/s velocity has been allowed to apply pressure on the dough until it tears apart. The force being recorded at the time of tearing apart is based on Newton and has been recorded as a criterion of bred samples' texture toughness.

Sensory evaluation

Sensory features including color, flavor, taste, texture, softness, and general acceptability have been evaluated using the sensory evaluation system's test panels (5-point hedonic). The panelists assigned a 1-5 score to the products and ranked it on a Likert scale from "I like it very much", to "I don’t like it that much" to define the most suitable combination (A'lim Zaker et al., 2012).

Statistical Analysis

To analyze the study data, descriptive and inferential statistics have been used. In descriptive statistics, central indices such as mean, and dispersion indices such as variance are used. In inferential statistics, any of the study hypotheses have been analyzed using proper statistical tests including covariance analysis. The comparison between the results of chemical, rheological, and sensory experience evaluation have been compared using Duncan Test in %95 confidence interval ($P < 0.05$) using SPSS software. To this end, at first, the repetitions have been inserted in SPSS software, then, the results have been compared using one-way ANOVA. To study the significance of the difference between means, the Duncan test has been used and their significance has been studied in %95 confidence interval. Microsoft Excel has been used to plot the diagrams by entering the mean values.

Results

Dough tests

Farinograph

In farinograph test conducted on baguette dough, different values including water absorption rate, stability, and dough developing time for the control sample and samples including %10, %20, and %30 of quinoa flour, have been measured. The mean results have been computed and their comparison is included in Table 2. The indices including water absorption, stability, and dough developing time are to be analyzed separately.

Table 2: the results of farinograph test obtained from different treatments as a result of adding different amounts of Chenopodium quinoa wild flour to baguette dough.

Study samples	Water absorption (%)	Stability (min)	Developing time (min)
T0 (control)	1.50 c	7 c	52.4 c
T10	6.27 b	11.43 a	52.8 c
T20	7.10 a	8018 b	54.1 b
T30	6.45 b	5.47 d	57 a

Similar letters in each column illustrate a lack of significant difference in results ($P < 0.05$)

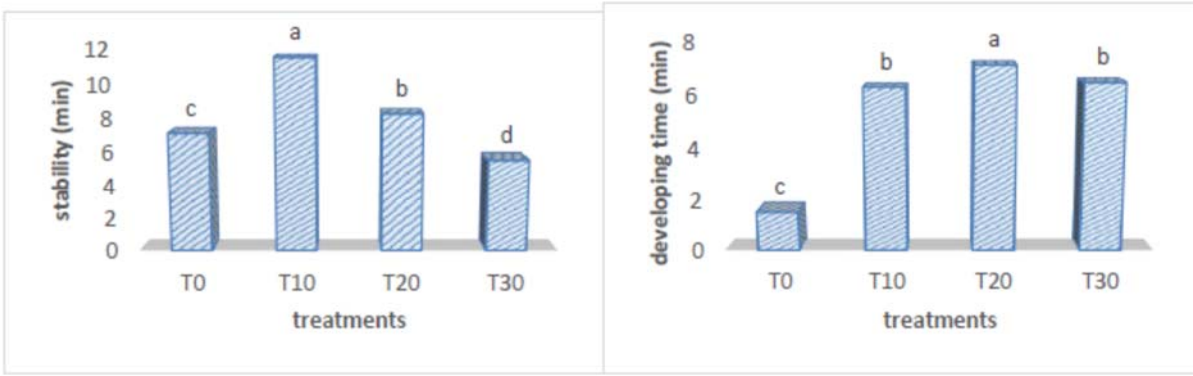
Stability

The graph for dough stability and its comparison with other samples as a result of adding different amounts of Quinoa is displayed in Figure 1-a. according to the results, up to %20 of dough stability will be increased as compared to the control treatment as a result of adding quinoa flour; however, higher amounts of quinoa flour, up to %30 significantly reduces the stability ($P < 0.05$). To this end, the highest stability among study treatments included %10 of quinoa flour (11.43 min) and the lowest stability is for the treatment containing %30 of quinoa flour (5.47 min). This illustrates the positive impact of quinoa flour on dough stability in samples containing less than %20 quinoa flour. Increasing the amount of this flour up to %20 will hurt dough stability.

