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# Production and evaluation of texture, color, sensory properties and cooking characteristics of pasta based on wheat alternative flours

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**ABSTRACT**

Celiac disease is a digestive disorder caused by a permanent intolerance to certain cereal prolamines with a specific oligopeptide sequence and manifests as gluten intolerance. The aim of this study is therefore to formulate and produce gluten-free pasta based on rice flour and wheat alternative flours and to evaluate their qualitative properties. Different samples of gluten-free pasta were produced from a mixture of rice flour and wheat alternative flours (chia, teff, quinoa, amaranth and buckwheat) with different weight ratios. A commercial pasta was used as the control sample. The color, texture, cooking properties and sensory characteristics of the samples were then investigated. The results showed that as the proportion of alternative flours increased, the color lightness index (L*) decreased and the b* and a* values increased, resulting in a decrease in the whiteness index and an increase in the yellowness index and overall color changes. In addition, the wheat alternative flours had a positive effect on the texture firmness and reduced the baking index, and reduced the glaze index of the final product. The pasta sample with 75% wheat alternative flours and 25% rice flour was selected as the ideal gluten-free pasta sample in terms of overall sensory evaluation. The results show that the use of alternative flours can significantly improve the quality characteristics of gluten-free pasta.

## 1. Introduction

Plant-based foods currently occupy a special place among consumers. In this group, cereal products have a special place in dietary recommendations. In most countries, people have a positive attitude towards the use of grain foods and recognize and consume them as healthy foods [1]. Pasta products are a simple grain-based food made from durum wheat semolina and water [2]. Pasta was one of the first products declared as fortified with iron and vitamins by the Food and Drug Administration of the United States of America in 1994, and the World Health Organization has introduced pasta as a suitable nutrient carrier [3]. In addition to production factors, the limited number of raw materials used has made pasta a suitable platform for studying the nutritional and technological potential of adding raw materials with a higher nutritional value [4]. The use of flavorings, colorants, vitamins, proteins, emulsifiers and, in general, substances with higher nutritional value is used to improve the color, taste, nutritional value, texture, sensory properties, etc. of the product [5-7]. This is despite the fact that the gluten protein contained in wheat flour can cause sensitivity or intolerance in coeliac patients. Celiac disease is a type of digestive disease that is due to permanent intolerance to some cereal prolamins with a special oligopeptide sequence. These compounds damage the villi of the small intestine and disrupt nutrients. This disease occurs as gluten intolerance. Gluten is a protein found in wheat, rye, barley and sometimes oats [8]. When patients with celiac disease consume gluten-containing foods, their immune system responds by destroying the small intestine, and this destruction occurs in the digital villi of the intestine where nutrients are absorbed [9]. Following the damage of the intestinal villi, a person suffers from malnutrition regardless of the food he eats. Celiac disease is also called celiac sprue, non-tropical sprue, and gluten-sensitive entropy. Celiac disease is a hereditary disease and is transmitted from one generation to another in the family and affects people in a different way, and symptoms appear in a group of patients from childhood and in others in adulthood [10]. Gluten is a substance found in wheat flour and insoluble in water, which forms an elastic mass after washing the dough.

When wheat flour is mechanically mixed with water, wheat proteins have unique properties to develop a viscoelastic matrix capable of holding the bubbles produced in the dough. This leads to the creation of a carbonated structure in the core of bakery products and is also a factor in creating structure and cohesion in pasta pieces [11]. The gluten matrix is the main determinant of dough characteristics, stretching, resistance to stretching, mixing and gas capability, and suitable textural characteristics in this type of products. Gums and some enzymes can be mentioned as texture improvers in gluten-free bakery products [12, 13]. Due to the fact that people with celiac disease are unable to use many products available in stores and the production of gluten-free products is limited, various researchers worked to provide suitable formulations for the production of high-quality gluten-free pasta. In this regard, Marengo et al. (2015) used fermented and germinated sorghum flour to produce gluten-free pasta [14]. Foschia and Beraldo (2016) investigated the physicochemical properties of gluten-free pasta enriched with resistant starch [15]. Menga et al. (2017) produced and investigated gluten-free pasta by incorporating chia seeds as a filler and nutritional improver on a laboratory scale and investigated the digestibility of carbohydrates [16].

Makdoud et al. (2017) evaluated and developed gluten-free pasta based on rice, quinoa and amaranth flour [17]. Lorusso et al. (2017) used fermented quinoa flour to make pasta [18]. . De Arcangelis et al. (2020) investigated gelatinization and pasta conditions for buckwheat-based gluten-free pasta [19]. Alinovi et al. (2023) investigated the effect of chestnut flour enrichment on the physical and chemical characteristics of fresh gluten-free pasta [20]. Zhao et al. (2024) investigated the effect of adding soy protein isolate, ovalbumin, and whey protein on the cooking characteristics of gluten-free pasta based on rice, corn, and potato [21].

