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Scientific Research

Investigating the potential of using quinoa flour in the preparation of a functional dairy dessert

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ABSTRACT

Quinoa, a nutritionally valuable pseudocereal, is rich in protein, carbohydrates, minerals, unsaturated fatty acids, vitamins, and fiber. Considering the high nutritional value of quinoa flour, this study aimed to produce Ferni (which is Porridge in English), a popular Iranian dairy dessert, using quinoa flour. For this purpose, quinoa flour (0, 20, 40, and 60%) was added to a mixture of cow's milk and buffalo milk (0, 50, and 100%) and sugar. The mixture was heated until the desired consistency was reached and then cooled in small containers and stored in the refrigerator for 14 days. Physicochemical and sensory tests were performed on the samples during storage. The results were analyzed using SPSS software and Duncan's test for mean comparison at a 95% confidence level. The results showed that with the replacement of rice flour with quinoa flour, the dry matter, ash, fat, acidity, water holding capacity, redness intensity (a*), firmness, adhesiveness, and texture acceptance of the dessert samples increased. On the other hand, the values of pH, yellowness intensity (b*), and odor and flavor acceptance of the dessert samples decreased. But, with increasing percentage of replacement of rice flour with quinoa flour, the values of lightness intensity (L*), color acceptance, taste acceptance, and overall acceptance decreased. On the other hand, the values of pH, water holding capacity, firmness, lightness intensity (L*), appearance color, odor and flavor, texture, and overall acceptance decreased. In conclusion, the results of this study suggest that up to 40% of rice flour can be replaced with quinoa flour to enrich Ferni.

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1- Introduction

Milk-based products play an important role in maintaining the human daily diet because they are the main source of calcium, vitamin D, phosphorus, potassium, manganese, riboflavin and nisin [1]. Dairy desserts can be mentioned among dairy products. Dairy-based desserts can be consumed with a meal or alone at any time during the day [2]. Due to its favorable nutritional and sensory characteristics, dairy desserts are widely consumed by many groups of consumers, especially children and the elderly, almost daily [3]. Dairy dessert is a dessert containing at least 50% of fresh cow's milk or reconstituted and recombined milk, which is prepared with the use of permitted additives such as flavorings, sweeteners, thickeners and stabilizers, after undergoing a thermal process including pasteurization, long-life pasteurization, and sterilization. . For example, porridge is a kind of milky dessert with a soft and uniform texture, which is made from milk and rice flour and can be used to improve its taste with permitted flavorings and sweeteners [4]. The most important feature of dairy desserts is high energy and a pleasant feeling that is created in the consumer due to the type of ingredients in it [5]. Food enrichment is one of the important tasks of food industry researchers. One of these sources for enriching dairy desserts is the use of semi-cereal flour such as quinoa, amaranth and buckwheat, which are rich in protein, minerals, vitamins, etc. Quinoa contains large amounts of protein, all essential amino acids, unsaturated fatty acids and a low glycemic index (GI), which is why 2013 was declared by the Food and Agriculture Organization of the United Nations (FAO) as the International Year of Quinoa. Its potential importance is recognized [6]. Quinoa has a high biological value (73%), which is similar to beef (74%) and more than the biological value of white rice (56%), wheat (49%), and corn (36%) [7]. Including quinoa in the diet can be a good way to consume proteins with high biological value as well as all essential amino acids [6]. Aminifar et al. (2016) used uncoated barley malt in a research to enrich dairy dessert. According to the results, they found that desserts with a high amount of malt have more starch, protein, ash and fat, and in terms of sensory characteristics, they had the highest acceptability among sensory evaluators [8]. Zabihi and Karajian (2021), used millet flour as a substitute for rice flour with the aim of improving its nutritional value and quality characteristics. Based on the results, they found that the desserts containing millet flour had less moisture and sugar but more ash and fat. According to sensory evaluation, desserts containing low and medium amounts of millet flour were more acceptable [9]. Codina et al. (2016), showed that in yogurt samples containing cow's milk that had quinoa flour, a very significant decrease in pH was observed compared to the control sample during the fermentation time. Also, the microscopic images of the investigated yogurt samples showed that a stable gel network with sufficient water resistance is created on the upper surface of quinoa flour [10]. EL- Shafei and Seker (2020) investigated the effect of adding quinoa extract to goat milk and its effect on milk fermentation. The addition of this extract decreased the fermentation time and increased the viability of *lactic acid bacteria*, which is due to faster changes in pH and titratable acidity in milk samples containing quinoa extract compared to the control sample [11]. Wang et al. (2023) investigated the effect of a beverage obtained from quinoa protein hydrolysis (QPH) on the physicochemical and sensory characteristics of coffee. According to the results of the sensory evaluation, they found that the unpleasant sensory characteristics such as bitterness and strong bitterness of the coffee drink were greatly reduced by the addition of quinoa drink, and its mouthfeel and sweetness increased and significantly delayed the oxidation [12]. Additionally, quinoa is a great gluten-free alternative available for celiac patients. Including quinoa in the diet can be a good way to consume proteins with high biological value as well as essential amino acids. Quinoa also contains unsaturated fatty acids, fiber and complex carbohydrates and other beneficial

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compounds and can help control type 2 diabetes and lose weight. The purpose of this research is to evaluate the potential of using quinoa flour in the formulation of dairy desserts based on rice flour and to produce a product with unique functional properties.

