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Nutritional Analysis of Gluten Free Products from Quinoa (*Chenopodium quinoa*) Flour

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ABSTRACT

Quinoa flour was used for the development and nutritional evaluation of gluten free products i.e. ladoo, chapatti, parantha, mathri, cookies and pop-ups. Test samples were found to be highly acceptable with overall acceptability score of 8.04 for ladoo(7.66), chapatti(7.36) , parantha (8.04), mathri(7.02), cookies(7.94) and pop-ups (7.78). Nutritional analysis revealed that test samples prepared from quinoa flour have higher crude protein ranging from 11.02 to 15.00percent, crude fat 4.09 to 59.14 percent, total ash 1.75 to 4.19 percent and crude fibre 0.27 to 3.24 percent as compared to controls. Lysine which is a limiting amino acid in cereals, have significant higher values ranging from 2.83-9.40g/100 protein among the developed products. Methionine, tryptophan, calcium, magnesium, iron and zinc content of test samples were also found to be significantly ($p<0.05$) higher as compared to controls. Neutral detergent fibre values ranged from (24.90 % to 73.30 percent) and acid detergent fibre values ranged from (19.70 to 35.50percent) for test samples. Gluten free quinoa flour products were found to be highly acceptable and nutritionally better as compared to the control samples.

Key words: *Quinoa flour, Organoleptic evaluation, Nutritional analysis, Gluten free products.*

INTRODUCTION

Quinoa (Chenopodium quinoa) is a species of goosefoot (Chenopodium) a grain crop grown primarily for its edible seeds. It is a staple food of ancient civilizations and got originated in the Andean region of South America. It is a small seed which look like a cross between sesame seeds and millets. Quinoa (the name is derived from the Spanish spelling of the quechua name kinwa or occasionally "qin-wah". In botanical terms, quinoa is not true cereal; it is dicotyledonous plant as opposed to most cereals (e.g. wheat, rice and barley) which are monocotyledonous. They are referred to as pseudo cereals, as their seeds resemble in function and composition those of the true cereals. Quinoa tolerates a wide range of acidic conditions of the soil pH 6.0 to 8.5. In quinoa seeds the embryo or germ which is circular in shape, surrounds the starch-rich perisperm and together with the seed coat represents the bran fraction which is relatively rich in fat and protein. India is located between 8° and 38°N and 68° and 93.5°E exhibits enormous diversity for agro-climatic regions and edaphic-climatic conditions.

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Quinoa's aptitude to produce high protein grains under ecologically extreme conditions makes it important for the diversification of agriculture as in high-altitude regions of the Himalayas and North Indian Plains[5].Quinoa is a treasure trove of nutrients. The protein of quinoa seed is rich in essential amino acids, particularly methionine, threonine and lysine which are the limiting amino acids in most cereal grains. Unlike wheat, rice and corn which are low in lysine, quinoa contain balanced set of essential amino acid such as methionine, cysteine and lysine and also making quinoa a good complement to legumes which are limiting in these amino acids[8]. Quinoa grains contain large amounts of minerals like calcium, iron, zinc and copper[27]. Quinoa contains 4.4-8.8 percent crude fat with the essential fatty acids linoleic and linolenic acid accounting for 55 to 63 percent of the total fatty acids and has lipid lowering effect[2]. The main flavonoids in quinoa are kaempferol and quercetin both are strong antioxidants and free-radical scavengers[14].A pseudo-cereal contains gluten-free high-quality protein so it can play an important role in the diet of people suffering from celiac disease[13]. Celiac disease is one of the most common lifelong disorders worldwide with an estimated mean prevalence of 1 percent of the general population. The only acceptable treatment for celiac disease is the strict lifelong elimination of gluten from the diet[7].

MATERIAL AND METHODS

Procurement and processing of quinoa grains

Quinoa (Chenopodium quinoa) grains were procured from the local market of Ludhiana. The grains were cleaned and rendered free of dust, dirt, foreign material and broken seeds. Quinoa grains were finely milled to obtain flour. For standardization and development of food products using quinoa, commonly consumed food items i.e. milk, vegetables and fruits were procured from the local market along with other ingredients like oil, spices, sugar and salt.

