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Evaluation of the effect of quinoa flour and monoglyceride emulsifier on physicochemical and sensory properties of gluten-free cookie

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ABSTRACT

The purpose of this research is to investigate the replacement of different levels of chickpea flour (0, 25, 50, 75 and 100%) with quinoa flour and the addition of monoglyceride emulsifier at levels of 0, 0.5 and 1% to the formulation of gluten-free cookies. In this research, the amount of ash, protein, moisture, specific volume, firmness and sensory properties (form and shape, surface, texture, cheweness, odor and taste, and overall acceptance) of the samples were evaluated. The results showed that the moisture, ash and fat content of quinoa flour was higher and its protein content was lower than chickpea flour. By increasing the level of replacing chickpea with quinoa flour in the formulation of gluten-free cookies, the amount of moisture and ash was increased and the amount of protein was decreased. The sample containing 25% quinoa flour and 0.5% monoglyceride emulsifier had the highest specific volume (0.98 ml/g) and the lowest firmness (31.37 N). The presence of quinoa flour and the increase of its level in the formulation showed L* value decreased and a* value increased. The sensory evaluation showed the sample containing 25% quinoa flour (without emulsifier) and the sample containing 25% quinoa flour and 0.5% monoglyceride emulsifier had better than other samples. It should be noted that the samples containing 50% quinoa flour in the presence of 0.5% monoglyceride emulsifier were of high quality and quantity, and the overall acceptance score and physicochemical characteristics of these samples were favorable. Therefore, samples containing 25 or 50% quinoa flour and 0.5% monoglyceride emulsifier are introduced as the best samples of gluten-free cookies in this research.

1. Introduction

Gastrointestinal diseases are very important among human societies, especially in developing countries. Celiac disease is an autoimmune digestive disorder. Patients with celiac disease cannot tolerate the gliadin part of wheat and the prolamins of rye (scaline), barley (hordein) and oats. By consuming gluten in these people, the small intestine becomes inflamed and causes damage to the intestinal mucosa and problems in the absorption of nutrients. The only way to treat it is to use a gluten-free diet [1]. In recent years, there has been a lot of interest in gluten-free bakery products. Because flour products are the main food consumed in the whole world and have the highest amount of consumption due to their cheapness, wide accessibility, appropriateness in terms of carbohydrate source and energy supply [2].

Nakhodchi bread or khodchi cookie is one of the traditional sweets of Qazvin and one of the most famous Iranian sweets. This sweet is based on chickpea flour [3]. Ardi chickpea flour is gluten-free and this sweet is suitable for celiac patients due to its gluten-free ingredients. Creating diversity in the appearance, color, smell and taste, improving the texture and structure and increasing the nutritional value of this traditional sweet by replacing a part of chickpea flour with other gluten-free flours and using permitted additives of bakery products such as emulsifier. can multiply its attractiveness. Today, much attention is paid to the use of quinoa seeds and flour in food, especially in bakery products. Quinoa with the scientific name*Chenopodium quinoa Willd*) is an annual plant from the dicotyledonous plants and from the Chenopodiaceae family[4 and 5]. The very high value of its seeds has caused it to be compared with milk powder by the World Food and Agriculture Organization (FAO). Quinoa is a rich source of protein, amino acids lysine, methionine, cysteine, threonine and magnesium, potassium and iron. This pseudo-cereal has less starch and more dietary fiber than other grains (wheat, barley, corn and rice) and is rich in antioxidants [6]. Compared to some common grains (wheat and barley), quinoa is rich in Various vitamins such as niacin, folic acid, vitamins A, B_2 and E is [5]. Quinoa has been used to produce gluten-free products with high nutritional value such as muffins, cookies, pan bread, biscuits and bread [7-11].

Emulsifiers, which are surface active agents, when used in bakery products, act as a substance with multiple roles, whose three important functions are: helping to mix and emulsify raw materials, helping to the characteristics of shortenings and useful connections of flour with other components in the mixture [12]. Monoglycerides are one of the most important common emulsifiers that are generally recognized as safe (GRAS). This emulsifier has lipophilic properties, so it has a low HLB of 3 to 6 [13]. Monoglycerides act as emulsifiers and stabilizers in many food products such as bakery products, margarine confectionery oils and food doughs. Adding this emulsifier to shortenings improves the emulsification of shortening in dough or dough. In addition to reducing staleness, these emulsifiers in bakery products reduce the interfacial phase, improve the distribution of raw materials, increase aeration, more foam stability and crystal modification. becomes fat [14]. Binding of monoglyceride with starch, especially amylose, is the most important in increasing the shelf life of bakery products and creating a soft texture in them. Also, among other uses of monoglycerides, we can mention reducing blisters on the surface and creating a more uniform surface [13]. Monoglyceride emulsifier has been used in many bakery products, such as steamed gluten-free rice cakes, egg-free cakes, gluten-free breads, and breads containing wheat flour, and existing reports indicate improvement in the texture and sensory characteristics of the production samples. [15-18]. Therefore, considering the society's need for new and enriched gluten-free products and considering the nutritional benefits of quinoa flour and the positive performance of monoglyceride emulsifier on the technological and appearance characteristics of bakery products, the aim of this research is to replace chickpea flour. with quinoa flour (at levels of zero, 25, 50, 75 and 100%) in gluten-free sweets and improving the quantitative and qualitative characteristics of the production product using monoglyceride emulsifier (zero, 0.50 and 1%).