2- Materials and Methods

2-1- Materials used in the preparation of dairy dessert

This research was carried out in 2021 in the technology laboratory of the Faculty of Animal Science and Food Technology, Agricultural Sciences and Natural Resources University of Khuzestan. In order to perform the tests, the white variety of quinoa, rice flour and sugar were obtained from the local market of Ahvaz, and cow milk and buffalo milk were obtained from the animal husbandry station of Agricultural Sciences and Natural Resources University of Khuzestan.

2-2- Production of dairy dessert containing quinoa flour

To prepare the treatments, buffalo milk was substituted for cow's milk at levels of 0, 50 and 100% and quinoa flour was substituted for rice flour at levels of 0, 20, 40 and 60%. For this purpose, milk formulation (88.88%), flour (4.44%), and sugar (6.68%) were used. To prepare the porridge, first the milk was pasteurized and cooled, and after standardizing its fat, a mixture of rice flour, quinoa flour, and sugar was added to the milk and stirred. Then it was placed on the heat and stirred for 10 to 15 minutes until the porridge reaches the desired consistency. After cooling, the porridge was poured into a disposable plastic container, closed and stored in a refrigerator at 4°C.

2-3-Evaluation of physicochemical properties of dessert

The amount of dry matter of dairy desserts produced was measured according to the Iranian National Standard Method No. 695. Ash content was measured according to AOAC standard method. Gerber's method was used to measure fat. Measurement of pH (Metrohm, M826) and acidity was performed according to Iranian National Standard Method No. 2852 [13, 14]. To evaluate the water holding capacity (WHC) of the samples, 10 grams of the dessert sample was centrifuged inside the Falcon for 20 minutes at 7°C and 5000 rpm. After centrifugation, the separated water was separated and weighed, and the amount of syneresis of the dessert samples was calculated as a percentage [15]. The texture properties of samples were determined utilizing a Texture Analyzer TA-XT2i (Stable Micro Systems, Surrey, UK). Before measuring the texture, the samples were placed in the environment for 30 minutes so that the temperature of all the samples is the same when evaluating the texture [16]. The color index of the samples was quantified with a Minolta Colorimeter CR-400 (Konica Minolta, Inc., Osaka, Japan) with illuminant D_{65} and a viewing angle of 10 based on L*, a*, and b* color system. The color indices were measured in three replicates from three different points of the samples.

2-4- Evaluation of physicochemical properties of rice flour and quinoa flour

Determination of chemical compounds was done according to the standard of the American Chemical Society (AACC, 2003). Moisture percentage was evaluated using an oven (Electro-Helios 2285), fat percentage using the Soxhlet method, protein content using the Kjeldahl method, and ash percentage using an electric furance.

2-5-Evaluation of sensory properties of dessert

The sensory characteristics (taste, texture, appearance color, smell, appearance and overall acceptance) of the produced porridge samples were evaluated in the framework of a 9-point hedonic test by 10 female students of the Agricultural Sciences and Natural Resources University of Khuzestan, and scoring was based on a scale of 1 to 9 (one the lowest and 9 the highest scores) was done [17].

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2-6- Statistical analysis

All tests were performed in three replicates. The results obtained were analyzed by SPSS software version 18 (SPSS Inc., Chicago, IL, USA) and the results were expressed as mean ± standard deviation. Means were compared with Duncan's test at 95% confidence level. The graphs were drawn by Microsoft Excel software.

3-Results and Discussion

3-1- Physicochemical characteristics of quinoa flour and rice flour

Based on the results, the amount of moisture, ash, fat, and protein in rice flour was 7.75%, ash 0.6%, fat 9.9% and protein 8.93%, respectively. In contrast, the values of moisture, ash, fat, and protein for quinoa flour were evaluated as 8.5%, 2.6%, 15.88% and 14.18%, respectively. The obtained values were close to the results of similar studies. [18-19] and the slight difference in some results was probably due to the difference in the different varieties used.

3-2- The amount of dry matter of dairy dessert

The results of the substitution effect of quinoa flour on the dry matter of dairy dessert are presented in Figure 1. By increasing the percentage of replacing rice flour with quinoa flour, the amount of dry matter in the dessert increased significantly ($p<0.001$). The lowest amount of dry matter corresponds to the 0% replacement level, which is not significantly different from the 20% level of quinoa flour ($p>0.001$). In the research of Sekhavizadeh et al. (2023), desserts containing quinoa protein isolate showed higher dry matter content compared to control desserts. Desserts enriched with 5% quinoa protein isolate had the highest amount of protein and dry matter among the samples (0, 1, 3 and 5%) [20]. As expected, more protein in quinoa flour compared to rice flour based on the results of the chemical test of this research has led to an increase in dry matter with an increase in the percentage of replacing rice flour with quinoa flour.

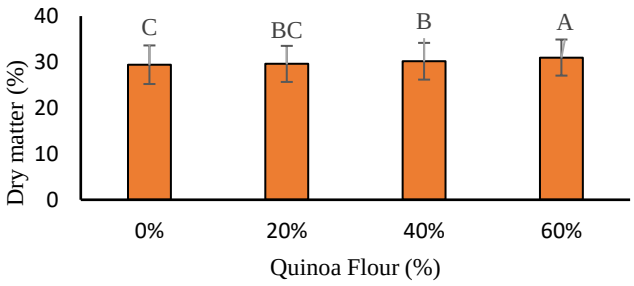

Fig. 1. Effect of quinoa flour substitution level on the dry matter content of dairy dessert