Development of products

Quinoa flour was used in preparation of chapatti, parantha, ladoo, mathri, cookies and pop-up. The developed products were organoleptically evaluated by a semi trained panel of 10 judges from Department of Food and Nutrition, College of Home Science, Punjab Agricultural University (PAU), Ludhiana. The judges were served each product with one control and one test sample. Control sample was prepared from ingredients used in the usual recipe i.e. wheat flour and maida and test sample was prepared by using quinoa. The samples were coded as C and S_1 to avoid any bias. Each product was tested thrice. Judges were asked to score the samples for various sensory attributes such as colour, appearance, flavour, texture, taste and overall acceptability using a score card of 9 point hedonic rating scale. All the products prepared were powdered and stored at ambient conditions in air tight plastic containers until used for chemical analysis.

Nutritional analysis

Proximate composition

Proximate composition viz. moisture, crude protein, crude fat, crude fibre, ash was analyzed by standard methods[3]. The moisture content of samples was determined by air-oven drying at 105˚C for 8 hrs. Protein content was calculated by determining total nitrogen employing Microkjeldhal method (Kel plus Classic, Pelican Equipments Inc., India). Crude fat was extracted with petroleum ether, using Socs Plus and for fibre, acid and alkali washing was given in Fibra Plus Apparatus (Pelican Equipments Inc., India). Available carbohydrate was calculated by subtracting the sum of percentage value of crude protein, crude fat, ash and crude fibre from 100 on dry matter basis. Gross energy was computed with the help of formula mentioned below

Gross Energy = (Crude Protein×4) + (Crude Fat×9) + (Carbohydrate×4)

Amino acid analysis

Extraction of amino acids was done by hydrolyzing the samples in autoclave for 6h at 15lb pressure. After filteration, hydrolyzed samples were used for the determination of

tryptophan[8] and methionine[19]. Lysine was assessed by method of Carpenter, 1960 modified by Booth[6]

Mineral content

For minerals, the samples were wet digested on hot plate using nitric acid and perchloric acid mixture in 5:1 ratio (v/v) and used for the determination of total amount of calcium, iron, magnesium and zinc by atomic absorption spectrophotometer.

Fiber fractions

The samples were estimated for neutral detergent fibre (NDF) and acid detergent fibre (ADF) by Goering and Van Soest (1970) method[14]. The samples were gelatinized by boiling for 2 minutes with 25ml water and 0.05g of alpha amylase was added to the gelatinized sample and kept in an oven and further treatment for NDF and ADF were done.

Statistical analysis

The values were taken in triplicate and the results are given mean ± standard error. Data were subjected to statistical analysis using statistical Package for Social Science (SPSS) version 16.0. Tukey test was used to compare the significant differences in mean values obtained. The significant difference was checked at 5% and 1% level of significance.

RESULTS AND DISCUSSIONS

Organoleptic evaluation

Organoleptic scores of the developed products are presented in Table 1. Two samples were prepared using quinoa flour for test sample (S_1) and control sample (C) was prepared with wheat flour as a main ingredient. The results revealed that mean scores of test ladoos for appearance, colour and texture were significantly lower i.e. 7.40, 7.40 and 7.50 than that of control i.e. 8.00, 8.10 and 8.20. These mean scores were lower because quinoa flour was gluten free, provide hard texture to ladoos and they were more dried in appearance and dull in colour as compared to control sample. A non-significant difference was found in the mean scores of flavour and taste of test sample i.e. 8.00 and 8.00 and the control sample 7.90 and 7.90 respectively. The mean score of overall acceptability of test sample i.e. 7.66 was significantly lower than the control sample i.e. 8.02. The control sample was liked very much and the test sample was moderately liked. the acceptability score of food product ladoo developed from maize in combination with ragi, green gram, gingelly seeds, amaranthus and jaggery. Organoleptic evaluation was done by 30 pregnant women by using 9 point hedonic scale. The scores for different parameters such as colour, flavour, texture, taste and general acceptability were recorded. Scores for all parameter was above 6 which indicated the acceptance of the product[23]. The pooped bajra ladoo prepared by popping whole grain in sand and then mixed with jaggery. A highly significant score i.e. 6.40, 6.20, 5.60, 5.30 and 6.80 for appearance, colour, texture, taste and flavour and overall acceptability respectively, of PHB-2168 were observed[32]. It was reported that ladoo prepared from 100 percent popped pearl millet was organoleptically acceptable[15]. The test sample of chapati has scores ranging from 7.00 to 7.70. The mean scores for appearance, texture, flavour and taste of control chapatis were significantly higher i.e. 8.10, 8.00, 8.00 and 8.00 than that of test sample i.e. 7.50, 7.00, 7.30 and 7.30. There was a non-significant difference found between the control and test sample because both possess almost same colour and the mean score for control and test sample was 8.00 and 7.70 respectively. Thus, the mean scores of overall acceptability of control chapati i.e. 8.02 were significantly higher than the test i.e. 7.36. Four samples of missi roti using wheat and bengal gram flour as control and oats supplemented at 20%, 25% and 30% level to wheat flour. The highest mean scores for texture and overall acceptability were 7.9 and 8.0 respectively which were scored by 30% level. The best of 8.3 for colour was also observed at 30% level[31].The results revealed that significantly high scores for appearance, colour, texture, flavour and taste were obtained by test Parantha ranging from 8.00 to 8.10 with an overall acceptability score of 8.04 being liked very much. The scores of control

