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Effect of Amalgamation of Quinoa on Contents of Essential Amino Acids, Proximates, Dialyzable Minerals and Storage Stability of Gluten and Egg Free Maize Muffins

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ABSTRACT

Background: Recently there has been increasing interest in the production of gluten-free (GF) foods from pseudo-cereals, without celiac activity, in order to fulfil the specific needs of people affected by celiac disease. Bakery products, particularly gluten-free muffins, represent one of the most consumed foods around the world and may be an interesting objective.

Methods: The present study assessed the nutritional composition, dialyzable mineral contents, lysine, methionine and storage stability of maize and quinoa muffins.

Result: The substitution of maize flour with quinoa flour augmented the crude protein (8.96 to 11.14%), fat (24.70 to 27.77%), fibre (1.54 to 6.28%), ash (1.86 to 2.62%) and carbohydrate (42.76 to 29.07%) in muffins. The lysine and methionine contents of quinoa muffins were 122.4 and 85.4 per cent higher than control muffins. The muffins could be stored at room temperature up to 3 days without any food additive. The distinctive protein, essential amino acid and mineral characteristics of quinoa muffins open a new promising prospect for utilization of quinoa flour not only on industrial scale but also at household scale, for prevention of hidden hunger and malnutrition. Quinoa muffins can also cater to the needs of wellness market segment with taste.

Key words: Gluten free, Lysine, Maize, Methionine, Muffins, Quinoa flour.

INTRODUCTION

Quinoa (*Chenopodium quinoa*) is a super smart gluten free pseudo-cereal food and is gaining popularity among health conscious clientele. It exhibits wonderful nutritional food quality, it is high in protein content with an abundance of essential amino acids, vitamins and minerals (Chandra *et al.* 2018; Nisar *et al.* 2018). It has exceptionally higher protein content (16-18%) and more than 37 per cent of the quinoa protein comprise essential amino acids and is comparable to casein (Drzewiecki *et al.* 2003).Quinoa contained total dietary fibre content of 13.4 per cent consisting of 11.0 percent insoluble and 2.4 percent soluble fibre. Quinoa contains 4.4-8.8 per cent 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 (Alvarez *et al.* 2010). Furthermore, quinoa is an excellent source of phosphorus and high in magnesium and iron contents as well as in vitamins such as vitamin E and B complex (Fleming and Galwey 1995; Sohaimy *et al.* 2018). Celiac and lactose-intolerant persons can consume quinoa because of its gluten-free nature and its high protein quality (Rules and Nair, 1992). The quinoa flour can be substituted in various products like bread, noodles, pasta and sweet biscuits (Zevallos *et al.* 2015). Celiac disease is one of the most common lifelong disorders and the only acceptable treatment for celiac disease is elimination of gluten from the diet (Catassi and Fasano 2010) and scientists are working for development of gluten free products (Tanwar and Dhillon 2016). In the present study, efforts were made to develop and analyse the nutritional characteristics of maize and quinoa flour muffins. It is anticipated that the popularization and utilization of maize and quinoa flour for preparation of gluten-free muffins can improve the nutritional and health status of celiac persons. Preparation of such products can serve to the deprived palate of the celiac patients and can also be given to children to meet the need for diet diversity and nutrition needs. Very few studies have been done to develop gluten and egg free products, thus the present study is an innovative work and can lead to processed food intervention specially for celiac patients.

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MATERIALS AND METHODS

Obtaining raw materials

The study was conducted in the Department of Foods and Nutrition, CCS HAU, Hisar from year 2020 to 2022. Quinoa and maize grains were procured from the local market of Hisar. Quinoa and maize grains were cleaned and finely milled to flour. All other ingredients were procured from local market of Hisar.

Formulating quinoa based muffins

Flours were divided into the ratios Maize flour : Quinoa flour (100:0 and 60:40, respectively for control and experimental sample), creamed refined oil (75 ml), added condensed milk (200 ml), vanilla essence (3-4 drops), water and blended well with electric beater. Folded the maize/quinoa flour in mixture, poured the mixture in the greased muffin tray and baked at 200°C for 20 minutes.