3-3-Ash amount of dairy dessert

Figure 2 shows the results of replacing quinoa flour with dairy dessert ash. By increasing the percentage of replacing rice flour with quinoa flour, the amount of ash increased significantly ($p<0.001$), which could be the reason for the higher ash values of quinoa flour (2.60 ± 0.10 %) compared to rice flour (0.60 ± 0.04 %). The results of the research of Javaheripour et al. (2022) showed that with the increase in the amount of quinoa flour and sprouted wheat flour, the amount of ash in sponge cake samples increased significantly ($p<0.05$), so that the highest amount of ash in the sample containing sponge cake 15% quinoa flour + 15% sprouted wheat flour and its lowest level was observed in the sponge cake without quinoa flour and sprouted wheat flour [21]

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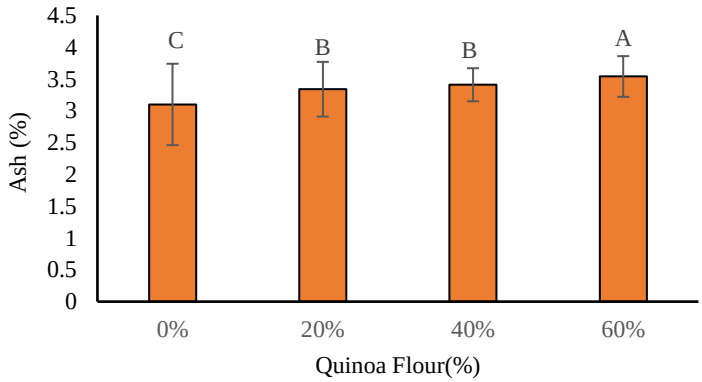

Fig. 2. Effect of quinoa flour substitution level on dairy dessert ash

Patricia et al. (2018) used whole and sprouted quinoa flour (0 to 30%) in the formulation of gluten-free muffins based on rice flour. Their results showed that the presence of quinoa flours (both types) in the formulation of gluten-free muffins with a 10% increase in minerals led to an increase in the ash of the production samples [22]. Poursalehi et al. (2013) also stated that buckwheat, amaranth and quinoa are pseudo-cereals, although they are not from the wheat family, but they are very similar to cereals. These plant seeds are very rich in mineral substances, and by adding them to food formulations, the amount of ash increases significantly [23].

3-4-pH and acidity of dairy dessert

The results of the effect of quinoa flour replacement levels on pH and acidity of dairy dessert are shown in Table 1. By increasing the percentage of quinoa flour replacement, the pH value of the samples decreased significantly and the acidity value increased ($p<0.001$). The lower pH of the dessert prepared from higher percentages of quinoa flour is due to the lower pH of quinoa flour (6.31) compared to the pH of rice flour (6.61). In the research of Sekhavizadeh et al. (2023), increasing the level of quinoa protein isolate in the dessert caused a decrease in pH and an increase in acidity [20]. The reason for the decrease in pH with the increase in the percentage of quinoa flour replacement is the pH of quinoa flour, which is lower than the pH of rice flour. The reason for the increased acidity of desserts containing quinoa flour compared to desserts containing rice flour is the high acidity of quinoa flour. Mohammad et al. (2020) reported that the addition of different levels of quinoa flour led to an increase in pH in low-fat processed camel milk cheese [24]. By increasing the amount of quinoa sprout paste, the pH level in Krish cheese increased [25]. These results were similar to the results of this research.

Table. 1. Effect of quinoa flour substitution level on the pH and acidity of dairy dessert

PH	Acidity	Amount of flour (%)
6.52 ± 0.153^{A}	25.11 ± 3.52^{B}	0
6.51 ± 0.154^{AB}	26.94 ± 3.62^{A}	20
6.49 ± 0.13^{B}	27.55 ± 2.83^{A}	40
6.46 ± 0.16^{C}	27.61 ± 2.78^{A}	60

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3-5- Fat content of dairy dessert

The results of the effect of replacing quinoa flour on dairy dessert fat are presented in Table 2. By increasing the percentage of replacing rice flour with quinoa flour, the amount of fat has increased significantly. In this study, the total fat content of quinoa flour was 15.88%. According to studies, approximately 70-89.4 percent of this amount is unsaturated fat [6]. Unsaturated fatty acids have beneficial effects in the treatment of cardiovascular diseases and improve the sensitivity of patients to insulin in diabetic patients [26]. In contrast, the fat percentage of rice flour used in this dairy dessert was determined to be 9.9. The reason for the significant increase in fat with the increase in the percentage of replacing rice flour with quinoa flour is the higher fat content of quinoa flour compared to the fat of rice flour. The reason for the significant increase in fat with the increase in the percentage of replacing rice flour with quinoa flour is the higher fat content of quinoa flour compared to the fat of rice flour. Ranjbary Vasegh et al. (2022) reported that the control sample had the lowest amount of fat, and with the increase in the percentage of quinoa, the amount of fat in the yogurt samples increased [27]. It was also reported that the amount of fat in pasta prepared with fermented quinoa flour is significantly higher than pasta containing wheat flour, which is due to the presence of unsaturated fatty acids and phospholipids [28].

