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The influence of the addition of germinated quinoa flour on the quality characteristics of wheat bread

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Abstract

The aim of this study was to highlight the effect of germinated quinoa flour addition, in different proportions (0%, 5%, 10%, 15%, 20%), in a refined wheat flour on bread quality properties. This effect has been highlighted analyzing the loaf volume, the porosity, the elasticity, the texture profile, the color parameters, the crumb microstructure and the sensory characteristics of the bread samples. At the end of the practical study, it was observed that at the maximum value of the addition (20%) the value of the parameters of volume, porosity and elasticity decreased, which led to the conclusion that the level of this addition must not be exceeded to obtain bread with superior characteristics quality. Analyzing the texture parameters, it was observed that the addition had an influence on all. For example, the springiness parameter had higher values only when the addition value of 15% is exceeded. Referring to the parameters of the sensory analysis, it can be said that the tasters positively appreciated the bread samples with the addition of germinated quinoa flour, especially up to a maximum of 15%.

Keywords: germinated quinoa, wheat flour, physical and sensorial characteristics, textural properties

1. Introduction

Bakery products are the most consumed foodstuffs worldwide [1]. However, consumers no longer enjoy the same nutritional intake after eating white bread because a low degree of extraction from the grain of wheat means a decrease of nutrients content. However, today people are increasingly interested in a healthy diet after years in which the majority of the population has faced various diseases and deficiencies caused by poor nutrition [2]. Thus, the consumer will certainly choose foods with a balanced nutritional profile, despite those who have nutritional deficiencies. Therefore, food specialists are always looking to find the best solutions to meet the nutritional needs of consumers, without negatively influencing the sensory characteristics of food. Speaking of white wheat bread, a solution to balance its nutritional profile would be the use of various flour additions. An example of this could be germinated quinoa flour.

Quinoa is part of the pseudo-cereals category. Pseudocereals belong to the dicotyledonous class and are an alternative to cereal consumption [3]. What makes them desirable in the diet, in addition to superior nutritional quality, is the fact that they do not contain gluten, which is an asset for people suffering from celiac disease [4]. Quinoa is a pseudo-cereal that, lately, is increasingly appreciated due to the fact that it has a balanced nutritional profile. Referring to the amino acid content, quinoa is in a superior position to wheat. The amount of lysine is twice in quinoa [5]. Among the nutritional compounds to be appreciated in the composition of quinoa beans are: saponins, phenolic compounds [6], high protein content [7, 8] and lower carbohydrate content [9]. Studies in the field have shown that the consumption of quinoa, in various forms, has a beneficial effect on health. For example, quinoa proteins have been shown to play a role in regulating blood pressure, in remediation of anti-inflammatory, anticarcinogenic and hypocholesterolemic problems [10]. Various studies have shown that quinoa has functional, nutritional, sensory and technological potential to be used successfully in food manufacturing recipes such as breakfast cereals, infants, fermented beverages, pasta and bakery products [11, 12].

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In this study, the use of quinoa flour in germinated form was chosen due to the advantages of the germination process. Studies have shown that germination has a positive effect on the nutritional profile of grains subjected to this process. Some authors have shown that the content of antinutritional compounds decreases after germination [13]. Other authors have pointed out that germination increases the bioavailability of some nutrients such as copper and zinc [14]. Moreover, experts claim that regular consumption of germs leads to a decrease in the incidence of chronic diseases (heart problems, cancer, neurodegenerative diseases). Moreover, the activation of the endoenzymes of quinoa grains during the germination process leads to the production of bakery products with superior quality properties because bread samples with improved volume could be obtained due to the addition of germinated quinoa flour in the recipe for making white wheat bread [15].

The aim of this study was to investigate the effect of germinated quinoa flour addition (in different proportion) in wheat flour, in order to highlight changes in the volume, porosity, elasticity, texture, microstructure, color and sensory properties of bread samples. As a final result, it was intended to establish the potential to use this addition in order to obtain bread with improved nutritional quality and to establish the optimal addition, so that the sensory properties do not suffer.

