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Development and Nutritional Evaluation of Gluten Free Bakery Products Using *Pseudocereal quinoa* (*Chenopodium quinoa*)

Sukhmandeep Kaur*, Navjot Kaur and Kiran Grover

Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana – 141001 (Punjab) India

*Corresponding Author E-mail: sukhmani.deep20@gmail.com

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ABSTRACT

Quinoa is a treasure trove of nutrients. Rising demands for gluten free products parallels the apparent or real increase in celiac disease, non-celiac gluten sensitivity and gluten allergy. The present study was aimed for the development and nutritional evaluation of gluten free bakery products using combination of rice and oats flour supplemented with quinoa flour. Five products namely cookies, cakes, muffins, pies and tarts were developed using standardized recipes with different levels of quinoa flour and organoleptically evaluated by a semi-trained panel of 10 judges using eight-point hedonic rating scale[13] and found to be acceptable at 10% level of quinoa flour. Nutritional evaluation was carried out to make comparison between the highly acceptable developed product and its control (100% refined wheat flour) counterpart. The findings revealed that the supplemented products were found to have higher protein (4.2-8.4%), fat (19.6-29.2%), fiber (0.46-1%) and mineral content i.e. calcium, iron, magnesium and zinc as compared to their control counterparts. Along with that, supplementation of quinoa flour in rice and oats flour resulted in significant ($p<0.05$) increase in three essential amino acids (i.e. tryptophan, methionine and lysine). Anti-nutritional factors i.e. phytin phosphorus (16.38-37.02 mg) and saponins (0.14-0.32%) were also found in supplemented products. By keeping in view the nutritional benefits of quinoa flour, the products supplemented with it can be incorporated in daily diet so as to enhance the nutritional status of celiac patients.

Key words: *Quinoa flour, Celiac disease, Organoleptic evaluation, Nutritional evaluation, Anti-nutritional factors.*

INTRODUCTION

Celiac disease is a permanent intolerance to specific storage proteins in wheat (gliadin), barley (hordein) and rye (secalin) which are collectively called ‘gluten’. Ingestion of gluten causes damage to the small intestinal mucosa by autoimmune mechanism in genetically susceptible individuals. This can lead to a variety of symptoms and nutritional deficiencies[18]. A gluten free diet is currently the only effective means of treating the individuals with celiac disease. An increasing trend in research is focusing on the application of alternative grains potentially healthy to elaborate gluten free products.

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A promising area is the use of cereals (rice, corn and sorghum) or pseudocereals such as amaranth, buckwheat, quinoa[16]. Quinoa (*Chenopodium quinoa* Willd.) is a seed-producing crop which has been cultivated in the Andes for thousands of years. Quinoa protein is low in prolamins (0.5-7.0%), which indicates that it is free of gluten, therefore non-allergenic. Quinoa contained total dietary fiber content of 13.4 percent consisting of 11.0 percent insoluble fiber and 2.4 percent soluble fiber. Quinoa contains 4.4-8.8 percent crude fat, with essential fatty acids linoleic and linolenic acid accounting for 55 to 63 percent of the total fatty acids and has lipid lowering effect[1].Rice is staple food for two-thirds of the world's population. Rice is wholesome and nutritious cereal grain. Rice protein is considered one of the highest quality proteins. It has all eight of the essential amino acids and other essential nutrients - thiamin, riboflavin, niacin, phosphorus, iron and potassium. Similar to other cereal prolamins, the avenin polypeptides in oats tend to be rich in proline and glutamine and the protein regions enriched in these two amino acids are associated with elicitation of celiac disease. Prolamins account for 10-20 percent of the total protein in oats, compared to 40-50 percent of the total protein in wheat[7].The development of foods rich in essential compounds such as amino acids, minerals, fibers and fatty acids that are also free of anti-nutritional factors is necessary particularly due to the dietary restrictions of celiac disease sufferers. Products made from corn, rice, soyabean, tapioca, amaranth seeds and pseudocereal such as quinoa can be included in the diet of celiac patients[5]. Various products have been developed by using combination of flours at different levels because combination of flours improves the nutritional quality and the acceptability of the products. By keeping in view all the properties of foods and rising demands for gluten free products for celiac patients, study was planned to develop some gluten free bakery products by using quinoa, rice and oats flours. Quinoa, rice and oats are potential healthy and high quality ingredients in gluten free products. Therefore, the present study was conducted with the following objectives:

1. To develop and evaluate the nutritional and anti- nutritional composition of developed bakery products.

Development and organoleptic evaluation of products

Raw ingredients namely refined flour, rice flour, oat flour, powdered sugar, butter, including quinoa grains were procured from the local market of Ludhiana (Punjab). The quinoa grains were sorted and then ground to get flour. The flour was roasted to 110°C for 3-4 hours for flour sweetness and fine texture. Various products namely cookies, cakes, muffins, pies and tarts using quinoa flour, oats flour, rice flour were prepared and standardized in the Food Laboratory of Department of Food and Nutrition, College of Home Science, Punjab Agricultural University. Experimental products were prepared using combination of rice, oats and quinoa flours. Quinoa flour was supplemented at different levels ranging from 5 – 15 percent whereas control samples were prepared using 100 percent refined wheat flour. The developed products were organoleptically evaluated using eight-point hedonic rating scale by a semi-trained panel of 10 judges from Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana. The judges were served one control (100% refined wheat flour) and three test samples. Depending upon the acceptability of the products, scores were given by the panel on eight point hedonic rating scale ranging from One- disliked extremely to Eight- liked extremely.

Table 1: Ingredients used in the products

Product	Ingredients used		Method
	Control (100% refined wheat flour)	**Test sample**	
Cookies	Refined flour (100g) Powdered Sugar (50g) Fat (58g) Milk (11ml) Baking powder (2g)	Quinoa flour (10 g) Rice flour (45g) Oats flour (45g) Powdered Sugar (50g) Fat (Dalda) (58g) Milk (11ml) Baking powder (2g)	1. Fat was rubbed on a clean surface. 2. Flours were sifted and baking powder was added gradually. Sugar was added in it. 3. Smooth dough was made by using milk and rolled to ¼ inch thickness. 4. Round shapes were cut and baked at 150° C for 20 minutes.
Cakes	Refined flour (100g) Powdered Sugar (100g) Butter (50g) Eggs (80g) Baking powder (2g) Vanilla essence (4ml)	Quinoa flour (10g) Rice flour (45g) Oats flour (45g) Powdered Sugar (100g) Fat (Butter) (50g) Eggs (80g) Baking powder (2g) Vanilla essence (4ml)	1. Flours and baking powder were sifted twice. 2. Fat and sugar were creamed together till light and fluffy. 3. Eggs were beaten along with vanilla essence. 4. Beaten eggs were added to the creamy mixture little by little mixing continuously. 5. Flour was folded gently using cut-and-fold method. 6. Milk was added to bring the mixture to dropping consistency. 7. Mixture was poured in a greased cake tin and was leveled properly. 8. Cake was baked at 180°C for 20 minutes.
Muffins	Refined flour (100g) Powdered Sugar (100g) Refined oil (42g) Butter (33g) Eggs (167g) Baking powder (2g) Vanilla essence (4ml)	Quinoa flour (10g) Rice flour (45g) Oats flour (45g) Powdered Sugar (100g) Refined oil (42g) Butter (33g) Eggs (167g) Baking powder (2g) Vanilla essence (4ml)	1. Flours with baking powder were sifted twice. 2. Eggs were beaten in a bowl. 3. Vanilla essence and sugar was added and mixed till the contents became very stiff. 4. Melted butter was added and mixed well. 5. Enameled bowl containing beaten eggs was taken out from hot water. 6. Flour was added gradually and gently mixed with other ingredients. 7. Mixture was poured into prepared muffin tray.