Table. 2. Effect of quinoa flour substitution level on the fat content of dairy dessert

Fat (%)	Amount of flour (%)
3.23 ± 0.003^{C}	0
3.25 ± 0.003^{C}	20
3.3 ± 0.003^{B}	40
3.35 ± 0.003^{A}	60

3-6-Water holding capacity (WHC) of dairy dessert

Figure 3 shows the results of replacing quinoa flour on the water holding capacity (WHC) of dairy dessert. The amount of WHC increased significantly by increasing the percentage of replacing rice flour with quinoa flour ($p<0.001$). Sekhavizadeh et al. (2023) observed that desserts enriched with the highest amount of quinoa protein isolate (5%) had the highest WHC [20]. On the other hand, control desserts showed the lowest consistency, which caused a decrease in WHC compared to other desserts ($p<0.05$). The addition of protein causes the creation of finer networks, denser crosslinks, smaller pores, and increased WHC [29]. The higher protein content of quinoa flour compared to rice flour has increased the WHC by increasing the percentage of replacing rice flour with quinoa flour.

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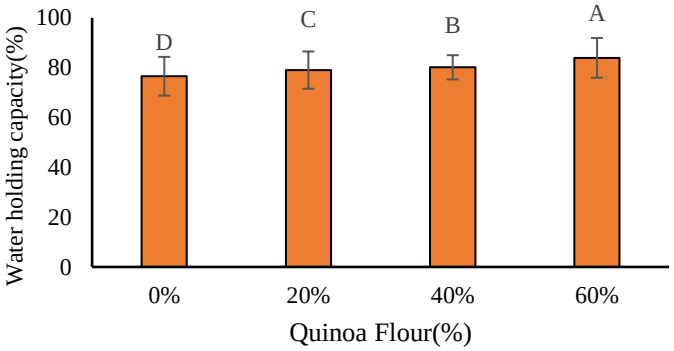

Fig. 3. Effect of quinoa flour substitution level on water holding capacity of dairy dessert

3-7- Evaluation of color characteristics of dairy dessert

The results of the effect of flour on the color indices L*, a*, and b* of dairy dessert are presented in Table 4. As can be seen, with the increase in the replacement percentage of quinoa flour, the value of color index L*, a*, and b* of the samples has decreased, increased and decreased significantly ($p<0.001$), respectively. Sarlak et al. (2023) reported that the presence of colored compounds in *Sargassum angustifolium* algae has reduced the brightness (L*) and transparency of milk dessert samples [30]. Barakawa et al. (2006) reported that the yellow, red or black color of quinoa seeds is due to the presence of betalin pigment in it. Also, the total carotenoid content of white, red, and black quinoa seeds is 11.87, 14.97, and 17.61 µg/g, respectively [1, 31]. It seems that the presence of carotenoid and betalin pigments in quinoa flour has caused the lightness of dairy dessert samples to decrease. Moazeni et al. (2018) in the study of enrichment of Barbari dough with whole quinoa flour reported that the amount of color indices L* and b* in breads containing whole quinoa flour decreased compared to the control bread, but the amount of a* increased significantly. The presence of betalanin pigment and reducing sugar such as glucose and amino acids such as lysine in the composition of quinoa flour causes the Maillard reaction to occur more during the baking process compared to breads containing wheat flour, which increases the intensity of the redness of the bread crust [32]. It seems that the presence of pigments in quinoa flour has increased the redness of dairy dessert samples. Ebrahimzadeh et al. (2015) reported that with increasing percentage of quinoa in bread, L* and b* index decreases and a* index increases. The reason for the dark color of the dessert is the difference in the color of the used flours due to the presence of betalin pigment, carotenoids and amino acids such as lysine in quinoa flour [33].

Table 3. Effect of quinoa flour substitution level on color index of dairy dessert

Color index L*	Color index a*	Color index b*	Amount of flour (%)
71.84 ± 3.92^{A}	-5.77 ± 1.26^{D}	9.48 ± 1.78^{D}	0
67.79 ± 4.77^{B}	-5.34 ± 1.24^{C}	9.06 ± 1.76^{C}	20
64.65 ± 4.79^{C}	-4.74 ± 1.23^{B}	8.32 ± 1.7^{B}	40
62.68 ± 3.98^{D}	-4.6 ± 1.21^{A}	7.8 ± 1.63^{A}	60

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3-8- Evaluation of textural characteristics of dairy dessert

3-8-1- Firmness

The results of the effect of flour on the firmness of dairy dessert can be seen in Table 4. By replacing quinoa flour, the firmness of the dessert texture increased significantly. No significant difference was observed between 0% and 20% levels of quinoa flour. Demir and Clearinge (2017) reported that the use of quinoa flour increased the hardness of cookies [34]. The increase in protein content due to the large number of proteins participating in the protein network leads to an increase in WHC and hardness [20]. In addition, the firmness may be due to the absorption of more moisture by quinoa flour due to its high WHC [35]. In another research, the reason for the hardening of the texture of compact food bars based on quinoa flour has been attributed to enzymatic reactions, changes in the moisture content of the samples, or reactions in food polymers that cause cross-linking and hardening of the texture [36].

Table 4. Effect of quinoa flour substitution level on firmness of dairy dessert

Firmness(g)	Amount of flour (%)
0.0109 ± 0.0037^{C}	0
0.011 ± 0.0025^{C}	20
0.014 ± 0.0057^{B}	40
0.0168 ± 0.0047^{A}	60

3-8-2- Adhesiveness

The results of the effect of replacing quinoa flour on dairy dessert adhesiveness are presented in Table 5. By increasing the substitution of quinoa flour, the adhesiveness of the dessert texture increased significantly. Sekhavizadeh et al. (2023), reported that the addition of quinoa protein isolate to low-fat milk dessert increased adhesiveness [20]. In the present study, the chemical composition of both flours showed that the amount of protein of quinoa flour (14.18 ± 0.50%) is higher than the protein of rice flour (8.93 ± 0.30%), and since the amount of protein is greater than the amount adhesiveness is effective, the reason for adhesiveness is more with increasing the percentage of replacing rice flour with quinoa flour, the higher amount of quinoa flour protein.