2- Materials and methods

2-1- Materials

Saponinized white quinoa flour (Titicaca) (moisture 7.67%, fat 5.7%, protein 7.67% and ash 2.84%), chickpea flour (moisture 23.5%, fat 1.4% , protein 24.23% and ash 63.2%), powdered sugar and shortening were purchased from a reputable attari in Mashhad. Monoglyceride emulsifier (E471) was purchased from Pars Bebehd Company (Mashhad-Iran) and all laboratory chemicals were purchased from reputable companies.

2-2-The method of making sweets

The control gluten-free pastry (without quinoa flour and monoglyceride emulsifier) contained 100 grams of chickpea flour, 50 grams of shortening, and 50 grams of powdered sugar. To prepare the treatments, chickpea flour was replaced with quinoa flour at zero, 25, 50, 75 and 100% levels. Also, monoglyceride emulsifier (E471) was used in the formulation of gluten-free sweets at zero, 0.5 and 1% levels. To prepare gluten-free sweets, powdered sugar and shortening were first mixed in a laboratory mixing tank (model BJY-BM5N, manufactured by Bake Sanat, Iran) for 5 minutes until a smooth and uniform mixture was reached. In the next step, flour was added to the mixture of powdered sugar and shortening in several stages, and the mixing continued until a uniform dough was reached. Then the transferred pastry dough was placed in polyethylene bags for 24 hours at 4 degrees Celsius (refrigerator temperature). After the resting period, the pastry dough was removed from the refrigerator and placed in the environment until it reached a temperature of about 25 degrees Celsius. Next, the gluten-free pastry dough was rolled out to a diameter of 1 cm wide and molded with a small four-pin mold. At the end, the prepared samples were placed in a special tray and baked in a laboratory oven (model XFT135, made in Italy) at a temperature of 160 degrees Celsius for 20 minutes.

2-3-protein

AACC method (2000) No. 46-12 (Kjeldahl method) was used for protein measurement [19].

2-4-ash

AACC method (2000) No. 01-08 (furnace method) was used to measure ash [19].

2-5-humidity

The moisture content was measured using the AACC (2000) method number 16-44 (Ironization method)[19].

2-6-Special volume

For this purpose, the weight of each sample was measured using a digital scale. Then, the volume replacement method with rapeseed was used according to the AACC standard (2000) No. 72-10 to measure the volume. Finally, by dividing the volume by the weight of the sample, the specific volume was calculated in terms of milliliters per gram [19].

2-7-texture

The tissue evaluation of the samples was done using a tissue measuring device based on the method of Nasahi et al. (2018) with some changes. For this purpose, each treatment (a complete gluten-free pastry) was compressed with a probe plate larger than the cross-sectional area of the sample at a speed of 5 mm/s up to 50% of the thickness of the pastry, and the maximum required force will be considered as the stiffness of the tissue in Newtons. became [20].

2-8-Color

Color evaluation was done according to the method of Sarikoban and Yilmazu et al. (2010). For this purpose, the samples were placed in a box with a white background for photography, and photography was done using a digital camera. Factors related to color in the Hunterlab system ($L^*a^*b^*$), were obtained by transferring images to a computer and using image processing software. This model has L factor*(including black to white spectrum ranging from zero to 100) and two color factors a^*(including the color spectrum from green to red with a range of +120 to -120) and b^*(Includes blue to yellow color range with a range of +120 to -120). After determining the color components to compare the color of production samples (different treatments) from the color change index (ΔE ΔE) was calculated using equation 1 [21].

$$\Delta E = \sqrt{(L-L0)^2 + (a-a0)^2 + (b-b0)^2}$$

L_0 ،a_0 and b_0 The color components of the sample are witnesses.