2.Materials and methods

2.1. Methods

For the preparation of bread samples, commercial white wheat flour was used, without the addition of additives. White wheat flour type 650 was purchased from the company *S.C. Dizing S.R.L.*, from Suceava, România. The germinated quinoa flour was obtained from red quinoa (*Chenopodium quinoa*). After the quinoa beans were germinated, they were lyophilized to reduce moisture and then grounded. The parameters of the germination process were: temperature of 25°C, constant humidity of 80% and germination was done in dark conditions, without exposure to light. After a germination period of four days, the germs were subjected to the lyophilization process, using a *Biobase BK-FD12* type lyophilizer (Jinan, China). The parameters of the lyophilization process were: temperature of -50°C, pressure of 10 Pa and duration of 15 hours. After completion of the lyophilization process, a 3100 laboratory mill, Perten Instruments, (Hägersten, Sweden) was used. It was chosen the lyophilization because, according to studies in the field, this process retains the nutritional properties very well [16]. All raw materials and bread samples were analyzed according to the specific standards that are in force at present.

2.2. Methods

To prepare the bread samples, all ingredients were mixed at 100 rpm in a Kitchen Aid laboratory mixer (Whirlpool Corporation, USA), for 15 minutes. The dough obtained was then divided, shaped and leavened at 35°C for 40 minutes. Then, the bread samples were baked in a bakery oven at 180°C, for 50 minutes.

After cooling the samples, specific analyzes were performed: specific loaf volume (with Fornet device, China), porosity, elasticity (according to SR 91: 2007). The Perten TVT 6700 Textural Analyzer (Sweden) was used to determine the texture of the bread samples, using the 35 mm cylinder and the two cycle's method under the action of the cylinder. The microstructure of the bread samples was highlighted using the Motic SMZ-140 stereo microscope (Motic, Xiamen, China). The color parameters of the bread samples were determined using Konica Minolta CR-400 colorimeter (Tokyo, Japan). The parameters L^* (darkness / brightness), a^* (shade of red / green) and b^* (shade of blue / yellow) were analyzed. A hedonic method (9-point scale) was used for the sensory assessment by the tasters of the bread samples. The following were considered: appearance, color, taste, smell, texture, flavor, overall acceptability of the bread samples. At this determination, 20 semi-experienced evaluators participated. They had age between 21 and 23 years.

2.3. Statistical analysis

All determinations were made in duplicate and were expressed as the means of the measurements ± standard deviation. For this, the IBM SPSS statistical package (free trial) was used and the significance of the variation among the samples ($p < 0.05$) was highlighted.

3.Results and Discussion

3.1. Effect of germinated quinoa flour addition on the physical characteristics of bread samples

The bread physical characteristics are shown in Table 1. As it may be seen, the loaf volume of bread samples was influenced by the addition of germinated quinoa flour. Thus, compared to the control sample, the value of the loaf volume of bread samples increased, but without the addition exceeding the percentage of 15%. At an addition of 20%, the loaf volume of the bread samples was lower than that of the control sample. The increase in the volume of bread samples with the addition can be due of the endoenzymes of quinoa grains, endoenzymes that were activated during the germination process and that led to improved yeast activity. Thus, it can be said that a larger amount of CO_2 has formed, which has the effect of increasing the volume of bread samples [17].The fact that the volume of bread samples was not adversely affected by the addition leads to the conclusion that the formation and the stabilization of the gas network during fermentation and baking were not greatly influenced by the addition. At the same time, the increase or the decrease of the volume due to the addition is attributed to the change of the nutritional composition of the dough matrix due to the contribution brought by the addition of germinated quinoa flour. Due to the addition, the amount of sugars in the samples increases, which has the effect of improving the activity of the yeast during the fermentation process and, implicitly, the production of gases [15].