Table 5. Effect of quinoa flour substitution level on the adhesiveness of dairy dessert

adhesiveness (mJ)	Amount of flour (%)
-0.0032 ± 0.0008^{B}	0
-0.0028 ± 0.0006^{A}	20
-0.0026 ± 0.0012^{A}	40

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-0.0025±0.0007[A]	60

3-9- Evaluation of sensory characteristics of dairy dessert

3-9-1- Appearance color

The results of the effect of replacing quinoa flour on the color of the dairy dessert are shown in Figure 5. By increasing the percentage of quinoa flour substitution, the color score of the samples decreased significantly ($p<0.05$). Ranjbar Vasegh et al. (2022) reported that, according to panelists, with the increase in the amount of quinoa seeds, the color acceptance rate of yogurt samples decreased [27]. The reason for the darker samples with a higher percentage of quinoa flour is the presence of reducing sugars such as glucose and amino acids such as lysine in quinoa flour, which during the cooking process causes a non-enzymatic browning reaction and darkens the color. On the other hand, the presence of betalanin pigment in quinoa flour causes the color of the product to darken [36].

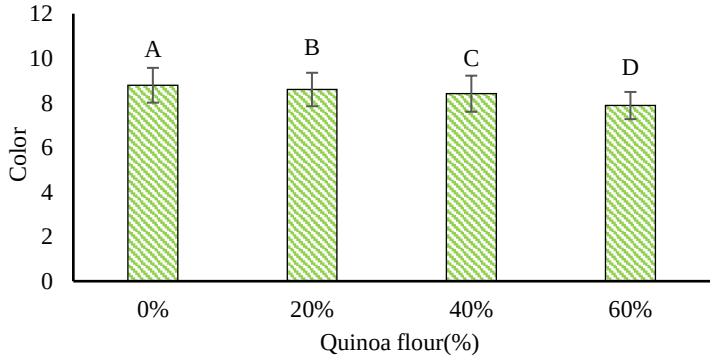

Fig. 5. Effect of quinoa flour substitution level on the appearance color of dairy dessert

3-9-2-Odor

The results of the substitution effect of quinoa flour on the odor and aroma of dairy dessert are presented in Figure 6. By increasing the percentage of quinoa flour substitution, the odor score in the samples decreased significantly ($p<0.05$). Sekhavizadeh et al. (2023) showed that among the samples, with the increase in the amount of quinoa protein isolate, the odor score in the dessert samples decreased [20]. Thermal processing was also effective on the odor and taste of the samples, and increasing the substitution of quinoa flour instead of rice flour led to a decrease in the sensory acceptance of the product in terms of odor and taste. Karimi Abdolmaleki et al. (2017) also stated that the application of heat caused an increase in the aromatic compounds created during the Maillard reaction in the cake produced based on chickpea flour [37]. Moazeni Esfanjani (2017) in the research he conducted on the production of gluten-free bread based on rice flour and quinoa, also pointed out the reduction of the odor score as a result of the increase of quinoa flour in the formula [38]. The reason for this can be attributed to the special flavor of quinoa.

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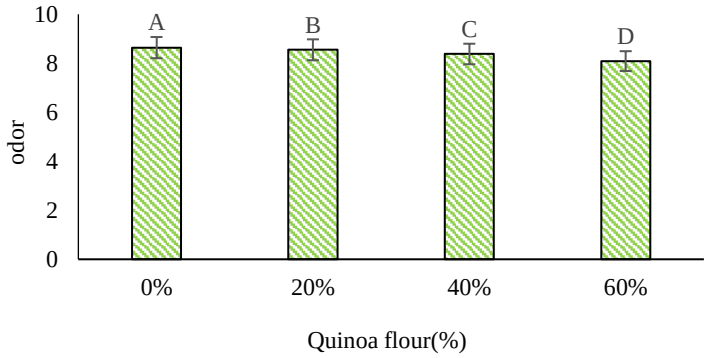

Fig. 6. Effect of quinoa flour substitution level on the odor of dairy dessert

3-9-3- Taste

The results of the effect of replacing quinoa flour on the taste of dairy dessert are presented in Table 6. By increasing the percentage of quinoa flour substitution, the taste score of the samples decreased significantly ($p<0.05$). Sakhavizadeh et al. (2023) reported that among the dessert samples, the taste score decreased with the increase in the amount of quinoa protein isolate [20]. Quinoa seeds have an earthy-like flavor that gives a special characteristic to cooked products that may be considered as an acquired taste [39].

Table 6. Effect of quinoa flour substitution level on the taste of dairy dessert

Taste	Amount of flour (%)
8.75 ± 0.7^{A}	0
8.57 ± 0.6^{A}	20
8.55 ± 0.4^{B}	40
8.35 ± 0.5^{C}	60

3-9-4-Texture

The results of the effect of different levels of quinoa flour on the texture of the dairy dessert are presented in Figure 7. By increasing the percentage of quinoa flour replacement, the texture score of the samples increased significantly ($p<0.05$). Ranjbar Vasegh et al. (1401) reported that texture acceptance rate increased with the increase of quinoa percentage. The increase in protein content leads to an increase in firmness and cohesive texture [27]. The increase in firmness due to the addition of quinoa flour can be due to the decrease in specific volume and the trapping of air bubbles due to the decrease in the amount of gluten and the decrease in the formation of three-dimensional structure in the cake with the decrease in the amount of gluten [40]. An increase in the firmness of the texture in baked products due to the addition of quinoa flour has been reported in several studies [41-43].