Considering the existing concerns regarding maintaining and improving the health of celiac patients due to the limitation in the consumption of products made from wheat, barley, and rye and the disruption in the absorption of minerals and vitamins, in this research, the combination of gluten-free flours obtained from quinoa and buckwheat seeds , amaranth, chia, teff, along with rice flour were used to produce gluten-free pasta with texture and sensory characteristics similar to the types of pasta produced with wheat semolina flour available in the consumer market.

## 2- Materials and methods

### 2-1- Materials

Rice flour was purchased from Golha Company, teff seeds from Migros store in Istanbul, Turkey, and amaranth, quinoa, buckwheat and chia seeds were purchased from Kian Food Company and stored in the refrigerator until consumption. Xanthan gum was obtained from Fufeng Company (China). Other materials needed in the experiments were purchased from Merck (Germany).

### 2-2- Methods

### 1-2-2 Preparation of pasta

First, in order to remove impurities, all the seeds were washed and dried in a German oven at a temperature of 27±3 °C. Then, flour and their particle size were analyzed by Silver crest Germany semi-industrial mill with a power of 200 watts. Different samples of pasta were produced based on rice flour, and then the ratio of rice flour was reduced and replaced by weight ratios of 5: 95, 25:75, 50:50, 75:25 and 95:5 respectively (according to the percentage of total flour used). A mixture of gluten-free alternative flours (chia, teff, quinoa, buckwheat and amaranth) was used.

On this basis, depending on the formulation of each treatment, rice flour was mixed with alternative flours with different proportions for at least 3 minutes in the German Vospeed mixer together with 0.5 wt% xanthan gum (according to the results of Milde et al. (2020) [22]) until the sample is completely homogeneous while the materials were mixed together. After preparing the treatments, water was slowly added in the ratio of 20% by weight of the flour until the ingredients were completely and uniformly mixed. Finally, the mixture was extruded at a temperature of 45 °C using a Fermi bronze mold and under a pressure of 120 mm Hg. The pastas removed from the mold were first poured onto plastic trays and dried in an automatic oven from Memmert. The drying process took place in two stages, first at a temperature of 55 °C for 2 hours and then at a temperature of 75 °C. Once the drying process was complete and a moisture content of around 10 % had been reached, the pastas were placed in polypropylene bags after cooling until the tests were performed.

**2-3- Experimental Testing Methods**

**2-3-1- Chemical compositions**

The particle size of the flour mixture prepared according to the standard of the American Society of Agricultural Engineers (ASAE) was measured by sieve with sizes of 475, 180, 125 and 106 microns. Sifting was done using 100 grams of flour for 10 minutes. The remaining components on each sieve and sub-sieve of 106 microns were weighed separately Also, the chemical composition of rice flour and alternative flours (chia, teff, quinoa, buckwheat and amaranth) were measured based on the standard methods of the American Association of Cereal Chemists (AACC) , (2000).Based on this, pH was determined according to standard number 02/52-01 by a digital pH meter made by AICA Germany. Ash measurement was done according to standard number 01-08 by the American Paragon electric furnace. Humidity measurement was done according to standard No. 15- 44A by oven model made by Memmert, Germany. Total protein was measured according to the standard number 46-13 by Gerhardt Klodahl device, Germany. Fat measurement was done according to the standard number 30-10 by Soxhlet Quickfit device in England [23].

**2-3-2- Cooking indexes**

The glaze number was measured by measuring the percentage of total solids in the cooking water and the baking number was measured by weight after baking according to the standard of the Iranian Institute of Standards and Industrial Research No. 213 [24].

**2-3-4- Texture, color and sensory properties**

To evaluate the texture, color and sensory properties, the pasta samples were first boiled in 2 liters of water with 0.5% salt to the optimum boiling time and then rinsed with 100 ml of distilled water for 10 minutes.

The texture was examined using the Hounsfield device from England and a vertical uniaxial compression test. This test was carried out at room temperature with a pressure test probe, code P36, load cell 5 Newton, end point 75% and machine speed 2 mm/s [25] in three repetitions.