Regarding porosity, it is observed that its value has been improved, up to a maximum of 15% addition. The increase in porosity is due to the fact that the addition has led to an increase in CO_2 production during fermentation and baking. The decrease in porosity to an addition of more than 15% is due to the fact that the amount of gluten in the bread is decreasing due to the fact that quinoa flour does not contain gluten. Gluten plays an important role in the fermentation and pore formation stage [18].

From Table 1 it can be seen that the porosity of the samples has been improved to a maximum of 15% addition. This can be attributed to the activity of the enzyme α-amylase [19], which was activated during the germination of quinoa beans.

Regarding the three physical characteristics of bread samples (volume, porosity, elasticity) it can be concluded that it is desirable to improve them because they are direct indicators of bread quality and greatly influence consumer choice. Thus, an addition of 10-15% germinated quinoa flour is desirable because, according to Table 1, it had a positive effect on the three physical characteristics of the bread samples.

3.2. Texture Profile Analysis of Breads Samples

The texture of the bread samples are shown in Table 2. As it may be seen, the addition had an influence on all the texture parameters that were tested. The value of the parameters springiness, gumminess, chewiness and cohesiveness increased compared to that of the control sample only after exceeding the percentage of 15% of the addition. The value of the resilience parameter decreased more and more with the increase of the addition percentage, without exceeding the value of 15% of the addition. However, the value of the resilience parameter was not greatly influenced by the addition of germinated quinoa flour. The results are consistent with those obtained in previous studies [20]. In general, the change in texture parameters can be attributed to the change in gluten networks structure, which was due to the addition of germinated quinoa flour. The decrease the value of the chewiness parameter can be explained by the weakness in the starch-gluten network.

3.3. Color Parameters of Breads Samples

The color characteristics of the crust and the crumb of the bread samples are also included in the category of bread quality indicators. Visual sensations have an important impact on consumer preference. Table 3 shows how the addition of germinated quinoa flour influenced the color parameters *L**, *a** and *b** of the bread samples. Looking at table 3, it can be seen that the addition influenced each parameter. Thus, the value of the parameter *L** decreased with the increase of the value of the proportion of the addition (both in the case of the crust and of the crumb). The value of the parameter *a** increased due to the addition, which means that the addition gave the bread a reddish tint. The value of parameter *b** decreased, which means that the samples took on a bluish tint, darkened in color. In general, the influence of color parameter values is attributed to the nutritional composition of quinoa beans.

Compared to wheat flour, quinoa flour contains a higher amount of protein, lipids and sugars [5], which influences the Maillard browning reaction. The change in the value of the color parameters of the bread samples is also due to the pigments that give the specific color to the outer coating of the quinoa grain. Regarding the quinoa pigments that contributed to the change in the color parameters of the bread samples, it can be stated that the red quinoa grains contain as pigment substances: β-caroten (12.42-32.71 mg/100g), lycopene (22.75-51.52 mg/100 g) and chlorophyll [21].

3.4. Crumb Microstructure of Breads Samples

The structure of the bread is defined by the pores that form during the leavening and baking stage of the bread. The pores are formed due to the release of CO_2 and gas retention. Consumers prefer bread with small and uniform pores, which are an index of quality. Figure 1 shows that when the addition value of 10% was exceeded, samples with larger pores and less density were obtained.

This was due to the fact that the amount of gluten in the matrix decreased and this influenced the CO_2 retention in the samples, which also had an impact on the microstructure of the bread core. Similar results were obtained for other studies on the possibility of using quinoa flour as addition to the bread making recipe [22].

Table 1.Physical characteristics of the bread samples with different levels of germinated quinoa flour (GQF) additions.