9-2-sensory features

For this purpose, 10 referees were selected from the Research Institute of Food Science and Technology of Razavi Khorasan Academic Jihad. Sensory characteristics of gluten-free sweets in terms of form and shape (asymmetrical shape, and the presence of any cavity or internal space), surface (burntness, abnormal color, wrinkles, cracks and abnormal surface), firmness and softness of texture (doughy or unusual softness, firmness, crispness and fragility), chewability (dry and hard doughnuts, balls and dough in the mouth and sticking to the teeth) and smell, taste and taste (pungent taste, The smell of rawness or sourness or the natural aroma of gluten-free sweets) were evaluated. Attribute evaluation coefficient based on five-point hedonic from very bad (1) to very good (5) and the ranking coefficient of each of the characteristics (form and shape, surface, firmness and softness of texture, chewability and smell and taste) respectively It was 4, 2, 2, 3 and 3 [12 and 22]. Finally, with this information, the overall acceptance score (quality number of gluten-free sweets) was calculated using equation 2.

Relationship 2

$$Q= \frac{\sum (P \times G)}{\sum P}$$

2-10-Statistical analysis

The effect of quinoa flour and monoglyceride emulsifier (E471) on the physical, chemical and sensory characteristics of gluten-free sweets was investigated based on a completely randomized design based on two factors. In this research, the first factor was quinoa flour at five levels of zero, 25, 50, 75 and 100% (as a substitute for chickpea flour) and the second factor was monoglyceride emulsifier at three levels of zero, 0.5 and 1%. Mini-Tab17 software was used for statistical analysis, and Tukey's test with a confidence level of 95% was used to compare the means (P<0.05). All experiments except sensory characteristics will be done with three repetitions. 10 repetitions were considered for sensory characteristics. Graphs were drawn using Excel software.

3. Results and Discussion

1-3-Protein and ash

Table 1 shows the protein and ash content of gluten-free sweets. As the results show, by increasing the replacement of chickpea flour with quinoa flour, the amount of protein in the produced samples decreased and the amount of ash increased significantly (P<0.05). So that the samples containing 100% of quinoa flour in the presence of all three levels of emulsifier (zero, 0.5 and 1%) had the lowest amount of protein and the highest amount of ash. The protein content of chickpea flour was about 24% and quinoa flour was about 17%, and of course it was expected that with the increase of quinoa flour in Miran's formulation, the protein of gluten-free sweets would decrease. Pea protein is very high compared to other legumes and grains, but peas are deficient in sulfur-containing amino acids such as tryptophan, cysteine, and isoleucine. It is possible to eliminate the deficiency of cereal and pseudo-cereal protein, and on the other hand, to compensate for the lack of legume amino acids through the mixing of cereals and legumes [23]. Ronda et al. (2011) and Goulart et al. (2012) reported that chickpea flour is high in protein, so it is recommended for the production or enrichment of baked products [5, 24]. The average protein reported in quinoa seed is 12-23%. Although this amount of quinoa protein is significant and this quasi-grain is considered a protein source and its average protein is higher than that of common grains such as rice, barley or wheat, but its amount is lower than that of legumes. The sentence is peas. Nevertheless, due to the high amount of essential amino acids in quinoa, it can be considered as a supplement for legumes that often have little methionine and cysteine [25]. They reported 2% and 1.68% of ash in chickpea flour [26, 27]. Jankarova and Danddar (2009) studied and compared the chemical composition of quinoa with some common grains. Based on the observations of these researchers, the amount of ash in quinoa, wheat, corn, rice, and barley was 3.8, 2.2, 1.7, 3.4, and 2.2 percent, respectively, and these researchers reported that the amount of quinoa ash was significantly It was significantly more than other cereals [28]. In this regard, the results of Movado et al. (2018) showed that gluten-free bread and biscuits containing 100% quinoa flour contained the highest percentage of protein and ash compared to samples containing corn and rice [16]. Patriciav et al. (2018) from flour Whole and malted quinoa (zero to 30%) were used in the formulation of gluten-free muffins based on rice flour. The results of these researchers 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 [14]. And 50% was replaced with wheat flour. The results showed that quinoa flour increased the mineral content of bread. So that minerals such as calcium increased from 0.35 to 1.28 mg/g and iron from 17 to 34 μg/g [29]. Also, the results of Jeffrey et al.

(2015) showed an increase in the amount of ash in breads containing quinoa flour [30].

Table 1 The effect of quinoa and monoglyceride emulsifier on the amount of protein and ashof gluten-free cookie.

Treatments	Quinoa Flour (%)	Emulsifier (%)	Protein (%)	Ash(%)
1	0	0	11.69±0.23[a]	1.16±0.03[It is]
2	0	0.5	11.65±0.05[a]	1.14±0.01[It is]
3	0	1	11.61±0.03[a]	1.15±0.01[It is]
4	25	0	11.15±0.02[ab]	1.32±0.02[d]
5	25	0.5	11.08±0.08[ab]	1.31±0.02[d]
6	25	1	10.98±0.08[ab]	1.33±0.03[d]
7	50	0	10.25±0.21[b]	1.43±0.01[c]
8	50	0.5	10.21±0.31[b]	1.46±0.01[c]
9	50	1	10.14±0.27[b]	1.49±0.00[c]
10	75	0	9.04±0.03[c]	1.72±0.01[b]
11	75	0.5	90.01±0.09[c]	1.75±0.06[ab]
12	75	1	9.00±0.23[c]	1.73±0.02[b]
13	100	0	8.17±0.12[d]	1.82±0.01[a]
14	100	0.5	8.07±0.13[d]	1.76±0.00[ab]
15	100	1	8.02±0.08[d]	1.86±0.01[a]

Different letters in each column represent significant difference from one another ($p<0.05$).