A Minolta Hunter Lab Colorimeter from Japan (color index) was used to determine the color of raw and cooked pasta. Before measuring the color of the pastas, the machine was adjusted using a standard white screen. The samples were placed on a standard white screen as a background and measurements were taken. The parameters that the device displays are: brightness or L* (white=100 and black=0) and color parameters a* (green-red) and b* (blue-yellow). This test was repeated five times on different pastas of the same formula, and for each pasta, three points were randomly selected and the average of these three points was reported [26].

The characteristics investigated in the sensory evaluation of cooked pasta samples included appearance, color, aroma, taste, and texture. Based on this, 10 trained evaluators were asked to assign 5 (very good), 4 (good), 3 (average), 2 (bad) and 1 (very bad) points to the samples in the five-point hedonic system. Finally, by dividing the average of the total scores of 5 evaluation indices, the qualitative desirability number was obtained based on sensory evaluation [27].

### 2-4- Statistical analysis

The research was conducted based on a completely random statistical design and the difference between different treatments was determined using Analysis of variance (ANOVA) at a probability level of 5%. Comparison of mean data was done based on Duncan test using Statistical Package for Social Sciences (SPSS) version 19 and EXCEL software version 2013 (Chicago, USA).

## 3- Results and Discussion

### 3-1- Evaluation of flours

The results related to the chemical characteristics of the flours used to prepare pasta are as described in Table 1.

**Table 1-** The results of chemical analysis of flours

| | Moisture (%) | Fat (%) | Protein (%) | Ash (%) | pH |
|---|---|---|---|---|---|
| Rice flour | 8.51±0.61$^{b}$ | 1.12±0.11$^{f}$ | 8.12±0.28$^{d}$ | 0.57±0.04$^{d}$ | 6.04±0.03$^{e}$ |
| Chia flour | 7.08±0.94$^{c}$ | 33.22±0.12$^{a}$ | 22.58±0.57$^{a}$ | 1.93±0.09$^{c}$ | 5.95±0.07$^{f}$ |
| Teff flour | 10.09±0.81$^{a}$ | 2.05±0.08$^{e}$ | 13.41±0.44$^{c}$ | 4.72±0.07$^{a}$ | 6.79±0.03$^{b}$ |
| Quinoa flour | 9.17±0.51$^{ab}$ | 5.47±0.14$^{c}$ | 16.83±0.64$^{b}$ | 1.80±0.16$^{c}$ | 6.66±0.06$^{c}$ |
| Amaranth flour | 9.58±0.49$^{ab}$ | 6.21±0.06$^{b}$ | 13.38±0.46$^{c}$ | 2.27±0.10$^{b}$ | 6.51±0.03$^{d}$ |
| Buckwheat flour | 9.04±0.57$^{ab}$ | 2.62±0.12$^{d}$ | 13.81±0.44$^{c}$ | 1.96±0.06$^{c}$ | 6.94±0.05$^{a}$ |

* Data are mean ± standard deviation

** Means with different superscript(s) in each column are significantly different (p<0.05)

The result of comparing the average chemical analysis of different flours showed a significant difference ($P<0.05$). The average moisture content of the flours used in this research was in the range of 7.08-10.09%. The highest and lowest moisture levels were related to teff and chia flour, respectively. The average fat of the flours used in the research was in the range of 1.12-33.22 percent. The highest and lowest amount of fat was related to chia flour and rice, respectively. The average protein of the flours used in this research was in the range of 13.38-22.58%. The highest and lowest amount of protein was related to chia flour and rice, respectively. The average ash of the flours used in this research was in the range of 0.57-4.72%. The highest and lowest amount of ash was related to teff flour and rice, respectively. The average pH of the flours was in the range of 5.95-6.94 The highest and lowest pH values were related to buckwheat and chia flour, respectively.

The results related to the results of particle size analysis of flours used to prepare pasta are as described in Table 2

**Table 2.** The results of particle size analysis used

| Substitution of pseudo-cereal flour (%) | Sieve greater than 475 microns | Top of 180 micron sieve | Top of 125 micron sieve | Top of 106 micron sieve | Sieve smaller than 106 microns |
|---|---|---|---|---|---|
| 5 | 0.93±0.18$^{d}$ | 10.09±0.95$^{bc}$ | 36.55±1.88$^{a}$ | 7.33±0.92$^{a}$ | 44.53±2.14$^{a}$ |
| 25 | 1.67±0.48$^{cd}$ | 9.20±0.72$^{c}$ | 35.93±2.42$^{a}$ | 7.52±0.65$^{a}$ | 37.17±1.38$^{ab}$ |

| | | | | | |
|---|---|---|---|---|---|
| 50 | 2.20±0.26$^{c}$ | 11.75±0.66$^{b}$ | 36.26±2.56$^{a}$ | 6.81±0.38$^{b}$ | 32.92±1.82$^{b}$ |
| 75 | 2.94±0.59$^{b}$ | 11.66±0.81$^{b}$ | 34.08±1.39$^{a}$ | 7.82±0.42$^{a}$ | 28.83±1.05$^{c}$ |
| 95 | 3.28±0.49$^{a}$ | 16.84±0.86$^{a}$ | 34.62±2.06$^{a}$ | 6.79±0.49$^{b}$ | 23.41±1.62$^{d}$ |