Parantha for appearance, colour, texture, flavour and taste were significantly lower i.e. 7.50, 7.60, 7.50, 7.50 and 7.50 than that of test Parantha i.e. 8.10, 8.00, 8.10, 8.00 and 8.00. The mean scores of overall acceptability of test Parantha i.e. 8.04 was significantly higher than the control i.e. 7.52 and was liked very much as compared to control which was moderately liked. It was concluded that parantha prepared from quinoa flour was found to be more acceptable by the panelists. Goyal had prepared the cauliflower parantha by incorporating amla powder of all the five different cultivators[18]. The results showed the organoleptic score with the range of acceptability regarding colour, appearance and texture was found to vary from 7.8±0.4 to 8.0±0.0 on a nine point hedonic scale whereas for aroma, it was 7.8±0.4 and for taste, it varied from 7.7±0.5 to 8.2±0.4. The overall acceptability ranged from 7.7±0.5 to 8.0±0.00. The mean scores of test mathri for appearance, colour, texture, flavour and taste were significantly lower i.e. 7.20, 7.30, 6.70, 6.90 and 7.00 than that of control i.e. 8.00, 8.00, 7.78, 7.78 and 7.89. The control sample of mathri was given a score ranging from 7.78 to 8.00 for different quality attributes. The mean score of texture of test sample was significantly lowest among all other attributes because of the hard texture as compared to control sample and was neither like nor disliked. The mean score of overall acceptability of test mathri i.e. 7.02 was significantly lower than the control mathri i.e. 7.89. Four samples of mathi were prepared using refined flour for control (C) and for test samples refined flour was substituted with 20%, 25% and 30% level of potato flour. Highest scores of all parameters colour, appearance, flavour, texture, taste were obtained by S_2 ranging from 8.0-8.2 with an overall acceptability score of 8.08[21]. The results showed that the test cookies has higher scores than the control cookies in all the parameters of sensory attributes. The mean scores for appearance, colour, texture, flavour and taste of control cookies were significantly lower i.e 7.30, 7.40, 7.20, 7.10 and 7.40 than that of test sample i.e. 8.10, 8.00, 7.70, 8.00 and 7.90. A highly significant ($p \leq 0.01$) difference was observed in the flavour attribute of test sample which was liked very much. The mean scores of overall acceptability of test cookies i.e. 7.94 was significantly higher than the control cookies i.e. 7.28. Oshodi *et al.*[25] stated that quinoa flour, in combination with wheat flour or corn meal, is used in making biscuits, bread and processed food as seed flour has good gelation property, water-absorption capacity, emulsion capacity and stability. Lorenz and Coulter[24] evaluated the performance of quinoa-wheat flour blends (5/95, 10/90, 20/80, 30/70) in cookies. Cookie spread and top grain scores decreased with increasing levels of quinoa flour blended with high-spread cookie flour. Flavour improved up to 20% by quinoa flour in the blend. Cookie spread and cookie appearance was improved with a quinoa/low-spread flour blend by using 2% lecithin. The results revealed that the test pop-up have higher scores than the control pop-up for different quality attributes with an overall acceptability score of 7.78. The mean scores for appearance, colour, texture, flavour and taste of control pop-up were significantly lower i.e 7.20, 7.20, 7.00, 7.20 and 7.20 than that of test pop-up i.e. 7.70, 7.80, 7.60, 7.90 and 7.90. The mean scores of overall acceptability of test pop-up i.e. 7.78 were significantly higher than the control pop-up i.e. 7.16. Coulter and Lorenz (1991a, b) studied the use of quinoa in mixtures with corn for extrusion and the quinoa was utilized at three levels (10, 20 and 30 %) and organoleptic characteristics of the products were analyzed. It was observed that the most favorable products presenting the greater expansion were produced at 15 % initial moisture content. Sensory evaluation of the end products indicated a good consumer acceptance.