			8. Muffins were baked at 200°C for 20 minutes.
Pies	Refined flour (100g) Butter (67g) Powdered Sugar (33g) Baking Powder (3g) **For filling:** Sponge cake gluten free (20g) Apple (chopped) (20g) Sugar (10g) Cinnamon powder (10g) Raisins (5g)	Quinoa flour (10g) Rice flour (45g) Oats flour (45g) Butter (67g) Powdered Sugar (33g) Baking Powder (3g) **For filling:** Sponge cake (gluten-free) (20g) Apple (chopped) (20g) Sugar (10g) Cinnamon powder (10g) Raisins (5g)	1. Butter and sugar were creamed with hands and palms on flat surface. 2. Flours were added and mixed it with hands by rubbing with palm. 3. Flattened with rolling pin to ¼ inch thickness. 4. Rolled dough was placed on the apple pie moulds. 5. Extra edges were cut using knife. 6. Shaped dough was pricked with fork. 7. All the ingredients were mixed together for filling. 8. Small amount of water was taken in a pan and cooked the mixture for 2 – 3 minutes. 9. The mixture was placed in pie tray and strips were placed on top. 10. Pies were baked at 200°C for 20 minutes.
Tarts	Refined flour (100g) Butter (67g) Powdered Sugar (35g) Baking powder (2.5g) **For filling:** Whipped cream (20g) Chocolate sauce (20g) Mango (10g) Kiwi (10g)	Quinoa flour (10g) Rice flour (45g) Oats flour (45g) Butter (67g) Powdered Sugar (35g) Baking powder (2.5g) **For filling:** Whipped cream (20g) Chocolate sauce (20g) Mango (10g) Kiwi (10g)	1. Fat and sugar were creamed together. 2. Flours and baking powder were mixed with fingers. 3. Balls were made and kept for rest for 10 – 15 minutes. 4. Balls were flattened with rolling pin and the shapes were cut with doughnut cutter. 5. Flattened balls were placed in tart mould and pricked with fork. 6. Extra batter was trimmed from sides of moulds. 7. Tarts were baked at 180°C for 20 minutes.

MATERIAL AND METHODS

Chemical analysis

The samples were thoroughly mixed in a blender and dried in oven at (60±20°C) in petri dishes. The dried samples were ground to fine powder and stored in airtight polythene bags for chemical analysis. Estimation of Proximate composition-moisture, protein, fat, fibre, ash, carbohydrate, energy and minerals (calcium, iron, magnesium and zinc) was done by using AOAC[2] standard methods. The estimation of amino acids such as tryptophan by Concon[8], methionine by Horn *et al*.[11], lysine by Carpenter[6], modified by Booth[5] and cysteine by Liddell and Saville[4] and anti-nutritional factors such as phytin phosphorus by Haug and Lantzsch[10] and saponins by Obadoni and Ochuko[17] was also carried out.

Statistical Analysis

From the data obtained, mean values and standard error for each sample was analyzed. Analysis of variance (ANOVA) one way followed by Tukey HSD significance test was applied to test the significant difference between the various levels of supplementation and control samples in organoleptic evaluation. Independent t-test (equal variances) was applied to compare the nutrient content of the control and the most acceptable supplemented product.

RESULTS AND DISCUSSION

Proximate composition of developed products

Cookies

The moisture content of cookies ranged between 16.2 percent for control and 15.82 percent for E2 (10% quinoa flour) treatment with a significant difference ($p<0.05$). The protein and fat content of the test sample was found to be significantly higher i.e. 4.2 and 24.94 percent whereas in control it was 4.02 and 23.32 percent. The crude fiber content of E2 treatment was also higher than the control i.e. 0.96 percent for E2 and 0.14 percent for the control. There was a significant increase in the ash content of E2 (1.54%) treatment than the control (1.06%). The carbohydrate content of control was found to be 55.25g and that of test sample was 52.54g per 100g. The energy content was found to be 451.42 Kcal for E2 treatment and 447 Kcal for the control. Bhathal[4] (2016) developed cookies by using 100 percent quinoa flour in test sample and 100 percent refined flour in control sample. The mean scores of overall acceptability of test sample i.e. 7.94 which were significantly higher than control cookies i.e. 7.28.