* Data are mean ± standard deviation

** Means with different superscript(s) in each column are significantly different (p<0.05)

As can be seen in Table 2, with the increase in the percentage of substitute flour, the remaining particles on the sieve increased by 475 microns. Also, the percentage of particles collected under the 106 micron sieve decreased.

**3-2- Evaluation of pasta samples**

**3-3- Color indexes**

The average color index L* of gluten-free pasta with the commercial control sample before and after cooking has shown significant changes among different treatments (P<0.05) (Table 3). The average color index L* of raw and cooked pasta was in the range of 83.4-47.9 and 57. 6-30.5 respectively, which is a considerable range. According to the results, with the increase in the proportion of alternative flours, the L* color index of the samples shows a significant decrease (P<0.05), which is related to the color of the raw materials. The highest L* color index of raw and cooked gluten-free pasta was related to the treatment with 5% substitution of alternative flours.

**Table 3-** Colorimetric L* index of control and uncooked/cooked gluten-free pasta

| Sample | Substitution of pseudo-cereal flour (%) | | | | | |
|---|---|---|---|---|---|---|
| | Control | 5 | 25 | 50 | 75 | 95 |
| Uncooked | 73.09±2.61$^{c}$ | 83.43±2.40$^{a}$ | 78.10±2.23$^{b}$ | 65.72±2.64$^{d}$ | 54.67±3.05$^{e}$ | 47.90±3.40$^{f}$ |
| Cooked | 52.78±1.88$^{b}$ | 57.65±1.96$^{a}$ | 51.84±1.49$^{b}$ | 44.33±1.50$^{c}$ | 39.48±2.06$^{d}$ | 30.52±2.37$^{e}$ |

* Data are mean ± standard deviation

** Means with different superscript(s) in each row are significantly different (p<0.05)

The result of comparing the average color index a* of gluten-free pasta with the commercial control sample showed significant changes only in raw samples among different treatments (P<0.05) (Table 4). The average color index a* of raw and cooked pasta was in the range of 1.6-7.2 and 4.9-4.5, respectively. According to the results, with the increase in the proportion of substitute flours, the color index a* of the raw samples shows a significant increase (P<0.05). The highest a* color index of raw and cooked gluten-free pasta was related to the treatment with 95% substitution of alternative flours.

**Table 4-** Colorimetric a* index of control and uncooked /cooked gluten-free pasta

| Sample | Substitution of pseudo-cereal flour (%) | | | | | |
|---|---|---|---|---|---|---|
| | Control | 5 | 25 | 50 | 75 | 95 |
| Uncooked | 3.25±0.16$^{d}$ | 1.62±0.17$^{f}$ | 2.46±0.34$^{e}$ | 4.25±0.19$^{c}$ | 5.70±0.20$^{b}$ | 7.28±0.16$^{a}$ |
| Cooked | 6.07±0.16$^{a}$ | 4.91±0.68$^{b}$ | 4.88±0.53$^{b}$ | 4.54±0.55$^{b}$ | 4.61±0.46$^{b}$ | 4.56±0.45$^{b}$ |

* Data are mean ± standard deviation

** Means with different superscript(s) in each row are significantly different (p<0.05)

The result of comparing the average b* color index of gluten-free pasta with the commercial control sample in raw and cooked samples has shown significant changes among different treatments (P<0.05) (Table 5). The average b* color index of raw and cooked pasta was in the range of 10.7-19.4 and 9.9-9.6, respectively. According to the results, with the increase in the proportion of substitute flours, the b* color index of the raw samples shows a significant increase (P<0.05). The highest b* color index of raw and cooked gluten-free pasta was related to the treatment with 95% substitution of alternative flours.