Proximate composition

The proximate composition of the samples are presented in the table 2. The moisture content of 1.36% was observed in control ladoo while the test ladoo which was prepared from quinoa

flour contain significantly more moisture content of 2.26%. The ash and crude fat of test sample i.e. 2.02% and 51.26% respectively was significantly higher than that of control ladoo in which ash content was 1.05% and crude fat 45.12%. The protein content in test ladoo 13.25% was significantly higher than control ladoo 10.65%. There was a non-significant difference between control and test sample as far as fibre content is concerned. The fibre content of test sample was 0.27% and of control 0.21%. The carbohydrate content was observed in control as 41.61% and test ladoo with 30.94%. The energy content of test ladoo with 638 Kcal was significantly higher than the control with 615 Kcal. The value added product had been prepared namely Ladoo by incorporating amaranth seeds at 30 percent, 40 percent and 50 percent level refers as T_1, T_2, T_3 respectively and the control T_0 for all the prepared products was made without the incorporation of puffed amaranth seeds. T_1 sample of ladoo contain higher amount of nutrients than the other and protein content in ladoo was found to be between 7.68- 12.77g, fat ranged between 0.145-3.70g, carbohydrate ranged between 110.14- 116.35g, Energy 497.35-514.15 Kcal, fiber 0.3-3.04g[22].The moisture content of control chapati was 1.50% while the test chapati contain significantly less moisture content of 1.20%. The test missi roti supplemented with 30% oats had 3.0% of moisture while the control had 4.6% moisture content. The protein content in test chapatti 11.25% was found to be significantly higher than control chapatti 9.05% because quinoa contains more protein than wheat[31]. The ash, crude fat and crude fibre of test sample i.e. 2.80%, 4.09% and 3.05% respectively was significantly higher than that of control chapatti in which ash content was 1.55%, crude fat 1.70% and crude fibre was 1.65%. The test sample which was prepared from quinoa has more moisture of 3.28%. The crude fibre and crude fat of test sample i.e. 3.12% and 12.45% respectively was significantly higher than that of control parantha in which crude fat content was 2.80% and crude fat 8.01%. A non-significant difference was found in the protein content of control parantha and the test parantha. The protein content in test parantha was 15% and control parantha was 13%. It was studied the protein content of various pearl millet based recipes ranged from 9.03 to 19.10%. The protein content was 19.10% in bajra nutritious parantha[32]. The ash content of test parantha and control parantha was found to be non-significant. The ash content of control sample was 3.00%. Overall, the different attributes of proximate composition of test sample was higher than the control sample.The moisture content of control mathri was 1.80% while the test mathri contain significantly less moisture content of 1.48%. The protein content in test mathri 11.02% was found to be significantly higher than control mathri 9.13%. The ash, crude fat and crude fibre of test sample i.e. 2.71%, 40.88% and 2.31% respectively was significantly higher than that of control mathri in which ash content was 1.55%, crude fat 35.78% and crude fibre 0.12%. The moisture content of 3.54% was observed in control cookies while the test cookies which were prepared from quinoa flour contain significantly less moisture of 2.45%. The ash and crude fat of test sample i.e. 1.75% and 59.14% respectively was significantly higher than that of control cookies in which ash content was 0.95% and crude fat was 53.42%. The protein content in test cookies 11.25% was significantly higher than control cookies 9.38%. The fibre content of test cookies 2.75% was significantly higher than the fibre content of control 0.37%. The carbohydrate content was observed in control as 32.34% and test cookies with 22.66%. The energy content of test cookies with 647 Kcal was significantly higher than the control with 667 Kcal. Quinoa flour is low in gluten due the low contents of prolamines and glutamines. It is usually used to enhance baking flours in the preparation of biscuits for the preparation of baked foods to maintain the moisture and give an agreeable flavour[34]. Incorporation of amaranth, quinoa and buckwheat was done at levels of 25, 50, 75 and 100% in a gluten-free biscuit formulation. Biscuit crispiness was in the order buckwheat > quinoa > amaranth, and

