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Effect of quinoa flour addition on quality characteristics of rice gluten-free cookies

Adriana Păucean, Simona Man*, Sevastiţa Muste, Anamaria Pop

University of Agricultural Sciences and Veterinary Medicine, Faculty of Agriculture, 3-5 Mănăştur street, 3400, Cluj-Napoca, Romania

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Abstract

The purpose of this study was to obtain gluten-free cookies destined for gluten intolerant people and not only, which implies the substitution of wheat gluten. Gluten intolerance is a chronic illness of the small intestines which occurs in the case of people with a certain genetic predisposition. To optimize recipe of the aglutenic cookies obtained using rice flour (RF) and quinoa flour (QF) the following blends RF/QF, 90:10, 75:25, 55:45 were performed. Thus, the biscuits were prepared from the RF/QF blends and evaluated for physicochemical and sensory properties. The results showed that the protein and the fat contents of the flour blend cookies increased with increasing levels of QF. Sensory evaluation showed that above 10% quinoa substitution levels, the sensory scores for overall acceptability and all the sensory qualities evaluated decreased steadily. Biscuits (cookies) prepared from the blends of 90% rice flour and 10% quinoa flour were appreciated by panelists as the most acceptable.

Keywords: gluten-free biscuits (cookies), flour blends, chemical composition, sensory evaluation

1. Introduction

Coeliac disease represents life-long intolerance to the gliadin fraction of wheat and the prolamins or rye (secalins), barley (hordeins) and possibly oats (avenin) [1]. The gluten replacement in bakery products represents the major technological challenge due to its essential structural binding properties. Removal of gluten impairs dough structure to develop properly during kneading and baking [2].

In recent years, gluten-free foods, especially breads, cakes and biscuits have been commonly investigated by many researchers. Numerous studies have been conducted especially on gluten-free bread. Few studies have shown the application of soy flour, corn starch, buckwheat in the manufacture of gluten-free breads [2- 9].

Arendt et al., (2002) [9], studied the effects of rice, corn, soya, millet, buckwheat and potato starch, in combination with different fat sources on the formulation of gluten-free biscuits.

The gluten-free bakery products have become available in the market, prepared out of non-wheat flour such as rice, maize, soya, quinoa and amaranth [10]. Some studies showed, that gluten-free bakery could be enriched with fibers of various origin [11], beta-glucans [12] and inulin [13,14].

Currently the gluten-free food manufacturers are investing in the use of whole grains including corn, rice, sorghum, buckwheat, amaranth and quinoa, since the majority of these are excellent fiber, iron and vitamin B sources [15]. The pseudo cereals are considered as potentially gluten free grains with an

Corresponding author: *e-mail:* simona.man@usamvcluj.ro

excellent nutrient profile, capable of diversifying this rising market [15].

Rice flour is commonly used in gluten-free baked products due to its low levels of sodium, protein, fat and a high amount of easily digested carbohydrates [16] but and due to soft taste, colorless appearance, hypoallergenic properties, low levels of sodium and easy digestible carbohydrates, this is one of the most suitable cereals for gluten-free product formulations [17-20].

Despite of its numerous advantages, rice proteins have poor functional properties [16]. As it is known, rice protein does not have ability to develop viscoelastic network as wheat gluten does, which is responsible for retaining CO2 produced during the process of fermentation. Moreover, rice flour does not contain sufficient amounts of vitamin, minerals and fiber which are important for balanced diet of celiac patients. For this reason, rice flour should be combined with other flours such as corn, chestnut, chickpea, soybean, sorghum, buckwheat, quinoa and amaranth flour to give the structure in gluten free baked products [16].

Quinoa flour is a good alternative to be used in gluten free baked products since it contains high quality proteins (about 15%), and its essential amino acid balance is excellent because of a wider amino acid spectrum than cereals and legumes [21], with higher lysine (5.1-6.4%) and methionine (0.4-1.0%) contents [22].

Quinoa (*Chenopodium quinoa* Willd.) is a seed crop traditionally cultivated in the Andean region for several thousand years [23]. The seeds may be utilized for human food, in flour products and in animal feedstock because of its high nutritive value [24].

Quinoa seeds are a complete food with high-nutritional value [25] due mainly to their high content of good quality protein [26- 30]. Besides their protein content, many studies have been made of their lipids [31,32], starch [33, 34], minerals [29], and saponin [35- 37]. Quinoa seeds contain minerals (Ca, K, Fe, Mg, Mn, P) and vitamins like vitamin B [31], vitamin C [31,38], and vitamin E [21,24,39].