**Table 5-** Colorimetric b index of control and uncooked /cooked gluten-free pasta

| Sample | Substitution of pseudo-cereal flour (%) | | | | | |
|---|---|---|---|---|---|---|
| | Control | 5 | 25 | 50 | 75 | 95 |
| Uncooked | 17.70±0.34$^{b}$ | 10.77±0.33$^{e}$ | 12.46±0.36$^{d}$ | 14.33±0.35$^{c}$ | 17.25±0.46$^{b}$ | 19.47±0.43$^{a}$ |
| Cooked | 29.50±0.59$^{a}$ | 9.93±0.76$^{b}$ | 9.81±0.47$^{b}$ | 9.67±0.64$^{b}$ | 9.83±0.35$^{b}$ | 9.65±0.36$^{b}$ |

* Data are mean ± standard deviation

** Means with different superscript(s) in each row are significantly different (p<0.05).

Pasta color is one of the important quality indicators for consumers [28]. By comparing the appearance characteristics of the product, it can be seen that with the increase in the amount of substitute flour in the formulation of the produced pasta, the color index L* decreases and the color index b* and a* increases, as a result of which the whiteness decreases and the yellowness of the color increases, which indicates the darkening of the color. The produced product and the tendency of the color of the product is orange, which is expected due to the color nature of the used alternative flours. The total amount of light reflected from the surface of the sample is inversely proportional to the size of the particles. Therefore, with the increase in the percentage of alternative flours used in the formulation, there has been a decrease in brightness and L* index. The dark brown color of the cereal substitute flour mixture can also be another effective factor in reducing the brightness of the final product. As other researchers suggested a similar effect for resistant starch [29]. Based on this, the decreasing trend in b* and a* index can also be justified.[30]. Also, up to the level of 75% replacement of alternative flours, the overall color changes are incremental but negligible, but at the level of 95% replacement of alternative flours, the color changes are very high compared to the commercial sample.

**3-4- Textural analysis**

The result of comparing the average hardness, fracture and the ratio of fracture to hardness of gluten-free pasta with the commercial control sample obtained by vertical pressure showed significant changes among different treatments (P<0.05) (Figure 1). The average hardness, fracture and ratio of fracture to hardness of pasta were in the range of 1.3-2.9, 1.1- 2.6 and 0.8 -0.9 newton respectively. According to the results, with the increase in the proportion of alternative flours, the hardness and fracture of the samples increases significantly (P<0.05). The highest level of hardness and fracture of gluten-free pasta was related to the treatment with 95% substitution of alternative flours.

According to the results, with the increase in the proportion of alternative flours, the hardness and breakage of the samples increases significantly (P<0.05). The highest level of stiffness and breakage of gluten-free pasta was related to the treatment with 95% substitution of alternative flours.

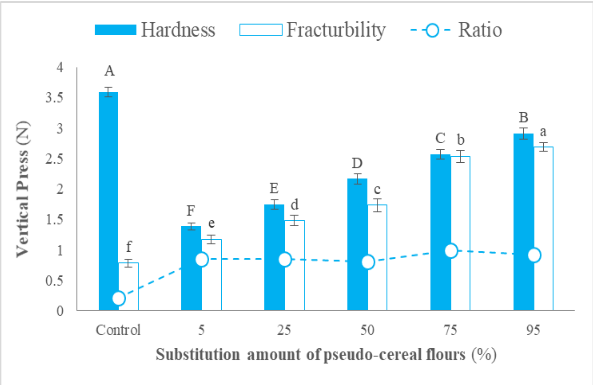


**Fig 1.** Textural characteristics of commercial and gluten-free pasta by vertical pressing

Before cooking, the texture of the pasta should be completely firm and stable so that it does not crumble during packaging and transportation. Also, the strength of the texture of the product after cooking also reduces the adhesion and prevents the softness of the final product. In the present research, with the increase in the proportion of alternative flours in the formulation of the produced pasta, the firmness and strength of the texture of the product increased, but in none of the levels did it reach the highest firmness index related to the commercial control treatment. Durum wheat was not used in the production formulations in the current research, therefore, a compact structure with a stable network was not created [31].

However, since the amount of protein does not have an important effect on the gluten strength, but it has an effect on the texture quality of the final product, therefore, due to the increase in the amount of protein with the increase in the ratio of alternative flours, the starch-protein complex of the final product is strengthened and increases the texture strength of the final product. . Previous studies have shown that the presence of vegetable fibers as prebiotics in pasta products has an adverse effect on texture indicators [32-34].

### 5-3- Baking indexes

The result of comparing the average glazing number and baking number of gluten-free pasta with the commercial control sample in cooked samples showed significant changes among different treatments (P<0.05) (Figure 2). The average glaze number and pasta cooking number were in the range of 9.3-19.3 and 54.2.4-68.4 percent, respectively. According to the results, with the increase in the proportion of substitute flours, the glaze number decreases and the baking number of the samples increases significantly (P<0.05). The highest glazing number and baking number of cooked gluten-free pasta were related to the treatment with 5 and 95% substitution of alternative flours, respectively.