Cakes

It was observed that the moisture content of cake prepared from 10 percent quinoa flour was 22.2 percent comparable to 22.54 percent of the control. Significantly higher protein content was observed in cake with 10 percent quinoa flour as compared to control as 7.35 and 5.68 percent respectively. Wright *et al.*[23], reported 14.8 and 15.7 percent of protein for sweet and bitter quinoa, respectively. The fat content also increased in E2 treatment than control i.e. from 18.58 to 19.6 percent. The fiber content in control was found to be 0.09 percent and higher in E2 treatment i.e. 0.60 percent. There was significant difference in ash content of control and E2 treatment i.e. 0.46 and 0.76 percent, respectively. The carbohydrate content of E2 was found to be 49.48g per 100g and the energy content was 403.75Kcal.

Muffins

The proximate composition of control and test samples of muffins presented in Table VII revealed that the moisture content of muffins ranged between 32.34 percent for control and 32.1 percent for the E2 treatment (10% quinoa flour). The protein content was found to be higher in the E2 treatment i.e. 8.4 percent as compared to 6.47 percent in the control. The fat content of the control samples was observed as 20.76 percent, which was lower than the E2 treatment i.e. 21.54 percent. Tang *et al.*[20], studied the composition of fatty acids, tocopherols, tocotrienols, carotenoids and their contribution to antioxidant activities in seeds of three coloured quinoa cultivars (white, red and black). The ratio of omega-6/omega-3 fatty acid was 6/1. The fiber content of control was found to be 0.06 percent and for E2 treatment 0.46 percent. The carbohydrate content of control was 39.63g per 100g and that of E2 treatment was 36.54g per 100g. The energy content of E2 treatment was observed to be 373.62 Kcal.

Pies

The moisture content of pies ranged from 13.06 percent for control to 12.5 percent for E2 treatment i.e. 10 percent quinoa flour. The protein content of the accepted level was found to be higher than control i.e. 5.6 and 5.25 percent respectively. The fiber content in E2 treatment was 1.0 percent and in control 0.15 percent. The ash content in control was 1.14 percent and in E2 treatment was 1.68

percent. The carbohydrate content of the control and E2 treatment was found to be 52.94g and 50.02g per 100g, respectively. The energy content of the E2 treatment was observed to be 485.28 Kcal. Alvarez *et al*.[1], investigated the baking properties of the pseudocereals amaranth, quinoa and buckwheat as potential healthy and high-quality ingredients in gluten free breads. Bread volumes were found to significantly increase for the buckwheat and quinoa breads in comparison with the control with softer crumb texture.

Tarts

Tarts supplemented with 10 percent quinoa flour had 12.4 percent moisture while control had significantly higher moisture content of 12.96 percent. The protein content ranged from 5.42 percent for control and 5.95 percent for E2 treatment with significant difference ($p<0.05$). The fat content was found to be 29 percent for the E2 treatment and 27.32 percent for the control. The fiber content was higher in E2 treatment i.e. 0.98 percent than the control i.e. 0.14 percent. Yamani and Suzana[24] studied the lipid content of quinoa and found between 2-3 times higher than in other cereals such as maize and wheat. Linoleic acid is the most abundant fatty acid (48.2 - 56.0) followed by oleic acid (24.5 - 26.7) and palmitic acid (9.7 - 11.0). Quinoa shows a high content of α-linolenic acid (values ranging from 3.8 % to 8.3 %) which is related to a reduction of biological markers associated with many degenerative diseases such as cardiovascular disease, cancer, osteoporosis and inflammatory and autoimmune diseases.