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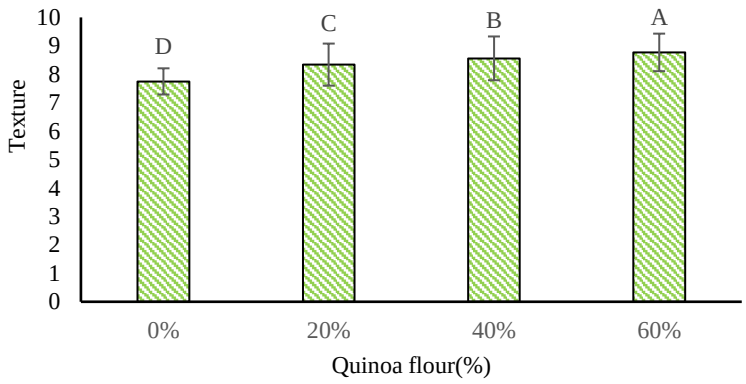

Fig. 7. Effect of quinoa flour substitution level on dairy dessert texture

3-9-5- Overall acceptability

The results of the substitution effect of quinoa flour on the overall acceptance of dairy dessert are presented in Table 7. With the increase in the percentage of quinoa flour substitution, the overall acceptance score of the samples decreased significantly ($p<0.05$). In the research of Sekhavizadeh et al. (2023), overall acceptance decreased among dessert samples with an increase in the amount of quinoa protein isolate. However, no significant difference was observed between control and 1% quinoa protein isolate samples in total acceptance score [20]. Alencar et al. (2017) reported that the distinct taste and odor of quinoa has a negative effect on the sensory properties of breads. Therefore, the lower acceptance scores may be due to a decrease in the panelists' familiarity with the taste of quinoa because they stated that they consumed quinoa mainly in the form of cooked seeds [44].

Table 7. Effect of quinoa flour substitution level on the overall acceptance of dairy dessert

Overall acceptance	Amount of flour (%)
8.66 ± 0.5^{A}	0
8.65 ± 0.5^{A}	20
8.37 ± 0.4^{B}	40
7.98 ± 0.4^{C}	60

4- Conclusion

The obtained results showed that quinoa flour is a pseudo-cereal with a special nutritional value that can be used to produce useful food products. In general, increasing the percentage of replacing cow's milk with buffalo's milk did not have an adverse effect on dairy dessert samples. The replacement level of 60% of quinoa flour is not recommended due to the adverse effect on pH, color and overall acceptance, and the replacement levels of 20 and 40% of quinoa flour are introduced as appropriate levels in dairy desserts.

5- Acknowledgment

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6- References

[1] Tang, Y., Li, X., Chen, P. X., Zhang, B., Hernandez, M., Zhang, H., Marcone, M. F., Liu, R., & Tsao, R. (2015). Characterisation of fatty acid, carotenoid, tocopherol/tocotrienol compositions and antioxidant activities in seeds of three Chenopodium quinoa Willd. genotypes. *Food Chemistry*, 174, 502–508.

[2] Tarrega, A., Duran, L., & Costell, E. (2004). Flow behaviour of semi-solid dairy desserts. Effect of temperature. *International Dairy Journal*, 14(4), 345–353.

[3] Tezcan, M. (2000). *Anthropology of Turkish food*. Genç Ofset.p.148.

[4] Institute of Standards and Industrial Research of Iran. (2012). *Milk and milk products- Milk-base desserts Specification and test method, ISIRI no 14681*. ISIRI.

[5] De Wijk, R. A., Rasing, F., & Wilkinson, C. L. (2003). Texture of semi-solids: Sensory flavor–texture interactions for custard desserts. *Journal of Texture Studies*, 34, 131–146.

[6] Bastidas, E., Roura, R., Rizzolo, D., Massanés, T., & Gomis, R. (2016). Quinoa (Chenopodium quinoa Willd), from nutritional value to potential health benefits: An integrative review. *Journal of Nutrition & Food Sciences*, 6(3).

[7] Sánchez-Chino, X., Jiménez-Martínez, C., Dávila-Ortiz, G., Álvarez-González, I., & Madrigal-Bujaidar, E. (2015). Nutrient and nonnutrient components of legumes, and its chemopreventive activity: A review. *Nutrition and Cancer*, 67(3), 401–410.

[8] Aminifar, M., Miani, S., Alami, M., Ghaffarpoor, M., Dastmalchi, F., Maghsoodloo, Y., & Mohammadi, M. (2016). Investigation on the physicochemical, textural and sensorial properties of functional dairy dessert prepared from hull-less barley malt. *Iranian Journal of Biosystems Engineering*, 47(3), 501-509.

[9] Zabihi, F., & Karazhiyan, H. (2022). Physiochemical and textural properties of dairy dessert containing millet flour as a substitute for rice flour. *FSCT*, 19(123), 329-340.

[10] Codină, G. G., Franciuc, S. G., & Mironeasa, S. (2016). Rheological characteristics and microstructure of milk yogurt as influenced by quinoa flour addition. *Journal of Food Quality*, 39(5), 559-566.

[11] El-Shafei, S. M., Sakr, S. S., & Abou-Soliman, N. H. (2020). The impact of supplementing goats' milk with quinoa extract on some properties of yoghurt. *International Journal of Dairy Technology*, 73(1), 126-133.