biscuits containing buckwheat and amaranth were preferred by a sensory panel[30].The protein content in test pop-up 12**.**45% was found to be significantly higher than control pop-up 5.80%. This is due to the presence of high protein in quinoa as compared to rice. The ash, crude fat and crude fibre of test sample i.e. 2.89%, 5.50% and 3.24% respectively was significantly higher than that of control pop-up in which ash content was 2.70%, crude fat 0.06% and crude fibre 0.27%.The carbohydrate content was observed in control as 90.33% and test pop-up with 75.16% which was significantly lower than the control sample. The energy content of test pop-up with 399Kcal was significantly higher than the control with 385Kcal. It was optimized the extrusion of quinoa flour. They demonstrated that quinoa can be used in novel, healthy, snack-type food products because of its high lipid and low amylose contents. However, extrusion cooking of quinoa required very high shear to disrupt the starch granules[12].

Amino acid analysis

The results of amino acid content in the developed products from quinoa flour are presented in table 3. The amino acid content namely lysine, methionine and tryptophan of the control (C) and test sample (S_1) of ladoo revealed that the test ladoo contain lysine content of 5.90g/100g protein which was significantly higher than the control ladoo that had lysine content of 1.72g/100g protein. The tryptophan and methionine content of test ladoo i.e. 0.90g/100g protein and 2.30g/100g protein respectively was observed to be significantly higher than the control ladoo i.e. 0.43g/100g protein and 0.75g/100g protein respectively. The amino acid content of the test sample (S_1) and control sample (C) of chapati showed that the lysine content of 1.41g/100g protein was observed in control chapatti while the test chapatti contain significantly more lysine of 5.21g/100g protein. The tryptophan content of test chapati was observed to be 0.89g/100g protein that is significantly higher than the control chapatti i.e. 0.58g/100g protein. The methionine content of test chapatti is 2.01g/100g protein which is significantly higher than the control chapatti i.e. 0.75g/100g protein.The test parantha contain lysine content of 9.40g/100g protein which was significantly higher than the control parantha that had lysine content of 4.60g/100g protein. The tryptophan and methionine content of the test parantha i.e. 2.50g/100g protein and 3.20g/100g protein respectively was observed to be significantly higher than the control parantha i.e. 2.20g/100g protein and 2.20g/100g protein respectively. The lysine content of 1.80g/100g protein was observed in control mathri while the test mathri contain significantly more lysine of 4.50g/100g protein. The tryptophan content of test mathri was observed to be 0.94g/100g protein that is significantly less than the control mathri i.e. 1.20g/100g protein. The methionine content of test mathri is 2.30g/100g protein which is significantly higher than the control mathri i.e. 1.80g/100g protein.Test cookies contain lysine content of 2.83g/100g protein which was significantly higher than the control cookies that had lysine content of 0.94g/100g protein. The tryptophan content of test cookies was observed to be 0.43g/100g protein that is non-significantly higher than the control cookies i.e. 0.41g/100g protein. The methionine content of test cookies is 1.01g/100g protein which is significantly higher than the control cookies i.e. 0.63g/100g protein. The lysine content of 3.24g/100g protein was observed in control pop-up while the test pop-up contain significantly more lysine of 5.87g/100g protein. The tryptophan content of test pop-up was observed to be 0.97g/100g protein that is significantly less than the control pop-up i.e. 1.24g/100g protein. The methionine content of test pop-up is 2.37g/100g protein which is significantly higher than the control pop-up i.e. 2.10g/100g protein. Nutritional properties, sensory evaluation and physical characteristics were examined in extrusion studies blending quinoa and corn grits[10].