Table 2: Proximate composition of the Quinoa based gluten free bakery products (g/100g on dry weight basis)

Treatment	**Moisture (%)**	**Protein (%)**	**Fat (%)**	**Fiber (%)**	**Ash (%)**	**CHO (g)**	**Energy (Kcal)**
Cookies							
Control (0% supplementation)	16.2±0.06	4.02±0.01	23.32±0.05	0.14±0.05	1.06±0.01	55.25	447
Accepted (E2- 10% supplementation)	15.82±0.05	4.2±0.05	24.94±0.06	0.96±0.06	1.54±0.05	52.54	451.42
t- value	4.65**	3.01*	19.84**	10.04**	8.27**	46.79**	0.76*
Cakes							
Control (0% supplementation)	22.54±0.05	5.68±0.01	18.58±0.05	0.09±0.01	0.46±0.06	52.64	400.54
Accepted (E2- 10% supplementation)	22.2±.06	7.35±0.05	19.6±0.06	0.60±0.05	0.76±0.05	49.48	403.75
t- value	4.16*	28.66**	12.49**	8.82**	3.67*	386.4**	55.35**
Muffins							
Control (0% supplementation)	32.34±0.05	6.47±0.01	20.76±0.05	0.06±0.01	0.72±0.05	39.63	371.28
Accepted (E2- 10% supplementation)	32.1±0.06	8.4±0.05	21.54±0.06	0.46±0.05	0.96±0.05	36.54	373.62
t- value	2.94*	33.17**	9.55**	6.75**	2.93*	53.37**	40.19**
Pies							
Control (0% supplementation)	13.06±0.01	5.25±0.05	27.46±0.05	0.15±0.05	1.14±0.05	52.94	479.9
Accepted (E2- 10% supplementation)	12.5±0.05	5.6±0.05	29.2±0.06	1.0±0.06	1.68±0.06	50.02	485.28
t- value	9.65**	4.28*	21.31**	10.41**	6.61**	50.32**	65.89**
Tarts							
Control (0% supplementation)	12.96±0.05	5.42±0.01	27.32±0.05	0.14±0.01	1.14±0.05	53.00	479.60
Accepted (E2- 10% supplementation)	12.4±0.06	5.95±0.06	29±0.57	0.98±0.06	1.66±0.06	50.01	484.84
t- value	6.85**	9.04**	2.89*	14.33**	6.36**	516.5**	90.61**

Values are expressed as Mean±SE.

*Significant at 5% level of significance

**Significant at 1% level of significance

Mineral content of the developed products

Cookies

The mineral content of the control and test sample of quinoa based gluten free cookies is given in the Table VIII. The calcium content of 20.16 mg was observed in control cookies while the test cookies contain significantly higher calcium content of 29.22 mg. The iron content in test cookies was 1.65 mg per 100 g which was significantly higher than the control cookies i.e. 1.34 mg/100g. The magnesium content of test cookies 31.42 mg and control 25.92 mg per 100 g. The zinc content of test sample of cookies with 0.51 mg was significantly different than the control with 0.28 mg. Ascheri *et al*.[3], found that Quinoa flour is also rich in minerals particularly K (546 mg/100 g), Fe (11.77 mg/100 g), Mg (160 mg/100 g), Ca (38.26 mg/ 100 g) and P (357 mg/100 g). It has been concluded that instant quinoa flour has high levels of many nutrients and so may find the application in foods e.g. infant foods and dietetics for sufferers from celiac disease.

Cakes

The mineral content of the control and test sample of cakes revealed that the calcium content of 25.5 mg was observed in control while the test sample contains significantly higher calcium content of 31.16 mg/100g. The iron content in test cake 1.57 mg had significant difference with control sample 1.38 mg per 100 g. The magnesium content of test cake (10% quinoa flour) 19.6 mg was significantly higher than the control 16.2 mg and zinc content of test sample was 0.32 mg with significant difference with control sample i.e. 0.18 mg/100 g. Galvez *et al*.[9], reported that quinoa and quinoa products are rich in not only macronutrients such as protein, polysaccharide and fats but also micronutrients such as polyphenols, vitamins and minerals. Polyphenols including phenolic acids, flavonoids and tannins make up the bioactive secondary plant metabolites that contribute to diverse physiological properties such as antimicrobial, antioxidant, anti-inflammatory, antitumor and anti-carcinogenic effects.