Developing time

The graph for investigation and comparing the impact of adding quinoa on dough development time is depicted in Figure 1-b. the results suggest that the addition of quinoa flour will increase dough's developing time among all study treatments. The highest developing time is for the treatment sample containing %20 of quinoa flour (7.10 min). Among the two treatment samples containing %10 and %30 of quinoa flour, there wasn't any significant difference between the results. The lowest developing time is for the control sough which lacks any quinoa flour (1.50).

Their results suggest the high impact of quinoa flour addition on dough's developing time compared with treatment samples lacking that.



B a

Figure 1: a) variations in dough stability as a result of adding different amounts of quinoa flour on baguette dough. Different letters illustrate a significant difference between results ($P < 0.05$); b) variations in dough development time as a result of adding different amounts of quinoa flour on baguette dough. Different letters suggest a significant difference in the results ($P < 0.05$).

Extensograph

Different features including maximum resistance, energy, and extensibility of the dough samples containing different amounts of quinoa flour as well as the control sample, have been analyzed using extnsograph device. The results obtained from such analysis and the impact of adding different amounts of quinoa flour on these features has been investigated and displayed in Table 3. Concerning the above-mentioned features, the results have been separately analyzed statistically, the results of which are included in the following tables.

Table 3: different extensogaph properties as a result of adding different amounts of quinoa flour on the quality of baguette dough during different intervals of 45, 90, and 135 minutes.

(extansibilitys)			HE(Maximum resistance)			Cm^2(Energy)			
135	90	45	135	90	45	135	90	45	Time (min)
$9/9^{aC}$	$11/9^{aB}$	$13/2^{aA}$	838^{aA}	685^{bB}	448^{bC}	100^{aB}	107^{aA}	83^{aC}	T0
$8/4^{cC}$	$9/3^{cB}$	$11/4^{bA}$	739^{bA}	700^{aB}	474^{aC}	79^{bB}	86^{bA}	77^{bC}	T10
$9/1^{bC}$	$9/8^{bB}$	$10/8^{cA}$	479^{cA}	509^{cB}	351^{cC}	63^{cB}	68^{cA}	59^{cC}	T20
$8/4^{cC}$	$8/6^{dB}$	$9/6^{dA}$	409^{dA}	371^{dB}	289^{dC}	49^{dA}	46^{dA}	41^{dB}	T30

Small letters in each column suggest a lack of significant difference among the results listed in that column and capital letters suggest a lack of significant difference between results listed in rows for that property ($p < 0.05$)

Energy

Dough's energy level has been measured in three different periods of 45, 0, and 135 minutes and the relevant results and variation trend has been displayed in Figure 2-a among different treatment samples containing different amounts of quinoa flour.

The analysis results illustrate that in all study samples, there would be an increase in energy level after 90 minutes. Then, this energy is reduced in a time frame of 13 minutes. This trend is observable within all treatment samples, with and without quinoa flour. The sample containing %30 of quinoa flour didn't display any significant difference in variations under a period of 90-135 minutes.

Besides, the study results illustrate that the addition of quinoa flour to all study samples resulted in a significant decrease in dough's energy level ($p < 0.05$), such that during all different time frames, the highest energy is for the control sample, i.e. the sample lacking quinoa flour and its energy level will be decreased after adding quinoa flour. It can be seen that the lower energy level is for the sample containing %30 of quinoa flour. In all cases, the variations in study results are included within a confidence interval of %95 among all other results ($P < 0.05$).

Extensibility

Dough's extensibility has been measured in different time intervals of 45, 90, and 135 minutes and the diagram for variations in dough's extensibility after addition of quinoa flour on dough's extensibility is displayed in Figure 2-b.

The results illustrate that among all studied samples, any increase in preserving the dough resulted in a significant decrease in its extensibility, such that among all study samples, the highest extensibility has been observed in 4 minutes and the lowest extensibility has been observed within 135 minutes after preparing the dough.