Also, quinoa has been found to contain compounds like polyphenols, phytosterols, and flavonoids with possible nutraceutical benefits isoflavons, and high quality lipids. Such a combination of factors contributes to excellent antioxidant properties and even the saponins in the seed coats, previously considered as antinutrients, can now be extracted for industrial and biomedical use. And it has some functional (technological) properties like solubility, water-holding capacity, gelation, emulsifying and foaming that allow diversified uses [40]. Besides, it has been considered an oil crop, with an interesting proportion of omega-6. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses [40].

The aim of the present work was to asses the influence of quinoa flour addition on rice gluten-free cookies targeting a good sensory acceptance and good nutritional value. Also, evaluation of the quality parameters of the cookies was another target.

2. Materials and Method

2.1. Materials

The study was conducted in the laboratory of the Department of Food Products Engineering, Faculty of the Food Science and Technology, University of Agricultural Sciences and Veterinary Medicine Cluj Napoca. The raw materials used in these experiments: rice flour (RF), quinoa flour (QF), margarine, eggs, brown sugar and cinnamon) have been purchased from markets of specialized stores. The plastic container and high density polyethylene bags procured from the local market.

2.2. Experimental plan and production of the gluten-free cookies

Table 1 lists the ingredients used in the preparation of cookies (in g) and figure 1 shows the flow chart for the cookies preparation.

Table 1. Design of dough preparation for the three cookies samples (T1-T3)

Raw materials and auxiliary, kg	% rice flour and quinoa flour		
	RF:QF T1(90:10)	RF:QF T2 (75:25)	RF:QF T3 (55:45)
Rice flour	90	75	55
Quinoa flour	10	25	45
Margarine	50	50	50
Eggs	0.150	0.150	0.150
Brown sugar	20	20	20
Cinnamon	1.6	1.6	1.6

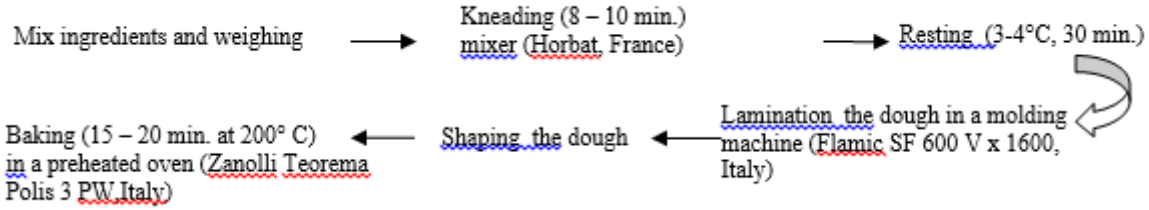

Figure 1. Cookies technological flow

2.3. Sensory analysis of gluten-free cookies

Gluten-free cookies were evaluated for overall acceptability (texture, colour, taste, odor and aroma) and the sensory evaluation was carried out as per 9 point Hedonic scale; the panell was composed by ten semi trained judges. Commercial cookies (100% rice flour) were used to compare with product samples developed in this study.

2.4. Physical evaluation of gluten-free cookies

Cookies average diameter (in millimeters) was measured by placing 6 cookies edge-to-edge. Cookies thickness was measured by stacking 6 cookies on top of each other and gets the average thickness.

Diameter: The diameter was measured in mm by Vernier caliper.

Thickness: The thickness was measured in mm by screw gauge.

Spread ratio: The spread ratio was determined by using formula (1)

$$Spread.ratio = \frac{diameter(mm)}{thickness(mm)} \quad (1)$$

2.5. Chemical characteristics of gluten-free cookies

Moisture, ash and fat content were determined according to the Romanian STAS 1227-3/1990. Protein content was determined as per (SR ISO1871/2002): Kjeldhal method, using the conversion factor of 5.7. The total fibers were determined by the gravimetric method according to the AACC 32-07 standard and total carbohydrate content by difference.

2.6. Statistical analysis

The results of three independent (n=3) assays performed with replicates each were expressed as mean. Data were compared by one-way analysis of variance (ANOVA). Linear regression analysis was carried out using Microsoft Excel 2010. Significance was accepted at $p \leq 0.05$.

3. Results and Discussion

3.1. Sensory evaluation for gluten-free cookies

Sensory analysis was carried out by using untrained panelists to measure sensory characteristics and acceptability of the cookies. Mean score for sensory evaluation of cookies given in table 2, revealed that there are significant differences ($p<0.05$) between treatments for sensory attributes like taste, colour,

flavor, texture and overall acceptability. Cookies samples, with rice and quinoa flour, was also compared with commercial cookies (100% rice flour) in order to obtain more information on the influence of quinoa flour on the sensorial product development

Sensory rating of gluten-free cookies for colour shows that replacement of rice flour with quinoa flour affects the color, which decreased from 8.8 (T1) to 8.5 (T3).