2-3-moisture

Table 2 shows the moisture content of gluten-free sweets. The results of this section showed that the sample containing 100% quinoa flour and 1% monoglyceride emulsifier had the highest moisture content. Patricia et al. (2018) investigated the replacement of rice flour with quinoa flour in gluten-free muffin formulations. The results of these researchers showed that with the increase of quinoa flour in the muffin, the amount of moisture increased. These researchers attributed this to the presence of more fiber in quinoa flour compared to rice flour. Also, these researchers reported that the initial moisture content of quinoa flour was higher than that of rice flour, which increased the moisture content of samples containing this flour [14]. The findings of these researchers were similar to the results of the present study. Because the moisture content of quinoa flour was higher than the moisture content of chickpea flour and since the formulation of gluten-free sweets produced in this study lacked water, therefore the moisture content of the samples was affected by the moisture content of the flours (pea and quinoa) and the performance of other compounds such as emulsifier monoglyceride in preserving The inherent moisture of the flour is during the baking process. As the results showed, the monoglyceride emulsifier and its level increase in the formulation of gluten-free sweets maintain the moisture of the flour in the pastry during the baking process, and the samples containing the emulsifier had more moisture than the samples without it. The effect of adding monoglyceride to gluten-free sweets improves the moisture retention of flour in the product in two ways. On the one hand, the higher strength of the hydrophobic chain in the monoglyceride molecule with a greater tendency to be placed in the oil phase by reducing the surface tension improves the spreadability and mixing of the oil. By creating a cover on the structure, this will seal the moisture and prevent its exit during the baking process. On the other hand, the hydrophilic groups of the emulsifier chain increase the water holding capacity by creating a connection with free water and, in turn, show an inhibitory effect in reducing humidity [31].

Table 2 The effect of quinoa and monoglyceride emulsifier on moisture, specific volume and firmnesof gluten-free cookie.

Treatments	Quinoa Flour (%)	Emulsifier (%)	Moisture (%)	Specific volume (ml/g)	Firmness (N)
1	0	0	1.21±0.03[of]	0.67±0.12[bc]	45.35±0.35[cde]
2	0	0.5	1.24±0.05[of]	0.88±0.16[ab]	41.34±1.29[if]
3	0	1	1.28±0.02[bcde]	0.71±0.13[bc]	40.68±1.12[if]
4	25	0	1.15±0.01[It is]	0.87±0.00[ab]	44.42±1.08[cde]

5	25	0.5	1.26±0.0[5cde]	0.98±0.16[a]	31.37±1.02[g]
6	25	1	1.38±0.01[abcde]	0.81±0.08[b]	41.64±0.44[if]
7	50	0	1.22±0.02[cde]	0.73±0.12[bc]	44.15±0.42[cde]
8	50	0.5	1.41±0.04[abcde]	0.75±0.11[bc]	36.66±0.54fg
9	50	1	1.47±0.01[abc]	0.67±0.04[bc]	40.90±2.63[if]
10	75	0	1.24±0.03[cde]	0.57±0.04[c]	55.72±2.19b
11	75	0.5	1.44±0.1[abcd]	0.74±0.30[bc]	48.94±2.03[bcd]
12	75	1	1.53±0.04[ab]	0.66±0.08[bc]	48.73±2.06[bcd]
13	100	0	1.29±0.01[bcde]	0.44±0.04[d]	71.35±1.61[a]
14	100	0.5	1.47±0.05[abc]	0.57±0.16[c]	68.44±3.50[a]
15	100	1	1.59±0.01[a]	0.45±0.02[d]	51.08±1.86[bc]

Different lettersin each column represent significant difference from one another ($p<0.05$).

3-3-Special volume

Table 2 shows the specific volume of gluten-free sweets. The results of this section showed that the sample containing 25% quinoa flour and 0.5% monoglyceride emulsifier had the highest specific volume, and the sample containing 100% quinoa flour (without monoglyceride emulsifier) and the sample containing 100% quinoa flour and 1% monoglyceride emulsifier had the lowest specific volume. Elghati et al. (2014) in the same direction, Patricia et al. (2018) and Nesliha et al. (2018) considered the presence of quinoa flour in gluten-free muffin and cake formulations as a factor in increasing volume [14 and 32]. Meanwhile, Turcato et al. (2016) considered the presence of only 25% of quinoa flour in the gluten-free bread formula to be a positive factor in increasing the volume, and adding higher levels of this flour did not have any significant effect on the volume of the bread. According to this study Researchers, if the consumption level of quinoa flour in bakery products is chosen correctly, not only the textural characteristics and the volume of the manufactured product will not decrease, but due to the increase in alpha glycosidase activity as a result of adding quinoa flour to the initial formulation, the volume of the final product will increase. increases and its texture becomes softer and more uniform [33].