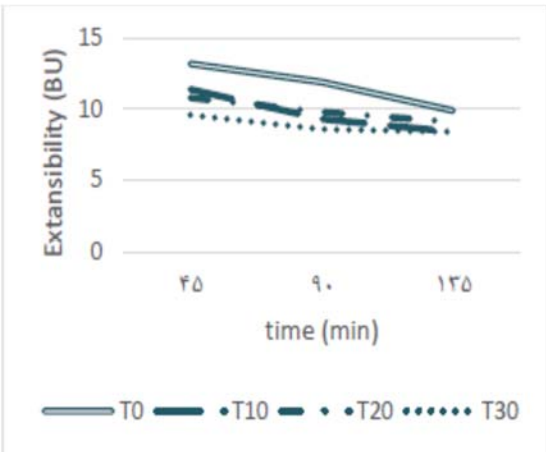
Moreover, the comparison of the results for all study samples suggested that the addition of quinoa flour resulted in a significant decrease in dough's extensibility ($P < 0.05$). The highest dough extensibility was for the control sample lacking any quinoa flour, and the lowest extensibility was for the study sample containing %30 of quinoa flour. The variations between all the results were within a %95 confidence interval from a statistical viewpoint.

Maximum resistance

Dough's maximum resistance will be measured in time frames of 45, 90, and 135 minutes just like other dough properties. The results obtained from comparing maximum resistance among all study samples are displayed in Figure 2-c. the results suggest that in all studied time frames, the higher conservation duration resulted in increased maximum resistance of the dough and this increase isn’t significant in the sample containing %30 of quinoa flour only; meanwhile, in all other study samples, the increasing trend was significant I a confidence interval of %95 from a statistical viewpoint ($P < 0.05$).

Besides, it has been observed in all study samples that the use of %10 of quinoa flour resulted in an increase in dough resistance in different time frames of 45, and 90 minutes as compared to the control sample; however, a descending trend has been observed under a time frame of 135 minutes. The addition of higher percentages of quinoa flour resulted in a significant decrease in maximum resistance, such that the least resistance has been observed within a sample containing %30 of quinoa flour which were significantly different ($p < 0.05$). In two study samples containing %20 and %30 of quinoa flour, a reduction in resistance has been observed in a time frame of 13 minutes; however, this reduction wasn’t statistically significant in these two study samples ($p < 0.05$).

a



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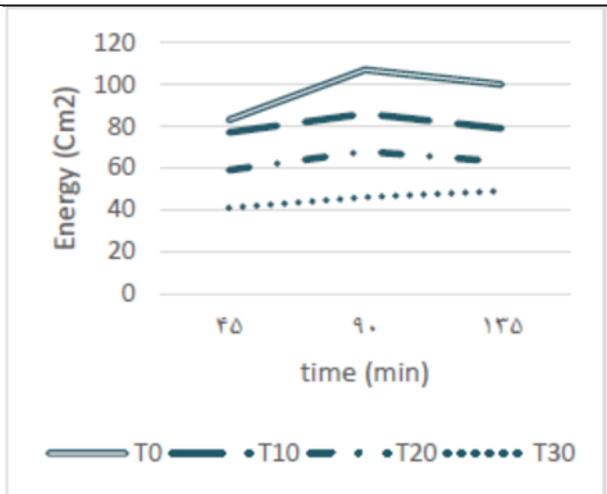

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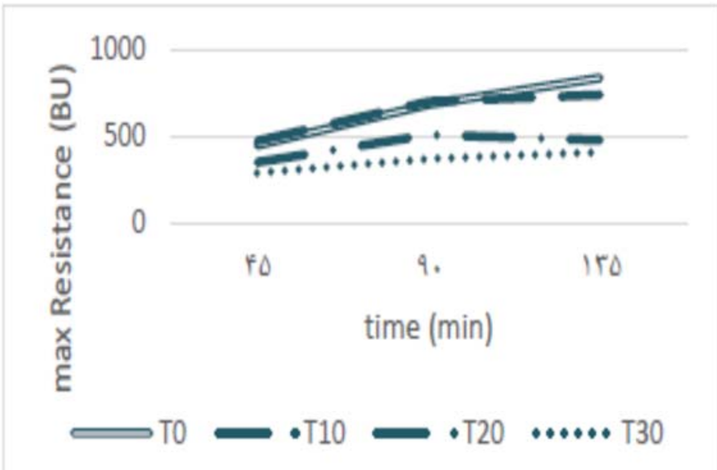

c

Figure 2: a) variations of dough's extensograph energy as a result of adding different amounts of quinoa flour on baguette dough under different time frames of 45, 90, and 135 minutes; b) variations of dough's extensograph extensibility as a result of adding different amounts of quinoa flour to baguette dough in different time frames of 45, 90, and 135 minutes; c) variations of dough's extensograph maximum resistance as a result of adding different amounts of quinoa flour on baguette dough in different time frames of 45, 95, and 135 minutes.