Muffins

The calcium content of control and test sample of muffins was 30.56 mg and 34.84 mg per 100 g. The iron and magnesium content of test sample was 1.58 mg and 14.82 mg, respectively with significant difference with control muffins i.e. 1.43 mg and 12.22 mg per 100 g, respectively. The zinc content observed in control and test sample of muffins was 0.13 mg and 0.24 mg, respectively.

Pies

The calcium content observed in test pies was 23.33 mg which was significantly higher than the control sample i.e. 13.5 mg per 100 g. The iron content of test pie was 1.73 mg/ 100 g which had significant difference with control sample i.e. 1.37 mg per 100 g. The magnesium and zinc content of test pie was 33.41 mg and 0.54 mg per 100 g which was significantly ($p<0.05$) higher than the control samples i.e. 27 mg and 0.30 mg.

Tarts

The mineral content of tarts revealed that calcium content in test tarts i.e. 23.04 mg which was significantly higher than the control sample i.e. 13.6 mg per 100 g. The iron content in test sample was 1.69 mg/100 g which had significant difference with the control tarts i.e. 1.37 mg per 100 g. The magnesium and zinc content was significantly higher in test samples of tarts i.e. 32.73 mg and 0.53 mg than the control sample i.e. 27 mg and 0.30 mg per 100 g, respectively. Alvarez *et al*.[1] studied that calcium, magnesium and iron are minerals that are deficient in gluten free products and in the gluten free-diet. The inclusion of these pseudocereals, which are a good source of these and other important minerals can assist to reduce this deficiency. In both of pseudocereals, calcium, magnesium, iron, and zinc can be found in high amounts when compared with wheat or barley. The content of calcium in quinoa can contribute 10 percent of the infant and adult requirements.

Table 3: Mineral content of Quinoa based gluten free bakery products (on dry weight basis)

Treatment	Calcium (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)	Zinc (mg/100g)
Cookies				
Control (0% supplementation)	20.16±0.01	1.34±0.01	25.92±0.006	0.28±0.005
Accepted (E2- 10% supplementation)	29.22±0.00	1.65±0.01	31.42±0.01	0.51±0.01
t-value	1.11**	37.97**	673.6**	28.17**
Cakes				
Control (0% supplementation)	25.5±0.05	1.38±0.006	16.2±0.05	0.18±0.01
Accepted (E2- 10% supplementation)	31.16±0.01	1.57±0.005	19.6±0.01	0.32±0.01
t-value	97.54**	23.27**	59.28**	17.14**
Muffins				
Control (0% supplementation)	30.56±0.01	1.43±0.01	12.22±0.01	0.13±0.01
Accepted (E2- 10% supplementation)	34.84±0.00	1.58±0.01	14.82±0.01	0.24±0.00
t-value	524.19**	18.37**	318.43**	13.47**
Pies				
Control (0% supplementation)	13.5±0.05	1.37±0.01	27±0.57	0.30±0.06
Accepted (E2- 10% supplementation)	23.33±0.01	1.73±0.06	33.41±0.01	0.54±0.08
t-value	169.4**	44.09**	11.10**	4.16*
Tarts				
Control (0% supplementation)	13.6±0.05	1.37±0.01	27±0.57	0.30±0.05
Accepted (E2- 10% supplementation)	23.04±0.01	1.69±0.00	32.73±0.01	0.53±0.01
t-value	162.6**	39.19**	9.92**	3.96*

Values are expressed as Mean±SE.
*Significant at 5% level of significance
**Significant at 1% level of significance

Amino acid content of the developed products

Cookies

The amino acid content of quinoa based gluten free bakery products developed by supplementing 10 percent quinoa flour with rice and oats flour has been given in the Table IX. The amino acid content showed that the tryptophan content of 53.01 mg/100g protein was observed in control cookies while the test cookies contain significantly higher tryptophan of 61.51 mg/100g protein. The methionine content in test sample was 91.43 mg/100g protein which was significantly different from control i.e. 80.18 mg/100g protein. The lysine content of test cookies was observed to be 187.51 mg/100g protein which is significantly higher than the control cookies i.e. 106.04 mg/100g protein and the cysteine was found to be significantly higher in control sample i.e. 119.48 mg/100g protein than the test cookies i.e. 68.06 mg/100g protein. Koziol[12] found that the protein quality of quinoa grain is superior to most cereal grains including wheat. The seeds have a balanced amino acid spectrum with high lysine, histidine and methionine.