Mineral content

The mineral content of the control (C) and test sample (S_1) of products were analysed. The

result for ladoo revealed that the calcium content of 45 mg was observed in control ladoo while the test ladoo contain significantly higher calcium content of 77 mg. The iron content in test ladoo 4.63 mg was significantly higher than control ladoo 3.90 mg. The magnesium and zinc content of test ladoo 180 mg and 3.23 mg, respectively was significantly higher than that of control 121 mg and 2.50 mg, respectively. Value added product was made namely ladoo was made by incorporating amaranth seeds at 30 percent, 40 percent and 50 percent level refers as T_1, T_2, T_3 respectively and the control T_0 made without the incorporation of puffed amaranth seeds. The nutritive value of the products increased with the incorporation of puffed amaranth seeds iron content in ladoo was found to be between 7.78-11.42 mg and calcium ranged between 59-178.2 mg per 100g[14]. The results revealed that the calcium content of 48 mg was observed in control chapatti while the test chapatti contains significantly higher calcium content of 78.30 mg . The iron content in test chapatti 5.01 mg was significantly higher than control chapatti 3.90 mg. The magnesium and zinc content of test chapatti 189 mg and 4.01 mg respectively which was significantly higher than the control 111.67 mg and 2.10 mg respectively. The calcium content of 98 mg was observed in control parantha while the test parantha contain significantly higher calcium content of 118 mg. The iron content in test parantha 6.88 mg was significantly higher than control parantha 6.01 mg. The magnesium content of test parantha 206 mg was significantly higher than the magnesium content of control 136 mg. The zinc content of test parantha with 4.80 mg was significantly higher than the control with 2.80 mg. It was reported that the calcium in whole wheat flour, refined wheat flour and rice flakes as 48, 23 and 20 mg/100g[17].The calcium content of 20 mg was observed in control mathri while the test mathri contain significantly higher calcium content of 68 mg. The supplementation of mathri with 10% partially defatted peanut flour shown increase in calcium content as 28.1 mg/100g from control as 23 mg/100g. The iron content in test mathri 4.10 mg was significantly higher than control mathri 2.40 mg[4]. It was also reported that with the supplementation of partially defatted peanut flour at 15% level, the iron content in mathri was 4.1 mg. The magnesium and zinc content of test mathri 140 mg and 2.20 mg respectively which was significantly higher than the control 34 mg and 0.60 mg respectively[4].

The calcium content of 15 mg was observed in control cookies while the test cookies contain significantly higher calcium content of 58 mg. The iron content in test cookies 2.01 mg was significantly higher than control cookies 1.29 mg. The magnesium content of test cookies 78 mg was significantly higher than the magnesium content of control 25 mg. The zinc content of test cookies with 1.64 mg was significantly higher than the control with 0.27 mg. The calcium content of 10 mg was observed in control pop-up while the test pop-up contain significantly higher calcium content of 54 mg. The magnesium and zinc content of test pop-up 98 mg and 3.04 mg respectively which was significantly higher than the control 64 mg and 1.30 mg respectively. The iron content in test pop-up 5.04 mg was significantly higher than control pop-up 0.70 mg. The addition of potato flour at 2.5%-50% level, the iron content increased significantly for biscuits where were cereal and pulse based showed non-significant difference for control. The iron content of biscuits was found to be 2.27 mg/100g and the calcium content of biscuits at 10% level of potato flour was found to be 16.48 mg/100g[13].

Fibre fractions

Data on the fibre fractions of various food products prepared from quinoa flour have been analysed. The values are on dry weight basis.The neutral detergent fibre (NDF) and acid detergent fibre (ADF) content of ladoo revealed that the neutral detergent fibre and acid detergent fibre content of test ladoo 47.10% and 35.50% respectively was found to be significantly higher than control ladoo with neutral detergent fibre 22.70% and acid detergent fibre content 31.50%. The NDF