Table 2. Sensory scores of prepared gluten-free cookies using different blends (RF:QF)

Treatments	Colour	Texture	Taste	Flavor	Overall Acceptability
Commercial cookies	8.8	8.5	8.7	8.9	8.7
T_1	**8.8**	**8.5**	**8.6**	**8.7**	**8.7**
T_2	8.6	8.1	7.4	7.9	7.9
T_3	8.5	7.8	7.0	7.2	7.5

*Data represents means of three determinations

Table 3. Physical properties of cookies

Coockies Samples	Diameter (mm)	Thickness (mm)	Spread ratio	Weight (g)
T_1	44.0	9.8	4.49	9.4
T_2	45.0	9.5	4.73	9.8
T_3	46.5	9.0	5.16	10.3

*Data represents means of three determinations

The result of the physical analysis of the functional cookies produced from rice (RF) and quinoa flour (QF) blends is shown in (Table 3). By analyzing the data we concluded that blending rice and quinoa flours (RF:QF) in different percentages a significant ($p<0.05$) effect on thickness, diameter, spread ratio and weight of cookies was recorded. The results are consistent with results reported by Atef A. et al., 2014 [40].

The mean thickness of the RF and QF cookies ranged from 9.8 mm (T1) to 9.0 mm (T3) for the composite flour cookies and the diameter increased from 44 mm (T1) to 46.5 mm (T3). The cookies thickness decreased steadily with increased concentration of QF in the blends while the diameter increased. The changes in diameter and thickness reflected the spread ratio which was consistently increased from 4.49 (T1) to 5.16 (T3) in the case of biscuits obtained from blends with 55% RF and 45% QF.

Other studies reported that cookies spread ratio increased by increasing the levels with QF.

Cookies having higher spread ratios are considered most desirable [42]. Other research reported that the thickness of supplemented biscuits increased, whereas diameter and spread ratio of biscuits decreased with the increasing level of rice bran-fenugreek blends, fenugreek flour, maize-rice-soy flour blends and different bran blends [43-46].

Also the mean weight of the RF and QF cookies ranged from 9.4 g and 10.3 g. The cookies weight increased steadily with increased concentration of QF in the blends. It may be due to increasing of resistant starches with increased addition of quinoa flour. Quinoa starch has physicochemical properties (such as viscosity, freeze stability) which give it functional properties with novel uses [40]. The results were consistent to Hassan, (2002) [47] who found that biscuits samples prepared with replacement of wheat flour by 50% resistant corn starch showed spread ratio higher than control sample. Also Hassan, (2002) [47] founded that addition of resistant starches to wheat flour led to biscuits with high spread ratio and low thickness than control.

A linear relation was found between these parameters and the amount of resistant starch.

3.3. Chemical analysis of gluten-free cookies

Effect of RF:QF blending on physicochemical parameters for gluten-free cookies are shown in figures 2-4.

During the present research no highly significant difference was found in the moisture content and total carbohydrates for the three gluten-free cookies (T1-T3). The moisture content of the gluten-free cookies ranged between 6.7% and 7.6% (Figure 2). The moisture content of the cookies increased with the increase of the quinoa flour, due to the fact that quinoa flour and rice flour absorb higher amount of water. The total carbohydrates content decreases from 63.11% to 49.42% (Figure 3). These results are very close to the data reported by literature. Starch is the major component of quinoa carbohydrates, and quinoa's starch content ranges between 32% and 69.2% in accordance with the literature [29,30,35,36, 48,49,50,51,52].

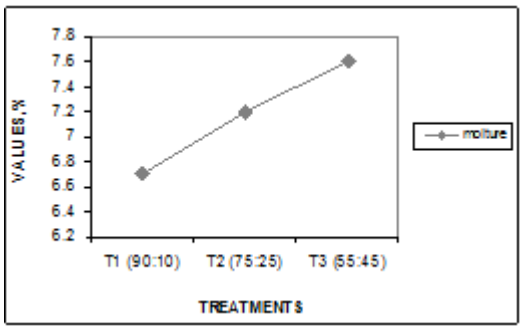

Figure 2. Effect of flours blending on moisture content of gluten-free cookies

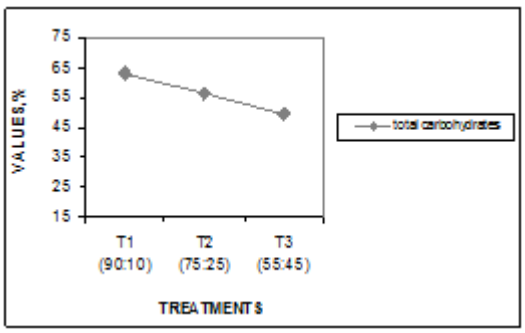

Figure 3. Effect of flours blending on total carbohydrates of gluten-free cookies