Bread's texture

The variations trend in bread's texture as a result of adding different amounts of quinoa flour and its comparison with the control sample lacking quinoa flour is displayed in Figure 3.

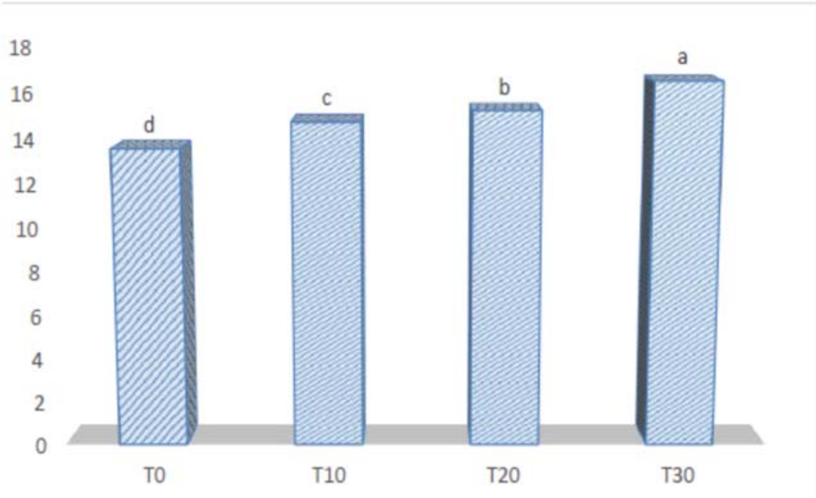

Figure 3: variations in the toughness of bread's texture as a result of adding different amounts of quinoa flour in baguette dough. Different letters illustrate the presence of significant difference among study results ($P < 0.05$)

The analysis of baguette's texture toughness illustrated that the addition of quinoa flour resulted in a significant increase in baguette's toughness, such that in all study samples, the highest baguette's toughness has been observed in the sample containing %30 of quinoa flour (16.5). Upon decreasing the content of quinoa flour, the baguette's toughness has been decreased as well and the lowest toughness has been observed in the control sample lacking any quinoa flour (13.5). The difference between study results was significant in a confidence interval of %95.

Sensory evaluation

The results related to the sensory evaluation of different properties of baguettes as a result of adding different amounts of quinoa flour are displayed in Table 4. The results are related to four senses including taste, flavor, color, and general acceptability the results showed that the addition of quinoa flour u to %10 results in a significant improvement of all sensory properties compared with the control sample. Higher addition of quinoa flour content, i.e. more than %10, in %20, and %30 quinoa flour samples, resulted in a significant decrease in all sensory properties which suggests the negative impact of the high amount of quinoa flour content on all baguette sensory properties. Among all properties being analyzed, the lowest and highest sensory acceptability is for samples containing %30 and %10 of quinoa flour respectively. All the obtained differences have been significant within a confidence interval of %95 $p < 0.05$)

Considering the sensory evaluation results, one can argue that the optimal content of quinoa flour is %10 and the addition of higher quinoa four will negatively influence various properties of baguettes.