Devised muffins were chemically analyzed for following parameters

Proximate composition

Moisture, crude protein, fat, ash and crude fiber were estimated by employing the standard method of analysis (AOAC, 2000). Conversion factor of N X 6.25 was used for estimation of crude protein.

Dietary fiber and total mineral content

Total, soluble and insoluble dietary fiber constituents were determined by the enzymatic method discussed by Khare *et al.* (2021). Total mineral content was determined following the methods mentioned by (Lindsey and Norwell 1969). Two gram sample was taken in a 150 ml conical flask. To this, added 20 ml diacid mixture (HNO_3:$HClO_4$: 5:1,v/v) and kept overnight and digested next day to white precipitates. The precipitates were dissolved in double distilled water and filtered through Whatman No. 42. The filtrate so obtained was diluted to 100 ml with double distilled water and determined calcium, phosphorus, iron and zinc.

Mineral availability

Available calcium and zinc (*in vitro*) were determined by Atomic Absorption Spectrophotometer. Samples (2 g) were rehydrated, added 20 ml of pepsin solution (0.1% pepsin in 0.1 N HCl) and incubated (37°C in a shaker cum water bath, 1 hour). pH raised (6.8) with sodium bicarbonate solution, added 2.5 ml of suspension containing 0.5% pancreatin and 5% bile and again incubated (37°C, 1 hour). Total volume was made to 50 ml with distilled water, centrifuged and filtrate was oven dried, digested in the diacid mixture and preceded for the estimation of available minerals. Free iron was extracted using 0.5% pepsin in 0.1 N HCl, reacted with α′, α′ dipyridyl and determined (AOAC 2010).

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 methionine (Horn *et al* 1946). Lysine was assessed by method of Carpenter (1960) modified by Booth (1971).

Shelf life

Subjective evaluation of fresh and stored muffins

All types of muffins were organoleptically evaluated, by a panel of ten semi trained judges. The scores were assigned using 9-point Hedonic Rating Scale (Saharan and Jood, 2020).

Fat acidity

The fat acidity was determined by method elaborated by AOAC (2010). Sample (10g) was extracted with petroleum ether on Soxhlet apparatus and mixed with 50 ml benzene-alcohol-phenolphthalein solution. Titrated against potassium hydroxide (1 g/lt) to orange pink colour. Blank was also titrated and the value was subtracted from titration value of the sample. Fat acidity was calculated as-

$$\text{Fat acidity} = 10 \times (T\text{-}B)$$

in this, T = ml of KOH required to titrate sample extract.
B = ml KOH required to titrate blank.

Statistical analysis

The values were taken in triplicate and data were subjected to statistical analysis using statistical Package for Social Science (SPSS) version 2.0. The significant difference was checked at 5 and 1per cent level of significance.

RESULTS AND DISCUSSION

Proximate composition

The moisture content of control muffins (100% maize flour) was 20.18 and that of quinoa-maize muffins was 23.12

Table 1: Moisture, crude protein, fat, fibre, ash and carbohydrate contents of quinoa flour powder supplemented muffins (g/100g, on dry matter basis).

Muffins	Moisture*	Crude Protein	Crude Fat	Crude fibre	Ash	CHO
Control M.F (100%)	20.18±0.12	8.96±0.06	24.70±0.54	1.54±0.04	1.86±0.16	42.76±0.58
Type I (MF:QF::60:40)	23.12±0.67	11.14±0.47	27.77±0.20	6.28±0.67	2.62±0.26	29.07±0.04
	(14.56)	(24.33)	(12.42)	(307.79)	(40.86)	(32.01)
't' value	7.49**	5.80**	9.16**	12.18**	3.36*	51.99**

Values are mean ± SE of three independent determinations.

MF=Maize flour; QF = Quinoa flour

*Significant at 5% level of significance.

**Significant at 1% level of significance.

*Moisture content fresh weight basis.

Table 2: Per cent increase in total, soluble and insoluble dietary fibre contents of quinoa flour powder supplemented muffins (g/100 g, on dry matter basis).

Muffins	Total dietary fibre	Soluble dietary fibre	Insoluble dietary fibre
Control (MF 100%)	7.14±0.23	1.37±0.47	5.78±0.29
Type I	9.54±0.59	2.24±0.12	7.30±0.48
(MF:QF::60:40)	(33.61)	(63.50)	(26.29)
't' value	6.61**	3.13**	4.68**

Values are mean ± SE of three independent determinations.