Changes in volume index are known as one of several parameters with high importance in products. The importance of this parameter, in addition to its appearance, has a significant impact on the texture and structure of the final product. Active compounds on the surface such as emulsifiers have a positive effect on the increase in volume due to their increasing effect on the ability to retain moisture inherent in the system (flour moisture) or formulation water and lack of tissue compression [34], which the positive effect of monoglyceride emulsifier at the level of 0.5% on the increase The special volume of gluten-free sweets is a proof of this. On the other hand, the results of the present study showed that the volume of gluten-free sweets containing 1% levels of monoglyceride emulsifier (the highest consumption level) has decreased compared to the samples containing the middle level (0.5% level). From the structural aspect, surfactants as amphiphilic compounds are composed of hydrophobic groups that play the role of the tail and hydrophilic groups that play the role of the head in the hydrocarbon chain of the emulsifier. The existence of this dual nature in the chain structure of these compounds gives it unique characteristics. The longer the hydrocarbon chain of the emulsifier, the greater the tendency to absorb at the interface, which is effective in reducing surface tension [35]. Adding emulsifiers in baking products based on shortenings (such as gluten-free sweets produced in this research)) affects the viscosity of the dough. This influence is the result of reducing the surface tension of shortening as a structuring component in our system. Therefore, increasing the level of emulsifier in the system by reducing the surface tension to more than optimal values leads to a decrease in the consistency of the dough and subsequently to a weakening of the structure and a decrease in the volume of the samples in the baking stage, which the results of the present study prove. Armelo et al. (2022) used bioemulsifier and biosurfactant produced from native fermented milk (Pendidam) in the formula of Shirmal bread dough. The results of these researchers showed that the viscosity of the dough and the hardness of the final product decreased significantly, which was effective in creating a more continuous bread texture and increasing the volume of the production samples compared to the control sample [36]. Yanan et al. (2020) used soy lecithin, sodium stearoyl 2-lactylate, diacetyl tartaric esters and monoglyceride emulsifiers in potato enriched steamed bread. The results showed that the addition of emulsifier to the bread formula increased the strength of the dough and its viscoelastic property, which led to an increase in the volume of the bread by increasing the gas storage capacity during the fermentation and baking process [37].

3-4-texture

Table 2 shows the firmness of gluten-free sweets. The results of this section showed that the sample containing 25% quinoa flour and 0.5% monoglyceride emulsifier had the lowest and the sample containing 100% quinoa flour (without monoglyceride emulsifier) had the highest texture stiffness. Jan et al. (2018) used quinoa flour in the formulation of gluten-free cookies. The results of these researchers showed that the use of quinoa flour at levels less than 50% led to the improvement of the texture of the produced samples. These researchers reported that the presence of quinoa flour in the formula of gluten-free cookies increased the spreadability of sugar and oil in the formulation, thereby reducing the stiffness of the texture [38]. (2014) reported that as a result of replacing wheat flour with quinoa, the amount of protein, crude fiber and oil increased compared to the control sample (bread with 100% wheat flour). This caused a linear increase in the hardness of the bread core and its strength at levels of more than 50% replacement [39]. On the other hand, the results of the present study showed the positive effect of monoglyceride emulsifier on tissue healing. Surface-active compounds such as emulsifiers, in addition to being able to be placed at the interface of 2 non-extractable phases and improving structural properties, create functional properties by interacting with compounds present in the food matrix. The stiffness parameter is known as the main texture index as a measure of the structural matrix. As mentioned in the previous sections, the presence of monoglyceride emulsifier in the formulation of gluten-free sweets kept the moisture produced after the baking process compared to the control sample (the sample without monoglyceride emulsifier). Maintaining moisture in the structure by reducing the compression between the particles improves the textural properties and reduces the hardness of the product. On the other hand, the interaction between starch and emulsifier plays a significant role in improving the textural properties of baked products [40]. Starch granules are formed from amylopectin and amylose in a crystalline structure in β form. If a specific heat is applied to the starch structure, the structure changes to alpha crystalline form by breaking the intra-granular hydrogen bonds. The crystalline nature of starch is one of the most determining textural parameters in baking products. The gradual hardening of starch systems is done instantaneously and after the thermal process due to cooling. This change of nature in the structure is related to the amylose component of starch. As a result of heat, the structure of amylose changes to a spiral structure (helix). In the presence of emulsifiers in the system containing starch compounds, the starch-emulsifier complex is formed by placing the hydrocarbon chain in the spiral structure of amylose. The complexes formed by creating spatial hindrance lead to the non-formation of inter-structural connections and as a result the development of stiffness in the baking product [41].