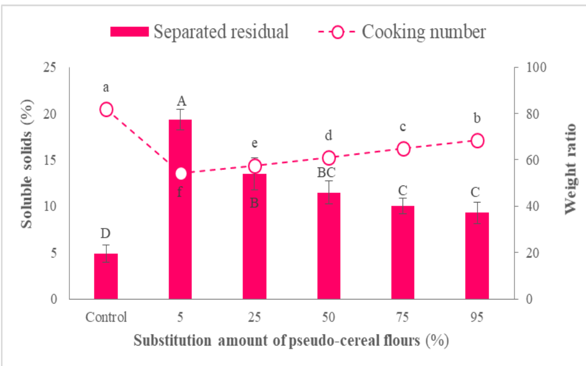


**Fig 2.** Cooking characteristics of commercial and gluten-free pasta by compression

The glaze number is a measure of the preservation of the pasta structure during the cooking process. The higher the quantity and quality of protein in the pasta texture, the lower the glaze number. Due to its higher protein content and quality, durum wheat has a higher strength in forming a gluten network when mixed with water [35]. Naseri et al (2009) investigated the effects of soy protein isolate on the properties of pasta and found that the amount of protein in the pasta had a positive effect on reducing cooking loss and dehydration of the product during cooking, which was also observed in this study [36]. Also, the reduction in the total solids content in water (glaze) in the samples tested in this study may be caused by the increase in protein content and the resulting increase in hydrogen bonding between water and protein molecules in the texture of the product. High protein content is also an effective factor causing this due to its emulsifying properties [37].

The fragility of pasta depends more on its protein content and less on starch. Protein acts as a coating in the structure of the product and prevents the starch from leaving the pasta texture, ultimately making the pasta texture firmer. Calgos Infante et al. (2010) investigated the effect of Mexican bean flour on the properties of spaghetti and reported that the lower the protein content of the initial flour, the greater the cooking loss [38], which is consistent with the results of this study.

### 6-3- sensory characteristics

The result of the comparison of the overall desirability of the gluten-free pasta with the commercial control sample showed significant changes between the different treatments (P<0.05) (Figure 3). The average overall desirability of the pasta was in the range of 1.9-3.1.

The highest overall desirability of pasta was observed in the treatment with a 75% replacement of alternative flours.

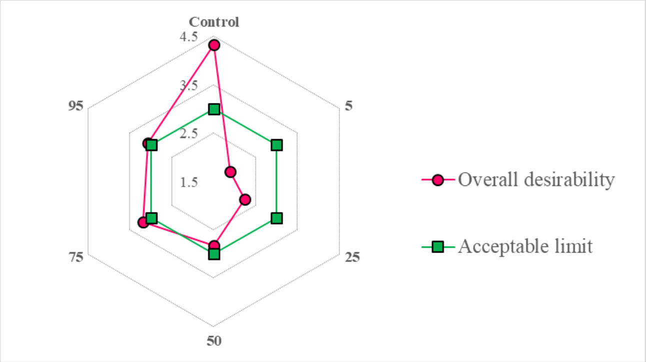


**Fig 2.** Overall desirability of commercial and gluten-free pasta by sensory characteristics

## 4 - Conclusion

According to the results of this study, the production of gluten-free pasta based on alternative flours results in a product with similar characteristics to commercial pasta. Increasing the proportion of alternative flours in the formulation has a positive effect on the chemical-functional properties (especially on the protein content and glaze of the product), baking properties and texture, although it causes a decrease in the colorimetric indices of the product. Considering that none of the treatments included all the positive effects, the formulation containing 25% rice flour and 75% alternative flours had an overall more favorable situation than the other samples.

## 5-References

[1] Palavecino, P.M., et al., *Sorghum Pasta and Noodles: Technological and Nutritional Aspects.* Plant Foods for Human Nutrition, 2020. **75**: p. 326-336.

[2] Dendy, D.A. and B.J. Dobraszczyk, *Cereals and cereal products: chemistry and technology*. 2001: Aspen publishers.