[12] Ji, X., Wang, L., Zhao, J., & Jiang, J. (2023). Possible role of polypeptide-chlorogenic acid interaction in the physicochemical and sensory characteristics of quinoa-modified coffee beverage. *Food Chemistry*, 425, 136359.

[13] Institute of Standards and Industrial Research of Iran. (2022). *Yoghurt- Specifications and test methods, ISIRI no 695, 6th Revision*. ISIRI.

[14] Institute of Standards and Industrial Research of Iran. (2022). *Milk and milk products– Determination of titrable acidity and pH – Test method, ISIRI no 2852, 2nd Revision*. ISIRI.

[15] Rinaldoni, A., Campderros, M., & Padilla, A. (2012). Physico-chemical and sensory properties of yogurt from ultrafiltreted soy milk concentrate added with inulin. *LWT - Food Science and Technology*, 45, 142-147.

[DOI: 10.22034/FSCT.21.157.205]

[16] Jooyandeh, H., & Minhas, K. (2009). Effect of addition of fermented whey protein concentrate on cheese yield and fat and protein recoveries of Feta cheese. *International Dairy Journal*, 46, 221-224.

[17] Soukoulis, C. H., Lyroni, E., & Tzia, C. (2010). Sensory profiling and hedonic judgement of probiotic ice cream as a function of hydrocolloids, yogurt and milk fat content. *Journal of Food Science and Technology*, 43, 1351-1358.

[18] Taghizadeh, M., Akhoundzadeh, H., & Zamani, Z. (2021). Study of the physicochemical properties of flour from three quinoa (Quinoa) varieties and the effect of pH on their functional properties. *Iranian Journal of Food Science and Technology Research*, 17(1), 13-27. https://doi.org/10.22067/ifstrj.v17i1.82383

[19] Ali, G., El-Dardiry, A., & El-rahmany, A. (2022). Study of the chemical, rheological, functional, microstructure, microbial, and sensory properties of Kareish cheese fortified with germinated quinoa seeds and processed using ultrasound technology. *Egyptian Journal of Chemistry*. https://doi.org/10.21608/ejchem.2022.152795.6615

[20] Sekhavatizadeh, S. S., Karimi, A., Hosseinzadeh, S., Shaviklo, A. R., Abedi, M., Mahmoodianfard, H. R., & Ghaedmohammadi, M. (2023). Nutritional and sensory properties of low-fat milk dessert enriched with quinoa (Chenopodium quinoa Willd) Titicaca protein isolate. *Food Science & Nutrition*, 11, 516–526.

[21] Javaheripour, N., Shahsevani Mojarad, L., Mahdikhani, S., & Inanloo, Y. (2021). The effect of adding quinoa flour and germinated wheat flour on the physicochemical, microbial, and sensory properties of sponge cake. *FSCT*, 18(119), 375-392.

[22] Patricia, P. M. V., Jesica, R. M., Antonella, E. B., & Edgardo, L. C. (2018). Effects of whole and malted quinoa flour addition on gluten-free muffins quality. *Journal of Food Science*, 84(1), 147-153.

[23] Poursalehi, M., Zeinali, F., Alizadeh, M., & Almasi, H. (2021). Production of functional chicken sausage using quinoa flour and investigation of its physicochemical and textural properties. *Food Industry Research (Agricultural Science)*, 31(3), 85-107. https://sid.ir/paper/954694/fa.

[24] Mohamed, A., Khalifa, S., Abdeen, E. S., & El-Shafei, S. M. (2020). Effect of quinoa (Chenopodium quinoa) flour on the production and quality of low-fat camel milk processed cheese spread. *Pakistan Journal of Biological Sciences*, 23, 439-453. https://doi.org/10.3923/pjbs.2020.439.453

[25] El-Dardiry, A. I. (2022). Study of the chemical, rheological, functional, microstructure, microbial, and sensory properties of Kareish cheese fortified with germinated quinoa seeds and processed using ultrasound technology. *Egyptian Journal of Chemistry*, 65(11), 515-529.

[26] Ng, S. C., Anderson, A., Coker, J., & Ondrus, M. (2007). Characterization of lipid oxidation products in quinoa (Chenopodium quinoa). *Food Chemistry*, 101(1), 185-192.

[27] Ranjbary Vasegh, S., Hesari, J., Peighambardoust, S. H., Moharrampour, H., & Bodbodak, S. (2022). Effects of quinoa addition on physicochemical, microbial and sensory properties of stirred yogurt. *FSCT*, 19(131), 233-246.

[28] Lorusso, A., Verni, M., Montemurro, M., Coda, R., Gobbetti, M., & Rizzello, C. G. (2017). Use of fermented quinoa flour for pasta making and evaluation of the technological

[DOI: 10.22034/FSCT.21.157.205]

and nutritional features. *LWT*, 78, 215-221. https://doi.org/10.1016/j.lwt.2016.12.046

[29] Amatayakul, T., Halmos, A., Sherkat, F., & Shah, N. (2006). Physical characteristics of yoghurts made using exopolysaccharide-producing starter culture and varying casein to whey protein ratios. *International Dairy Journal*, 16, 40-51.

[30] Sarlak, B., Sedaghati, M., & Mooraki, N. (2023). Production and characterization of dairy dessert enrichment with Sargassum angustifolium algae. *Food & Health*, 6(2), 24-30.

[31] Zevallos, V. F., Herencia, I. L., Chang, F., Donnelly, S., Ellis, J. H., & Ciclitira, P. J. (2014). Gastrointestinal effects of eating quinoa (Chenopodium quinoa Willd.) in celiac patients. *American Journal of Gastroenterology*, 109(2), 270-278.