3-5- Color and its changes

Table 3 shows the color of the sample of gluten-free sweets. The results of this section showed that with the increase of quinoa flour and monoglyceride emulsifier, the amount of the color component of L^* and b^*Production examples of reduction and amount of color component a^*Gluten-free sweets increased. In other words, the presence of quinoa flour and monoglyceride emulsifier in the formulation of production samples led to darkening of the color. The results of this research are similar to the results of some researchers. Mowad et al. (2018) investigated the effect of replacing wheat flour with quinoa flour in biscuits and reported the darkening of the color. These researchers considered the reason for the darkening of the color to be the difference in the color of the consumed flours, and on the other hand, the increase in the level of protein and amino acids in the formulation due to the higher level of these compounds in quinoa flour compared to wheat flour and their participation in the browning reaction [16]]. (2017) observed the darkening of pasta color by replacing semolina flour with quinoa flour. These researchers considered the difference in flour pigments, the increase in ash, and the presence of phenolic compounds to increase the color of the production samples [42]. Wang et al. (2015) used a mixture of quinoa flour and wheat flour to produce biscuits, steamed nano bread. The results of these researchers showed that by increasing the percentage of quinoa flour, the darkness (decrease in the color component of L^*) and red color (color component a^*) reported [43]. The change in the color of the candy samples without increasing the level of monoglyceride emulsifier in the system can be related to its effect on the proteins of chickpea and quinoa flour. Proteins are known as amphiphilic structures (simultaneous presence of hydrophilic and hydrophobic groups in the chain). Emulsifiers from the hydrophobic part of the chain have the ability to create hydrophobic interactions with the hydrophobic part of the protein chain. With the expansion of hydrophobic interactions in the chain, the protein structure undergoes denaturation and conformational structure change [44]. Protein denaturation in the presence of emulsifiers increases the level of structure and higher availability of amino acids in the protein chain. Therefore, as a result of the presence of sugar in the formulation, the Maillard browning reaction occurs at a higher rate, which increases the darkness of the samples.

Table 3 The effect of quinoa and monoglyceride emulsifier on color of gluten-free cookie.

Treatments	Quinoa Flour (%)	Emulsifier (%)	L*	a*	b*	Ed
1	0	0	70.25±0.14[a]	5.84±0.43[h]	36.55±1.31[a]	0.00±0.00[h]
2	0	0.5	69.62±0.25[a]	6.22±0.23[h]	37.05±0.27[a]	1.30±0.74[h]
3	0	1	65.72±0.27[b]	7.24±0.17[fg]	37.15±0.01[a]	4.87±0.11[g]
4	25	0	61.67±0.15[c]	7.81±0.12[if]	33.62±0.04[bc]	9.33±0.04[f]
5	25	0.5	61.03±0.32[c]	8.16±0.01[def]	33.81±0.23[b]	9.93±0.23[f]
6	25	1	57.15±0.79[d]	5.59±0.52[cde]	32.63±0.04[bcd]	13.98±0.78[Itis]
7	50	0	56.56±1.91[d]	9.31±0.49[bcd]	31.48±0.15[def]	15.02±2.03[Itis]
8	50	0.5	55.81±0.31[d]	9.35±0.11[bcd]	31.61±0.23[cde]	15.67±0.13[Itis]
9	50	1	52.41±0.46[Itis]	9.54±0.19[bc]	30.89±0.33[def]	19.09±0.22[d]
10	75	0	51.45±0.46[efg]	10.49±0.11[ab]	30.59±0.11[defg]	20.75±0.30[bcd]
11	75	0.5	52.11±0.56[if]	10.10±0.55[ab]	29.91±0.49[efgh]	19.79±0.34[cd]
12	75	1	50.70±0.49[efg]	10.26±0.21[ab]	29.46±0.06[fgh]	21.36±0.60[bcd]
13	100	0	49.82±1.03[efg]	10.94±0.47[a]	28.71±0.33[gh]	22.49±0.93[bc]
14	100	0.5	48.66±0.23[g]	11.15±0.60[a]	28.26±0.42[h]	23.28±0.95[b]
15	100	1	48.87±0.22[g]	11.07±0.00[a]	28.05±0.52[h]	28.13±0.99[a]

Different letters in each column represent significant difference from one another ($p<0.05$).