Cakes

The results for cakes revealed that the test sample contained tryptophan and methionine content 84.88 mg/100g protein and 166.33 mg/100g protein, respectively with significant difference with control sample i.e. 79.57 mg/100g protein and 159.3 mg/100g protein. The lysine content was also higher in test cakes i.e. 343.25 mg/100 g protein than the control cakes i.e. 292.32 mg/100g protein. The cysteine was found to be significantly higher in control cakes i.e. 148.4 mg/100g protein than the test cakes i.e. 116.26 mg/100g protein. Schumacher et al[19] (2010) observed an increase in the amount of amino acids by the addition of quinoa to the dark chocolate, particularly for some essential amino acids. The essential amino acids cysteine, tyrosine and methionine increased 104, 72 and 70 percent respectively in the chocolate containing 20 percent quinoa.

Muffins

The amino acid content namely tryptophan, methionine and lysine of test muffins i.e. 100.23 mg/100g protein, 209.93 mg/100g protein and 435.88 mg/100g protein was found to be higher than that of the control muffins sample i.e. 96.23 mg/100g protein, 204.62 mg/100g protein and 397.45 mg/100g protein, respectively. The cysteine content was also found significantly higher in control muffins i.e. 168.26 mg/100g protein than the test muffins i.e. 144.01 mg/100g protein. Vilche et al[22] found that the amino acid balance is better than that of wheat or maize, because the first limiting amino acid, lysine is present in relatively higher amounts in quinoa seeds. Quinoa flour has higher protein content than corn or rice flours and has higher contents of certain amino acids such as lysine (710 mg/100g) and aspartic acid (1160 mg/100g). It provides a nutritional, economical, easy-to-prepare, flavourful food source which is of particular relevance for people with gluten intolerance.

Pies

The results for pies showed that the tryptophan content of test pies was 61.34 mg/100g protein which had significant difference with the control sample i.e. 52.75 mg/100g protein. The methionine and lysine was found to be significantly higher in test pies i.e. 90.53 mg/100g protein and 181.12 mg/100g protein respectively than the control pies i.e. 79.13 mg/100g protein and 96.71 mg/100g protein, respectively. The cysteine content of control pies was observed to be significantly higher i.e. 123.08 mg/100g protein than the test pies 69.24 mg/100g protein. Valencia[21] evaluated that the quinoa flour can be mixed with maize or wheat flour. Several levels of quinoa flour substitution have been reported for instance in bread (10-13% quinoa flour), noodles and pasta (30-40% quinoa flour) and sweet biscuits (60% quinoa flour). Quinoa flour is low in gluten due to low contents of prolamines and glutamines. It is usually used to enhance baking flours in the preparation of biscuits, noodles and pastries and for the preparation of baked foods to maintain the moisture and give an agreeable flavour.

Tarts

The amino acid content of tarts revealed that the tryptophan was observed to be higher in test tarts 61.6 mg/100g protein than the control i.e. 52.8 mg/100g protein. The methionine content of test tarts is 90.84 mg/100g protein and control tarts is 79.2 mg/100g protein. The lysine and cysteine found in test tarts was 181.57 mg/100g protein and 69.52 mg/100g protein which was significantly different from control tarts i.e. 96.8 mg/100g protein and 123.2 mg/100g protein, respectively. Yamani and Suzana[24]) found the protein content is 14.0 - 16.5 percent for amaranth and 12.9 - 16.5 percent for quinoa. Compared with common cereals grains, the protein content (average of 14.60 % and 13.80 % respectively) is significantly higher than that of maize (10.20 %) and comparable to that of wheat (14.30 %). Quinoa presents high levels of histidine, isoleucine, and aromatic amino acids (phenylalanine and tyrosine) and has similarly in leucine and tryptophan contents.