Bread samples	Loaf volume (cm^3/100g)	Porosity (%)	Elasticity (%)
Control sample	327.91±2.24^{a}	64.65±0.93^{a}	68.53±0.71^{a}
GQF_5	348.46±1.24^{b}	66.81±0.89^{b}	71.58±0.56^{b}
GQF_10	351.15±2.56^{b}	69.17±0.32^{c}	75.47±0.58^{c}
GQF_15	363.74±1.01^{c}	72.56±0.88^{d}	77.48±0.44^{d}
GQF_20	318.74±2.42^{a}	63.68±0.59^{a}	60.40±0.52^{e}

The results are the mean ± standard deviation (n = 3). Bread samples containing germinated quinoa flour, GQF: a–e, mean values in the same column followed by different letters are significantly different ($p < 0.05$).

Table 2.Texture parameters of the bread samples with different levels of germinated quinoa flour (GQF) additions

Bread samples	Springiness (N)	Gumminess (N)	Chewiness (J)	Cohesiveness (Adimensional)	Resilience (Adimensional)
Control	8.48±0.46^{a}	6.12±0.47^{a}	6.12±0.47^{a}	0.60±0.06^{a}	1.27±0.01^{a}
GQF_5	7.47±0.45^{ab}	4.84±0.08^{b}	4.84±0.08^{b}	0.55±0.05^{ea}	1.21±0.02^{b}
GQF_10	6.63±0.33^{b}	4.20±0.13^{c}	4.20±0.13^{c}	0.53±0.02^{a}	1.18±0.01^{c}
GQF_15	4.47±0.32^{c}	3.18±0.12^{d}	3.18±0.12^{d}	0.53±0.07^{a}	1.16±0.01^{d}

Table 3. Color parameters of the bread samples with different levels of germinated quinoa flour (GQF) additions.

Bread samples	Crust color			Crumb color		
	*L**	*a**	*b**	*L**	*a**	*b**
Control	73.92±0.71^{a}	2.04±0.83^{a}	21.25±0.44^{a}	58.12±0.14^{a}	0.38±0.17^{a}	16.51±0.50^{a}
GQF_5	60.94±0.31^{b}	7.29±0.35^{b}	19.21±0.36^{b}	48.64±0.89^{a}	2.30±0.15^{b}	13.01±0.35^{b}
GQF_10	38.86±0.33^{c}	8.33±0.56^{bc}	15.76±0.38^{c}	39.05±0.72^{a}	2.58±0.22^{bc}	10.36±0.54^{c}
GQF_15	36.81±0.38^{d}	9.50±0.50^{cd}	14.58±0.51^{c}	36.38±0.37^{a}	2.84±0.13^{c}	9.57±0.24^{cd}
GQF_20	32.21±1.23^{e}	10.12±0.14^{d}	10.5±0.61^{d}	34.64±0.42^{a}	3.28±0.05^{d}	8.62±0.16^{d}

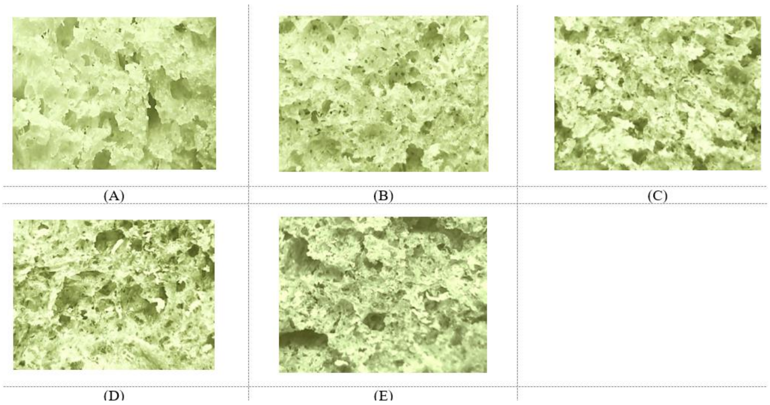

Figure 1. Structure of the crumb samples with germinated quinoa flour (GQF) at different levels: 0% (A), 5% (B), 10% (C), 15% (D) and 20% (E).