6-3-sensory features

Table 3 shows the sensory characteristics of a sample of gluten-free sweets. Based on the sensory evaluation and the results obtained from the examined parameters (form and shape, surface, firmness and softness of texture, chewability and smell and taste) and finally general acceptance, quinoa flour can be introduced up to 50% level for the production of sweets. Of course, it should be mentioned that the samples containing 25% of quinoa flour had better sensory characteristics and higher quality. Also, the results of this section clearly indicated the positive performance of the emulsifier on the quality characteristics of gluten-free sweets, and the positive effect of the 0.5% level of this additive was greater than the 1% level. Finally, this part shows the superiority of the sample containing 25% quinoa flour and 0.5% monoglyceride emulsifier compared to other samples. In this regard, there are similar results in the field of adding quinoa flour to the formulation of baking products, including the gluten-free category. (2018) investigated the effect of using quinoa flour in gluten-free cake formulation. The results of this research showed that with the increase of quinoa flour

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in the formulation, the softness of the cake texture increased and the sample containing 50% quinoa flour had the best sensory characteristics, especially in terms of aroma and taste and overall acceptance [32]. Turcato et al. (2016) studied the enrichment of gluten-free bread containing quinoa flour and concluded that increasing the consumption of quinoa flour in the bread formula did not affect the specific volume. This was while the sample containing 25% of quinoa flour had a softer texture and more favorable sensory characteristics [33]. Adriana et al. (2015) investigated the effect of using quinoa flour in gluten-free cookies. In this research, the ratio of rice flour to quinoa was 10-90, 25-75 and 45-55. The results indicated that with an increase of more than 10% of quinoa flour in the formulation, the score of sensory characteristics and overall acceptance score decreased. Therefore, the sample containing 90% rice flour and 10% quinoa flour was introduced as the best sample of this research [45].

Table 4 The effect of quinoa and monoglyceride emulsifier on sensory propertiesof gluten-free cookie.

Treatments	Quinoa Flour (%)	Emulsifier (%)	Sensory properties		
			Form &Shape	Surface	Texture
1	0	0	3.60±0.52^{bc}	3.30±0.67^{bcd}	3.40±1.07^{ab}
2	0	0.5	4.20±0.79^{ab}	4.00±0.47^{ab}	4.30±1.05^{a}
3	0	1	3.30±0.48^{bcd}	3.50±0.52^{abcd}	3.90±1.19^{ab}
4	25	0	4.10±0.74^{ab}	3.90±0.87^{ab}	4.30±0.81^{a}
5	25	0.5	4.80±0.42^{a}	4.50±0.52^{a}	4.50±0.53^{a}
6	25	1	3.70±0.67^{bc}	3.50±0.97^{abcd}	3.60±0.69^{ab}
7	50	0	3.50±0.52^{bc}	3.60±0.52^{abc}	3.40±0.52^{ab}
8	50	0.5	3.90±0.93^{abc}	4.00±0.81^{ab}	3.80±0.79^{ab}
9	50	1	4.20±0.63^{ab}	3.40±0.52^{bcd}	3.30±0.67^{ab}
10	75	0	2.90±0.57^{cd}	2.70±0.67^{cd}	3.30±0.67^{ab}
11	75	0.5	3.60±0.84^{bc}	3.30±0.67^{bcd}	3.60±0.84^{ab}
12	75	1	3.60±0.84^{bc}	3.40±0.84^{bcd}	3.40±0.96^{ab}
13	100	0	2.40±0.51^{d}	2.50±0.53^{d}	3.10±0.66^{b}
14	100	0.5	2.90±0.57^{cd}	3.00±0.71^{bcd}	3.50±0.53^{ab}
15	100	1	3.60±0.84^{bc}	3.20±0.42^{bcd}	3.20±0.57^{b}

Treatments	Quinoa Flour (%)	Emulsifier (%)	Sensory properties		
			Chewiness	Odor&Taste	overall acceptance
1	0	0	3.40±0.96^{bcd}	4.10±0.74^{abc}	3.59±0.38^{bcde}
2	0	0.5	4.20±0.92^{ab}	4.30±0.82^{a}	4.16±0.39^{ab}
3	0	1	3.90±0.71^{ab}	4.00±0.82^{abcd}	3.69±0.55^{bcd}
4	25	0	4.10±0.60^{ab}	3.90±0.99^{abcde}	4.01±0.46^{abc}
5	25	0.5	4.60±0.52^{a}	4.20±0.83^{ab}	4.54±0.38^{a}
6	25	1	3.90±0.74^{ab}	4.00±0.82^{abcd}	3.76±0.49^{bcd}
7	50	0	3.70±0.95^{abc}	3.60±0.96^{abcde}	3.46±0.49^{bcde}
8	50	0.5	4.10±0.7^{4ab}	3.40±0.96^{abcde}	3.77±0.61^{bcd}
9	50	1	3.30±0.48^{bcd}	3.30±0.82^{abcde}	3.40±0.33^{cde}
10	75	0	2.70±0.82^{cd}	3.00±0.81^{bcde}	2.91±0.44^{if}
11	75	0.5	3.30±0.48^{bcd}	3.20±0.63^{abcde}	3.27±0.36^{def}
12	75	1	3.40±0.69^{bcd}	2.80±0.78^{of}	3.30±0.57^{def}
13	100	0	2.50±0.71^{d}	2.70±0.67$^{It\ is}$	2.60±0.34^{f}
14	100	0.5	3.30±0.67^{bcd}	2.90±0.56^{cde}	3.08±0.44^{def}
15	100	1	3.20±0.63^{bcd}	2.80±0.79^{of}	3.20±0.53^{def}