value of control missi roti was 19.95 while supplementation of oats at 30% level increased to 21.4%. The ADF value for test missi roti was 4.9% while control sample had 3.1% of ADF[39].The neutral detergent fibre (NDF) and acid detergent fibre (ADF) content of test parantha 73.30% and 34.70% respectively was found to be significantly higher than control parantha with neutral detergent fibre 58.30% and acid detergent fibre content 20.30%. Singh (2007) reported the NDF content in nutritious parantha of pearl millet was 6.89 per 100g on dry weight basis. The neutral detergent fibre content of test mathri 48.70% which was significantly higher than control mathri i.e. 38.30%. The acid detergent fibre content in test mathri was 24.40% which was non-significantly lower than control mathri (24.50%). It also reported that 9.90 NDF content was found in sweet mathri whereas the wheat based sweet mathri contain 8.60 of NDF content[32]. The neutral detergent fibre and acid detergent fibre content of test parantha 57.60% and 19.70% respectively was found to be significantly higher than control parantha with neutral detergent fibre 36.60% and acid detergent fibre content 14.70%. It was reported that NDF value of control biscuit was 15% but supplementation of oats in test sample increased to 17.6%[21]. It was also reported 14.2% of NDF and 3.0% of ADF in biscuits supplemented with 15% oats. The neutral detergent fibre content of test pop-up was 24.90% which was significantly higher than control pop-up i.e. 13.20%[20]. The acid detergent fibre content in test pop-up was 20.70% which was significantly higher than control pop-up (3.60%).

Table1: Organoleptic scores of developed products using quinoa flour (Mean ±SE)

Sample		Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
Ladoo	**C**	8.00±0.0	8.10±0.10	8.20±0.13	7.90±0.10	7.90±0.10	8.02±0.06
	S_1	7.40±0.16	7.40±0.16	7.50±0.17	8.00±0.15	8.00±0.15	7.66±0.12
	t-value	3.67**	3.66**	3.28**	0.56^{NS}	0.56^{NS}	2.73*
Chapatti	**C**	8.10±0.10	8.00±0.00	8.00±0.00	8.00±0.00	8.00±0.00	8.02±0.02
	S_1	7.50±0.17	7.70±0.15	7.00±0.15	7.30±0.21	7.30±0.21	7.36±0.13
	t-value	3.09**	1.96^{NS}	6.71**	3.28**	3.28**	4.91**
Parantha	**C**	7.50±0.17	7.60±0.16	7.50±0.17	7.50±0.17	7.50±0.17	7.52±0.13
	S_1	8.10±0.10	8.00±0.00	8.10±0.10	8.00±0.00	8.00±0.00	8.04±0.04
	t-value	3.09**	2.45*	3.09**	3.00**	3.00**	3.90**
Mathri	**C**	8.00±0.00	8.00±0.00	7.78±0.22	7.78±0.22	7.89±0.11	7.89±0.11
	S_1	7.20±0.13	7.30±0.21	6.7±0.36	6.90±0.23	7.00±0.26	7.02±020
	t-value	5.68**	3.10**	2.44*	2.71*	3.04**	3.73**
Cookies	**C**	7.30±0.15	7.40±0.16	7.20±0.13	7.10±0.10	7.40±0.16	7.28±0.11
	S_1	8.10±0.10	8.00±0.00	7.70±0.15	8.00±0.00	7.90±0.10	7.94±0.04
	t-value	4.38**	3.67**	2.47*	9.00**	2.61*	5.49**
Pop-up	C	7.20±0.13	7.20±0.13	7.00±0.00	7.20±0.13	7.20±0.13	7.16±0.08
	S_1	7.70±0.15	7.80±0.13	7.60±0.16	7.90±0.18	7.90±0.23	7.78±0.12
	t-value	2.47*	3.18**	3.67**	3.13**	2.61*	4.22**

NS - non significant, *Significant at 5% level, **Significant at 1% level

Table 2: Proximate composition of developed products using quinoa flour (on dry weight basis)