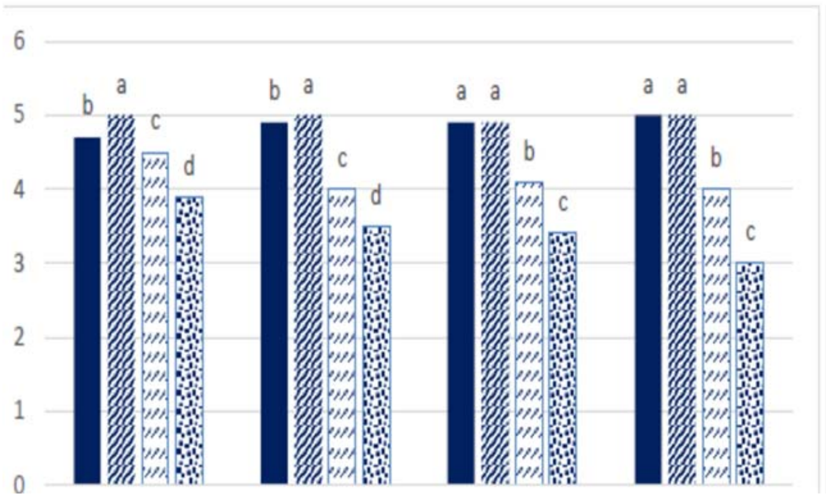

Figure 4: variations of sensory properties (color, taste, flavor, and general acceptability) of baguettes as a result of adding different amounts of quinoa flour. Different letters suggest the presence of significant differences among study results.

Conclusion

This study was an attempt to study the impacts of adding different amounts of chenopodium quinoa wild flour on different physical properties o baguettes addition of quinoa flour resulted in higher stability of the dough compared with the control sample lacking that. Dough's stability which is one of the fariongraph indices, suggests the time duration that the graph stays above 500 and suggests the dough's stability. The results suggest that the addition of up to %20 of quinoa flour resulted in a significant increase in dough's stability as compared with the control sample; however, higher contents of quinoa flour resulted in lower stability.

Dough stability is its potential in preserving primary humidity in the mixing stage. As with the results obtained in terms of water absorption, the dough will maintain the absorbed water inside itself due to the high fiber content of quinoa and doesn't lose water. Therefore, dough's stability will be increased. In dough samples with a quinoa content higher than %20, the dough's stability will be reduced which may be due to high water absorption, such that the dough sample cant preserve the excessive water anymore and will lose the extra water and this will be the main cause for lower dough stability. Moreover, due to lack of gluten structure as a result of high quinoa content, dough samples will form less gluten network and it can't maintain water inside its structure.

About the time required for dough development which is the required time through which the dough can reach the highest point in the graph, and highest water absorption, the addition of higher quinoa flour will result in lengthier dough development time and therefore, the duration of water absorption for the dough and achieving stability will be higher. This time duration is the lowest for the control sample and it seems that increasing its content will be favorable for %10 quinoa content and will improve the dough quality further.

Besides, in studying the extensograph test results, indices such as dough energy indices, maximum resistance, and extensibility duration have been studied as well. Dough energy displays the area under the graph depicted using extensograh and illustrates the dough potential during baking. Furthermore, dough's extensibility suggests they require tie for dough's extensibility until it tears away and it's a numerical marker (in seconds) on extensograph which cuts through the horizontal axis. Maximum resistance also displays the maximum resistance of the dough toward being torn apart while being pulled by the device.

The results suggest that among all study samples, the addition of quinoa flour led to a reduction in all the above indices, and the addition of %10 quinoa flour displayed fairly favorable results in terms of extensograph characteristics.

The reason behind these phenomena can be traced back to the inability of quinoa flour in forming a semi-gluten network, similar to that of wheat. Thus, the resulting dough isn't capable of preserving its resistance and forming a protein matrix; this, would be weaker compared with the quinoa sample and its strength will be lower.

It's noteworthy that in studying and selecting the most optimal study sample in terms of dough's texture properties, all the above-mentioned indices will be considered separately in defining the optimal sample.

The results obtained in this study are different from those obtained y Ebrahimzadeh et al. (2015) who studied the impact of quinoa on rheological properties of Barbari bread's dough in three substitution levels of %10, %20, and %30. The results of farinograph test didn't reveal any significant difference between the control sample and other study samples; however, there was a significant difference between the control sample and other study samples in resistance to extension, extensibility, and the required energy for dough extension.

Regarding the texture-related properties, the results suggested that addition of quinoa flour will result in the further softness of the baguettes, and increasing the amount of quinoa flour will enhance the bread's softness. This can be explained in the light of quinoa flour's inability in forming a gluten network due to its lack of gluten protein which will make it unable to preserve its water and will lose water during baking; this, the resultant read will be tougher.

The results obtained in this study are compatible with those obtained by Wong et al. (2015). They suggested that the addition of quinoa flour resulted in higher bread toughness and the softness of resultant bread would be decreased.

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