Different letters in each column represent significant difference from one another ($p<0.05$).

Loreno colleagues (2022) used the emulsifier Meno and glyceride in bread formulation. The results of these researchers indicated an increase in the volume and improvement of the texture, chewability and color of the production samples [45]. Yanen et al. By strengthening the gluten-like network and strengthening the consistency of the bread dough, they were effective on the technological and sensory characteristics, including form, shape, and texture [37]. Based on the results of their study, Zhant et al. (2012) reported the positive effect of monoglyceride emulsifier on improving the sensory characteristics of gluten-free bread, including color, firmness and softness of texture, and chewability [41]. Jing et al. (2018) reported the presence of monoglyceride emulsifier. They considered it a positive factor on the sensory characteristics of rice cake[8]. It is noteworthy that these researchers stated that this emulsifier has a better performance on texture and sensory characteristics in bakery products with minimum moisture content, which as mentioned earlier, the formulation of gluten-free sweets samples produced in this research They lacked water and this was one of the reasons for choosing monoglyceride emulsifier.

4-Conclusion

Based on the research conducted in this research, the sample containing 25 or 50% quinoa flour and 0.5% monoglyceride emulsifier can be introduced as the best gluten-free sweet in this research. Because these samples contain a mixture of chickpea flour and quinoa, along with desirable physicochemical and sensory characteristics. One of the goals of this research was to produce a gluten-free product with high protein content and to compensate for the deficiency of amino acids of cereals and legumes, which can be solved to a large extent by mixing these two flours, which, of course, requires detailed nutritional studies. Terry has

5- Resources

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مقاله علمی_پژوهشی

بررسی کاربرد آرد کینوا و امولسیفایر منوگلیسرید بر ویژگی‌های فیزیکوشیمیایی و حسی شیرینی بدون گلوتن

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چکیده

این تحقیق با هدف بررسی جایگزینی سطوح متفاوت آرد نخودچی (صفر، ۲۵، ۵۰، ۷۵ و ۱۰۰ درصد) با آرد کینوا و افزودن امولسیفایر منوگلیسرید در سطوح صفر، ۰/۵ و ۱ درصد به فرمولاسیون شیرینی بدون گلوتن انجام شد. در این تحقیق میزان خاکستر، پروتئین، رطوبت، حجم مخصوص، سفتی بافت و ویژگی‌های حسی (فرم و شکل، سطح، بافت، قابلیت جویدن، بو و مزه و پذیرش کلی) نمونه‌های تولیدی ارزیابی شدند. نتایج نشان داد رطوبت، خاکستر و چربی آرد کینوا بیشتر و میزان پروتئین آن کمتر از آرد نخود بود. با افزایش سطح جایگزینی آرد نخودچی با آرد کینوا بر میزان رطوبت و خاکستر افزوده و از میزان پروتئین شیرینی‌های تولیدی کاسته شد. این در حالی بود که نمونه حاوی ۲۵ درصد آرد کینوا و ۰/۵ درصد امولسیفایر منوگلیسرید از بیشترین حجم مخصوص (۰/۹۸ میلی‌لیتر بر گرم) و کمترین سفتی بافت (۳۱/۳۷ نیوتن) برخوردار بودند. در نتیجه حضور آرد کینوا و افزایش سطح آن در فرمولاسیون مؤلفه رنگی L^* کاهش و a^* افزایش یافت. ارزیابی حسی نشان‌دهنده برتری نمونه حاوی ۲۵ درصد آرد کینوا (فاقد امولسیفایر) و نمونه حاوی ۲۵ درصد آرد کینوا و ۰/۵ درصد امولسیفایر منوگلیسرید بود. لازم به ذکر است نمونه‌های حاوی ۵۰ درصد آرد کینوا در حضور ۰/۵ درصد امولسیفایر منوگلیسرید نیز کمیت و کیفیت بالایی برخوردار بودند. از این رو نمونه حاوی ۲۵ یا ۵۰ درصد آرد کینوا و ۰/۵ درصد امولسیفایر منوگلیسرید به عنوان برترین نمونه‌های شیرینی بدون گلوتن در این تحقیق معرفی می‌شوند.