[32] Moazeni, M., Zaringhalami, S., & Ganjloo, A. (2018). Effect of barbari dough enrichment with quinoa whole flour on farinograph characteristics and bread quality. *Food Research Journal*, 28(4), 103-112.

[33] Ebrahimzadeh, A., Yarmand, M. S., & Sepahvand, N. (2015). Evaluation of the properties of the chemical, physical and rheological bread enriched with quinoa flour. (Master's thesis, Islamic Azad University, Quds Unit).

[34] Demir, M. K., & Kılınç, M. (2017). Utilization of quinoa flour in cookie production. *International Food Research Journal*, 24(6), 2394-2401.

[35] Hosseini, F., & Ansari, S. (2019). Effect of modified tapioca starch on the physicochemical and sensory properties of liquid kashk. *Journal of Food Science and Technology*, 56(12), 5374-5385.

[36] Nowrouzian, A., Mehraban Sangh Atash, M., & Sahraiyan, B. (2023). Investigation the effect of processed quinoa on physicochemical and sensory characteristics of compact food bar. *FSCT*, 20(138), 119-132.

[37] Karimi Abdolmaleki, N., Aalami, M., Ziaiifar, A. M., Kashiri, M., & Fathi, F. (2018). Effect of raw and heat-treated chickpea flour on quality characteristics of rice flour-based gluten-free cake. *Journal of Food Science and Technology*, 15(80), 281-292.

[38] Moazeni Esfanjani, M. (2017). Production of functional gluten-free bread based on rice and quinoa flours. (Master's thesis, Food Science and Technology, Zanjan University).

[39] Franco, W., Evert, K., & Van Nieuwenhove, C. (2021). Quinoa flour, the germinated grain flour, and sourdough as alternative sources for gluten-free bread formulation: Impact on chemical, textural and sensorial characteristics. *Fermentation*, 7(3), 115. https://doi.org/10.3390/fermentation7030115

[40] Bellido, G., Scanlon, M. G., & Page, J. H. (2009). Measurement of dough specific volume in chemically leavened dough systems. *Journal of Cereal Science*, 49(2), 212-218.

[41] Martínez-Cervera, S., Salvador, A., & Sanz, T. (2014). Comparison of different polyols as total sucrose replacers in muffins: Thermal, rheological, texture and acceptability properties. *Food Hydrocolloids*, 35, 1-8.

[42] Nourmohammadi, E., & Peighambardoust, S. H. (2015). A comprehensive study on the effect of maltitol and oligofructose as alternative sweeteners in sponge cakes. *International Journal of Food Engineering*, 11(4), 557-562.

[43] Turkut, G. M., Cakmak, H., Kumcuoglu, S., & Tavman, S. (2016). Effect of quinoa flour on gluten-free bread batter rheology and bread quality. *Journal of Cereal Science*, 69, 174-181.

[44] Alencar, N. M. M., de Morais, E. C., Steel, C. J., & Bolini, H. M. A. (2017). Sensory

[DOI: 10.22034/FSCT.21.157.205]

characterisation of gluten-free bread with addition of quinoa, amaranth flour and sweeteners as an alternative for coeliac patients. *International Journal of Food Science & Technology*, 52(4), 872-879.

[DOI: 10.22034/FSCT.21.157.205]

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بررسی پتانسیل استفاده از آرد کینوا در تهیه دسر لبنی فراسودمند

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چکیده

هر ساله در طی فرآوری محصولات کشاورزی و تولید مواد غذایی، مواد زائد و فرآورده‌های جانبی زیادی تولید می‌شوند. اکثر این محصولات فرعی دارای خواص زیست‌فعالی مانند آنتی‌اکسیدان هستند که می‌توان آن‌ها را استخراج و در تولید محصولات سلامتی بخش به کار برد. در پژوهش حاضر، کنجاله بذر کتان که به عنوان محصول فرعی فرایند روغن‌گیری از بذر کتان حاصل می‌شود با استفاده از دو آنزیم تریپسین و پانکراتین با دو متغیر زمان (۲۱۰-۱۵ دقیقه) و نسبت آنزیم به سوبسترا (۱-۳ ٪) هیدرولیز شد. تاثیر پیش‌تیمار مایکروویو بر خواص آنتی‌اکسیدانی پروتئین هیدرولیزشده توسط روش سطح‌پاسخ بررسی شد. تیمار پروتئین هیدرولیزشده تولیدی با تریپسین و پیش‌تیمار مایکروویو در شرایط زمان هیدرولیز ۸٤/۰۲ دقیقه و نسبت آنزیم به سوبسترا ۱/۷۷ ٪ به عنوان تیمار بهینه با بیشترین خواص آنتی‌اکسیدانی (فعالیت آنتی‌اکسیدانی کل ۰/۷٤۵ (جذب در ٦۹۵ نانومتر)، فعالیت مهار رادیکال آزاد DPPH ۷۱/۳۵ ٪ و فعالیت شلاته‌کنندگی یون آهن ۷٦/۱۲ ٪) انتخاب شد. پروتئین هیدرولیزشده بذر کتان به عنوان یک محصول زیست‌فعال با خواص آنتی‌اکسیدانی، می‌تواند به‌عنوان یک آنتی اکسیدان طبیعی در تولید محصولات سلامتی‌بخش و مکمل غذایی ورزشکاران مورد استفاده قرار گیرد.

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