Table 4: Amino acid content of Quinoa based gluten free bakery products (mg/100 g protein on dry weight basis)

Treatment	Tryptophan (mg)	Methionine (mg)	Available Lysine (mg)	Cysteine (mg)
Cookies				
Control (0% supplementation)	53.01±0.05	80.18±0.05	106.04±0.01	119.48±0.05
Accepted (E2- 10% supplementation)	61.51±0.05	91.43±0.05	187.51±0.05	68.06±0.01
t-value	104.10**	137.78**	1404.1**	886.2**
Cakes				
Control (0% supplementation)	79.57±0.05	159.3±0.05	292.32±0.05	148.4±0.05
Accepted (E2- 10% supplementation)	84.88±0.06	166.33±0.06	343.25±0.06	116.26±0.06
t-value	65.03**	86.10**	623.76**	393.63**
Muffins				
Control (0% supplementation)	96.23±0.05	204.62±0.05	397.45±0.05	168.26±0.05
Accepted (E2- 10% supplementation)	100.23±0.06	209.93±0.06	435.88±0.06	144.01±0.06
t-value	48.99**	65.03**	470.67**	417.94**
Pies				
Control (0% supplementation)	52.75±0.06	79.13±0.01	96.71±0.05	123.08±0.01
Accepted (E2- 10% supplementation)	61.34±0.05	90.53±0.05	181.12±0.01	69.24±0.06
t-value	105.20**	196.47**	1454.7**	927.9**
Tarts				
Control (0% supplementation)	52.8±0.05	79.2±0.05	96.8±0.05	123.2±0.05
Accepted (E2- 10% supplementation)	61.6±0.06	90.84±0.06	181.57±0.06	69.52±0.06
t-value	107.77**	142.56**	1038.2**	657.44**

Values are expressed as Mean±SE.
*Significant at 5% level of significance

**Significant at 1% level of significance

Anti-nutritional factors of the developed products

The anti-nutritional factor of the control (C) and test samples (E2) of cookies is given in the Table X. The phytin phosphorus content of control samples of cookies, cakes, muffins, pies and tarts was 18.24, 11.4, 8.6, 19 and 19 mg respectively while the test cookies, cakes, muffins, pies and tarts contain significantly higher phytin phosphorus content of 34.74, 21.72, 16.38, 35.13 and 37.02 mg respectively. The total saponin content was observed only in test samples of cookies, cakes, muffins, pies and tarts i.e. 0.29, 0.18, 0.14, 0.32 and 0.31 percent. Valencia[21] stated that saponins and phytic acid are the main disadvantageous factors in quinoa. In cereals, phytic acid is located in the germ. In quinoa seeds, phytic acid is located in the external layers as well as in the endosperm. It has been reported that the mean phytic acid concentration was 1.18 g/100 g in five varieties of quinoa. Saponins have the ability to induce changes in intestinal permeability which aids in the absorption of particular drugs. Saponins are also known to lower blood cholesterol levels. The saponin content in seeds of sweet genotypes varies from 0.2 to 0.4 g/kg dry matter and in bitter genotypes from 4.7 to 11.3 g/kg dry matter.

CONCLUSION

Celiac disease is permanent intolerance to specific storage proteins in wheat, barley and rye collectively called 'gluten'. Ingestion of gluten causes damage to small intestinal mucosa. It is utmost important to develop diet based alternative strategies to reduce the incidence of celiac disease. The products developed by supplementing quinoa flour- cookies, cakes, muffins, pies and tarts, were found to have higher protein, fat, calcium, iron, magnesium, zinc, tryptophan, methionine and lysine as compared to their control samples. Incorporation of quinoa flour above 10% causes the colour of product to become darker and bitter due to presence of saponins in quinoa. Thus it can be concluded that development of gluten free bakery products at 10% level can be encouraged in the diet of celiac patients to fulfill their nutrient requirements and to improve nutritional status. Gluten free bakery products can prove a boon for celiac patients as gluten free diet is the only effective means of treating such individuals.

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