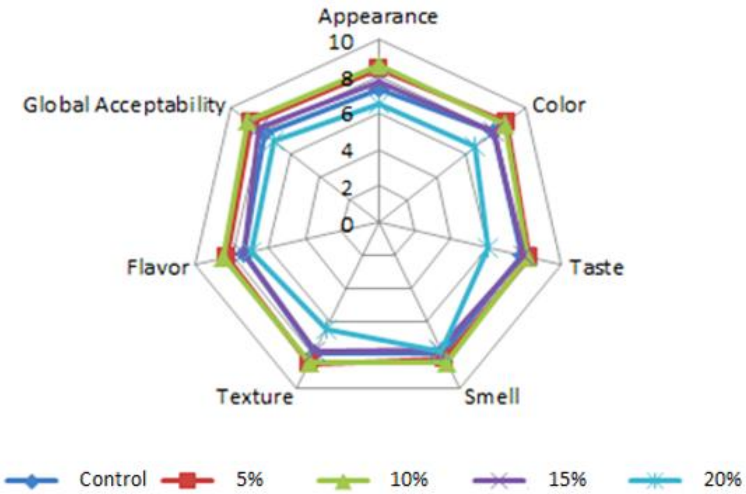

Figure 2. Representation of sensory analysis values

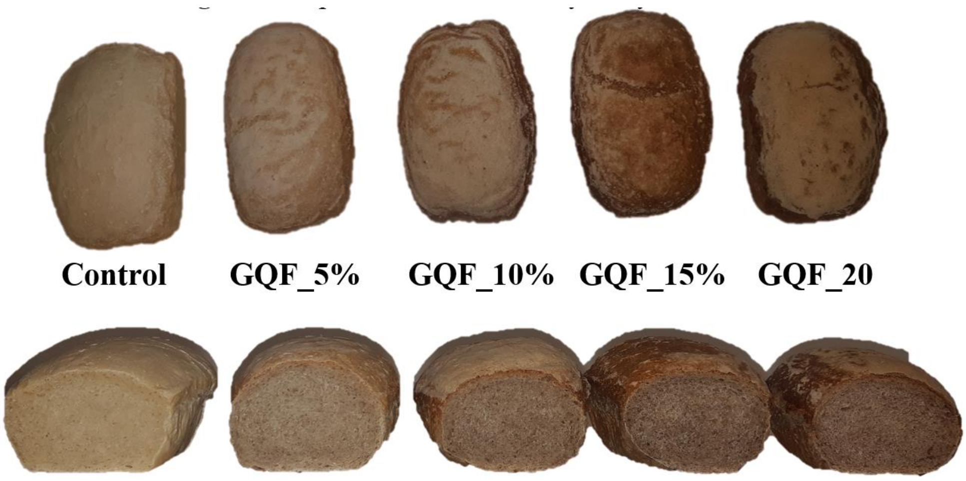

Figure 3. Bread samples with different levels of GQF addition

At an addition of 20%, the value of the score decreased slightly, but not at a lower value than for the control sample. Therefore, it can be concluded that the addition had a positive effect on the quality of the bread and on its flavor profile. Similar results regarding the improvement of the sensory profile of bread due to the addition of quinoa seeds were also obtained in other previous studies [5].

4.Conclusion

The addition of germinated quinoa flour to the white wheat bread making recipe had influence on all the quality characteristics of the samples. Speaking of the physical characteristics of the bread, their value has improved to a maximum of 15% addition. An addition of 20% resulted in bread samples with values of volume, porosity and elasticity lower than the control sample. Also, the textural properties of the bread samples had the same trend. Regarding the color characteristics, it can be said that due to the addition, darker samples were obtained, with a little shade of reddish and blue, due to the specific pigments for the outer coating of the quinoa beans. The addition led to bread with larger pores and less density. The tasters who participated in the study best appreciated the samples with a medium proportion of the addition. Thus, it can be concluded that, in order to obtain a bread with superior quality characteristics, an addition of 10-15% germinated quinoa flour can be used.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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