The protein content and fat content of the gluten-free cookies increased with the increase in supplementation of the quinoa flour. The protein content ranged by around 10%, from 9.5% to 19.69%, while the fat content varied from 16.6% to 18.82% (Figure 4, 5). The protein content of quinoa varies from 8% to 22%, which is higher on average than that in common cereals such as rice, wheat, and barley [53]. Significant changes in the cookies protein and fat values were recorded related to the increment of the quinoa flour content in the recipe. Quinoa is an excellent source of protein rich in amino acids like lysine, threonine and methionine that are deficient in cereals [23]. Addition of quinoa flour improve the quantity and quality of protein content of the food product, thereby has the great potential in combating with protein energy malnutrition [15].

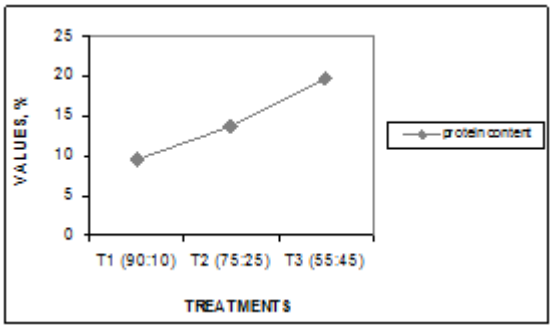

Figure 4. Effect of flours blending on protein content of gluten-free cookies

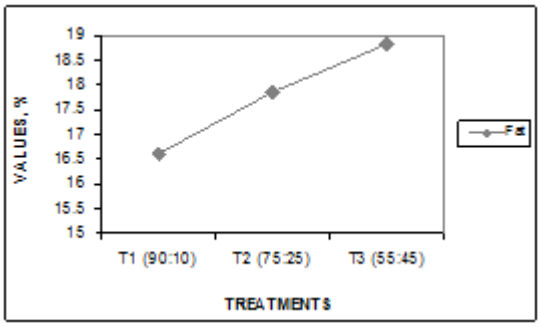

Figure 5. Effect of flours blending on fat content of gluten-free cookies

The increase in fat content (Figure 5) could be due to quinoa flour which is rich in oil. Quinoa contains from 2% to 10% fat. Quinoa and soya oils exhibit similar fatty acid compositions; thus, quinoa is a rich source of essential fatty acids such as linolenic (18:2n-6:52%) and linolenic (18:3n-6: 40%) [54].

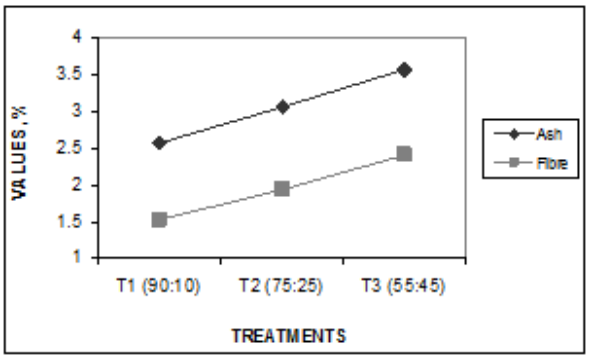

Figure 6. Effect of flours blending on ash and crude fiber content of gluten-free cookies

Also, cookies supplemented with quinoa showed increase in both ash and crude fiber contents (Figure 6) by nearly 1% in all tested samples. Quinoa is a good source of minerals. It contains more calcium, magnesium, iron, and zinc than common cereals, and the iron content is particularly high [54]. Proximate analysis of quinoa flour has showed the following composition: moisture 4.8%, protein 12.2%, lipids 5.6%, ash 2.3%, total carbohydrate 74.9%, and fiber 4.1%. It has been concluded that instant quinoa flour has high levels of many nutrients and so may find the application in foods, infant foods and dietetics for sufferers from coeliac disease [55].

4. Conclusions

Rice and quinoa flours can be combined to produce acceptable cookies with a greatly improved nutritional quality. The results of this study showed that up to 45% quinoa flour could be incorporated into rice flour without adverse effect on cookies quality. At this level of addition, the protein content increased almost three fold from 9.5 to 19.69%. However, the usage of quinoa flour as more than 45% of the blend, reduced the overall acceptability and the sensory quality attributes of the cookies.

These studies have shown the potential of rice flour and quinoa flour for produce gluten free cookies. The amino acid profile, which is crucial for assessing the protein quality of the RF/QF flour blended cookies, should be explored further.

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

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