*[3]* Alireza Sadeghi, M. and S. Bhagya, *Quality characterization of pasta enriched*

[4] *with mustard protein isolate.* Journal of food science, 2008. **73**(5): p. S229-S237.
[5] Ajila, C., et al., *Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations.* Innovative Food Science & Emerging Technologies, 2010. **11**(1): p. 219-224.
[6] Lucisano, M., E. Casiraghi, and R. Barbieri, *Use of defatted corn germ flour in pasta products.* Journal of Food Science, 1984. **49**(2): p. 482.٤٨٤-
[7] Prabhasankar, P., *Prebiotics: Application in Bakery and Pasta Products.* Critical reviews in food science and nutrition, 2014. **54**.(٤)
[8] Ekrami, M., et al., *Extraction and physicochemical characterization of gum*, in *Handbook of Natural Polymers, Volume 1*. 2023, Elsevier. p. 597-630.
[9] Ruh, T., et al., *Microbial transglutaminase treatment in pasta-production does not affect the immunoreactivity of gliadin with celiac disease patients' sera.* Journal of agricultural and food chemistry, 2014. **62** :(٣٠)p. 7604-7611.
[10] Bacchetti, T., et al., *The postprandial glucose response to some varieties of commercially available gluten-free pasta: a comparison between healthy and celiac subjects.* Food & function, 2014. **5**(11): p. 3014-3017.
[11] Vetrani, C., et al ,.*Fibre-enriched buckwheat pasta modifies blood glucose response compared to corn pasta in individuals with type 1 diabetes and celiac disease: Acute randomized controlled trial.* Diabetes research and clinical practice, 2019. **149**: p. 156-162.
[12] Zandonadi, R.P., et al., *Green banana pasta: an alternative for gluten-free diets.* Journal of the Academy of Nutrition and Dietetics, 2012. **112**(7): p. 1068-1072.
[13] Ekrami, M. and Z. Emam-Djomeh, *Water vapor permeability, optical and mechanical properties of salep-based edible film.* Journal of Food Processing and Preservation, 2014. **38**(4): p. 1812-1820.
[14] Padalino, L., A. Conte, and M.A. Del Nobile, *Overview on the general approaches to improve gluten-free pasta and bread.* Foods, 2016. **5**(4): p. 87.
[15] Marengo ,M., et al., *Molecular features of fermented and sprouted sorghum flours relate to their suitability as components of enriched gluten-free pasta.* LWT-Food Science and Technology, 2015. **63**(1): p. 511-518.
[16] Foschia, M., P. Beraldo, and D. Peressini, *Evaluation of the physicochemical properties of gluten-free pasta enriched with resistant starch.* Journal of the science of food and agriculture, 2016.
[17] Menga, V., et al., *Gluten-free pasta incorporating chia (Salvia hispanica L.) as thickening agent: An approach to naturally improve the nutritional profile and the in vitro carbohydrate digestibility.* Food chemistry, 2017. **221**: p. 1954-1961.
[18] Makdoud, S. and K.A. Rosentrater, *Development and testing of gluten-free pasta based on rice, quinoa and amaranth flours.* Journal of food Research, 2017. **6**(4): p. 91-110.
[19] Lorusso, A., et al., *Use of fermented quinoa flour for pasta making and evaluation of the technological and nutritional features.* LWT, 2017. **78**: p. 215-221.
[20] De Arcangelis, E., et al., *Gelatinization and pasta making conditions for buckwheat gluten-free pasta.* Journal of Cereal Science, 2020. **95**: p. 103073.
[21] Alinovi, M., et al., *Effect of chestnut flour fortification on physico-chemical characteristics of gluten-free fresh pasta.* International Journal of Food Science & Technology, 2023.
[22] Zhao, R., et al., *Improvement effect of different protein powder on cooking characteristics of gluten-free pasta and the establishment of quality evaluation based on principal component analysis.* International Journal of Food Science & Technology, 2024. **59**(2): p. 1138-1149.
[23] Milde, L.B., et al., *Incorporation of xanthan gum to gluten-free pasta with cassava starch. Physical, textural and sensory attributes.* LWT, 2020. **131**: p. 109674.
[24] AACC, *Approved Methods of the American Association of Cereal Chemists, 10th Ed., Vol. 2.* American Association of Cereal Chemists, St. Paul, MN., 2000.
[25] ISIRI, *Macaroni - Specifications and test methods.* Iranian national standard No. 213, 2009. **4th edition**.
[26] El-Sohaimy, S.A., et al., *Physicochemical, texture and sensorial evaluation of pasta enriched with chickpea flour and protein isolate.* Annals of Agricultural Sciences, 2020. **65**(1): p. 28-34.
[27] Wood, J.A., *Texture, processing and organoleptic properties of chickpea-fortified spaghetti with insights to the underlying mechanisms of traditional durum pasta quality.* Journal of Cereal Science, 2009. **49**(1): p. 128-133.
[28] Szydłowska-Tutaj, M., et al., *The effect of the addition of various species of mushrooms on the physicochemical and*

*sensory properties of semolina pasta.* Food & Function, 2022. **13**(16): p. 8425-8435.