Products	Moisture (%)	Crude protein (%)	Crude fat (%)	Total ash (%)	Crude fibre (%)	Carbo-hydrate (%)	Energy (Kcal)
Ladoo							
C	1.36±0.06	10.65±0.05	45.12±0.58	1.05±0.01	0.21±0.01	41.61±0.58	615
S_1	2.26±0.05	13.25±0.06	51.26±0.57	2.02±0.01	0.27±0.06	30.94±0.06	638
t-value	11.02**	32.60**	7.52**	118.80**	1.03^{NS}	18.39**	3.98*
Chapatti							
C	1.50±0.05	9.05±0.01	1.70±0.06	1.55±0.06	1.65±0.06	84.55±0.06	389
S_1	1.20±0.06	11.25±0.06	4.09±0.01	2.80±0.06	3.05±0.01	77.61±0.06	392
t-value	3.67*	37.92**	41.19**	15.31**	23.97**	84.99**	3.12*
Parantha							
C	3.20±0.05	13.00±0.58	8.01±0.01	3.00±0.58	2.80±0.06	69.98±0.58	404
S_1	3.28±0.06	15.00±0.57	12.45±0.06	4.19±0.01	3.12±0.06	60.18±0.58	412
t-value	0.98^{NS}	2.45^{NS}	76.52*	2.06^{NS}	25.72**	12.00**	14.93**
Mathri							
C	1.80±0.06	9.13±0.06	35.78±0.58	1.55±0.06	0.12±0.01	51.62±0.58	565
S_1	1.48±0.05	11.02±0.58	40.88±0.57	2.71±0.05	2.31±0.06	41.60±0.57	578
t-value	3.92*	3.26*	6.25**	14.21**	37.74**	12.27**	16.39**
Cookies							
C	3.54±0.05	9.38±0.06	53.42±0.57	0.95±0.01	0.37±0.01	32.34±0.57	647
S_1	2.45±0.06	11.25±0.58	59.14±0.58	1.75±0.06	2.75±0.06	22.66±0.58	667
t-value	13.35**	3.22*	7.01**	13.79**	41.02**	11.86**	3.49*
Pop-up							
C	0.85±0.06	5.80±0.06	0.06±0.01	2.70±0.01	0.27±0.01	90.33±0.57	385
S_1	0.76±0.05	12.45±0.58	5.50±0.06	2.89±0.06	3.24±0.06	75.16±0.58	399
t-value	1.10^{NS}	11.46**	93.76**	3.28*	51.19**	18.58**	18.27**

Values are Mean±SE , NS- Non-significant,*Significant at 5% level, **Significant at 1% level

Table 3: Amino acid content of developed products using quinoa flour (g/100g protein on dry weight basis)

Products	Lysine (g/100g protein)	Tryptophan (g/100g protein)	Methionine (g/100g protein)
Ladoo			
C	1.72±0.04	0.43±0.05	0.75±0.06
S_1	5.90±0.06	0.90±0.06	2.30±0.06
t-value	59.76**	5.76**	18.98**
Chapatti			
C	1.41±0.06	0.58±0.06	0.75±0.06
S_1	5.21±0.05	0.89±0.01	2.01±0.01
t-value	46.54**	5.34**	21.72**
Parantha			
C	4.60±0.06	2.20±0.06	2.20±0.05
S_1	9.40±0.05	2.50±0.05	3.20±0.06
t-value	58.79**	3.67*	12.25**
Mathri			
C	1.80±0.05	1.20±0.06	1.80±0.05
S_1	4.50±0.06	0.94±0.01	2.30±006
t-value	33.067**	4.48*	6.12**
Cookies			
C	0.94±0.01	0.41±0.01	0.63±0.00
S_1	2.83±0.06	0.43±0.06	1.01±0.01
t-value	32.57**	0.35^{NS}	46.54**
Pop-up			
C	3.24±0.06	1.24±0.06	2.10±0.0.05
S_1	5.87±0.01	0.97±0.01	2.37±0.01
t-value	45.33**	4.65**	4.65**

Values are Mean±SE, NS – Non-significant, *Significant at 5% level, **Significant at 1% level

CONCLUSION

Products namely *ladoo*, chapatti, *parantha*, *mathri*, cookies and pop-up developed by using quinoa flour were organoleptically highly acceptable. The recipes developed by using quinoa flour were found to have higher proximate, mineral content and fibre fractions as compared to the control recipes. Quinoa based recipes contain a balanced set of amino acid content as compared to control recipes. Lysine which is a limiting amino acid in cereals, have significant higher values ranging from 2.83-9.40g/100 protein among the developed products. Quinoa's highly proteinaceous grain containing balanced set of amino acids can be recommended to celiac patients. Quinoa flour can be utilized like the other cereal flours for the development of products.

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