[29] Rayas-Duarte, P., C. Mock, and L. Satterlee, *Quality of spaghetti containing buckwheat, amaranth, and lupin flours.* Cereal Chemistry, 1996 :(٣)٧٣ .p. 381-387.

[30] Ovando-Martinez, M., et al., *Unripe banana flour as an ingredient to increase the undigestible carbohydrates of pasta.* Food Chemistry, 2009. **113**(1): p. 121-126.

[31] Agama-Acevedo, E., et al., *Starch digestibility and glycemic index of cookies partially substituted with unripe banana flour.* LWT-Food Science and Technology, 2012. **46**(1): p. 177-182.

[32] ٣Ungureanu-Iuga, M., M. Dimian, and S. Mironeasa, *Development and quality evaluation of gluten-free pasta with grape peels and whey powders.* Lwt, 2020. **130**: p. 109714.

[33] Bustos, M.C., G.T. Perez, and A.E. León, *Sensory and nutritional attributes of fibre-enriched pasta.* LWT-Food Science and Technology, 2011. **44**(6): p. 1429-1434.

[34] Vernaza, M.G., et al., *Effect of supplementation of wheat flour with resistant starch and monoglycerides in pasta dried at high temperatures.* International Journal of Food Science & Technology, 2012. **47**(6): p. 1302-1312.

[35] Mishra, S., J. Monro, and D. Hedderley, *Effect of processing on slowly digestible starch and resistant starch in potato.* Starch-Stärke, 2008. **60**(9): p. 500-507.

[36] Marconi, E., et al., *Spelt (Triticum spelta L.) pasta quality: Combined effect of flour properties and drying conditions.* Cereal chemistry, 2002. **79**(5): p. 634-639.

[37] Naseri, A.R., et al., *Study of the effect of soy protein isolate on macaroni characteristics.* Iranian journal of food science and technology, 2009. **6**(2): p. 1-11.

[38] Fradinho, P., et al., *Edible brown seaweed in gluten-free pasta: Technological and nutritional evaluation.* Foods, 2019. **8**(12): p. 622.

[39] Gallegos-Infante, J., et al., *Quality of spaghetti pasta containing Mexican common bean flour (Phaseolus vulgaris L.).* Food Chemistry, 2010. **119**(4): p. 1544-1549.

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مقاله علمی_پژوهشی

# تولید و ارزیابی ویژگی‌های بافت، رنگ، حسی و پخت در پاستای فرمی بدون گلوتن بر پایه آردهای جایگزین گندم

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**چکیده**

بیماری سلیاک، نوعی بیماری گوارشی است که به علت عدم تحمل دائمی به بعضی پرولامین‌های غلات با توالی الیگوپپتیدی ویژه است و به صورت عدم تحمل گلوتن بروز می‌کند. از این رو هدف این تحقیق، فرمولاسیون، تولید و ارزیابی ویژگی‌های کیفی پاستای فرمی فاقد گلوتن بر پایه آرد برنج و ترکیب آردهای بدون گلوتن است. نمونه‌های مختلف پاستای بدون گلوتن با استفاده از مخلوط آرد برنج و آردهای بدون گلوتن با نسبت برابر (چیا، تف، کینوا، آمارانت و باکویت) با نسبت‌های وزنی مختلف تولید شدند. همچنین نمونه شاهد، پاستای تجاری موجود در بازار بود. ویژگی‌های رنگی، بافتی، پخت و حسی نمونه‌ها مورد بررسی قرار گرفت. نتایج نشان دادند که با افزایش ترکیب آردهای بدون گلوتن شاخص روشنایی رنگ ($L^*$) کاهش و شاخص‌های $b^*$ و $a^*$ افزایش می‌یابد که به‌تبع آن شاخص سفیدی کاهش و شاخص زردی و تغییرات کلی رنگ افزایش یافت. همچنین ترکیب آردهای بدون گلوتن اثر مثبت بر افزایش سفتی بافت و عدد پخت و کاهش عدد لعاب محصول نهایی داشتند. نمونه پاستای حاوی ۷۵ درصد ترکیب آردهای بدون گلوتن و ۲۵ درصد آرد برنج به عنوان نمونه پاستای فرمی بدون گلوتن از نظر مطلوبیت کلی در ارزیابی حسی انتخاب شد. نتایج نشان می‌دهد که استفاده از ترکیب آردهای بدون گلوتن می‌تواند بهبودی قابل‌توجهی در ویژگی‌های کیفی پاستای بدون گلوتن ایجاد کند.