MF=Maize flour; QF = Quinoa flour.

*Significant at 5% level of significance.

**Significant at 1% level of significance.

Table 3: Total minerals (mg/100g) of quinoa flour supplemented muffins (on dry matter basis).

Muffins	Iron	Calcium	Zinc	Phosphorus
Control (MF 100%)	1.31±0.02	20.40±0.24	1.21±0.23	186.8±0.73
Type I (MF:QF::60:40)	4.39±0.10	121.18±1.14	2.65±0.12	269.7±1.53
't' value	50.61**	150.44**	9.73**	84.66**

Values are mean ± SE of three independent determinations.

MF=Maize flour; QF = Quinoa flour.

*Significant at 5% level of significance.

**Significant at 1% level of significance.

per cent (Table 1). The moisture content of quinoa-maize muffins was significantly higher than that of control. This may be attributed to the high water absorption capacity of quinoa flour due to its high soluble fiber (gums) and high protein which retained higher moisture content in the final product. The crude protein and fat contents of control muffins (100% maize flour) was 8.96 and 24.70 per cent, respectively and that of quinoa muffins was 11.14 and 27.77 per cent, respectively. The crude protein (24.33%) and fat (12.42%) contents of quinoa maize muffins was significantly higher than that of maize muffins. The increased protein and fat contents of supplemented muffins were attributed to their higher contents in quinoa flour. Yamani and Suzana (2012) studied the lipid content of quinoa and found it 2 to 3 times higher than maize. Quinoa fat content (5.2 to 9.7%) was found to be higher than that of maize (4.7%). The crude fibre and ash content of control muffins was 1.54 and 1.86 per cent while the values for supplemented muffins were 6.28 and 2.62 per cent, respectively. The crude fibre and ash content of supplemented muffins increased by 307.79 and 40.86 per cent, respectively vis a vis maize flour muffins.

Dietary fibre

The total dietary fibre content of control muffins was 7.14g/100 g and that of quinoa muffins was 9.54 g/100 g, respectively (Table 2). The soluble dietary fibre content of control muffins was 1.37 g/100 g and at 40 percent supplementation levels it was 2.24g/100 g, respectively and the insoluble dietary fibre content of control muffins was 5.78 and at 40 per cent level of supplementation it was 7.30 g/100 g, respectively. Significant increase was observed in all types of dietary fibre contents of supplemented muffins. The increased content of crude fibre and total dietary fibre of quinoa flour supplemented muffins may be justified due to high dietary fibre profile of quinoa.

Table 4: Lysine and methionine content of quinoa flour supplemented muffins (g/100 g protein on dry matter basis).

Muffins	Lysine	Methionine
Control (MF 100%)	1.25±0.06	0.96±0.06
Type I (MF:QF::60:40)	2.78±0.22 (122.4)	1.78±0.01 (85.41)
't' value	11.85**	22.01**

Values are mean ± SD of three independent determinations.

MF- Maize flour; QF- Quinoa flour.

*Significant at 5% level of significance.

**Significant at 1% level of significance.

Table 5: *In-vitro* mineral availability (%) of quinoa flour supplemented muffins (on dry matter basis).

Muffins	Iron	Calcium
Control (MF 100%)	27.40±1.71	62.95±0.51
Type I (MF:QF::60:40)	24.73±0.73	59.83±0.23
't' value	21.65**	9.58**

Values are mean±SD of three independent determinations.

MF- Maize flour; QF- Quinoa flour.

*Significant at 5% level of significance.

**Significant at 1% level of significance.

Total minerals

The calcium content in maize muffins was 20.40 mg while the quinoa muffins contained significantly higher calcium content of 121.18 mg (Table 3). The iron content in quinoa

Table 6: Storage stability of quinoa flour supplemented muffins.

Muffins	Overall acceptability during storage (Days)			
	1	2	3	CD (P≤0.05)
Control (MF 100%)	8.4±0.08	8.1±0.01	5.8±0.02	0.16
Type I (MF:QF::60:40)	8.1±0.05	7.9±0.01	5.6±0.01	0.11
Values are mean±SE of ten penalists				
	Fat acidity (mg KOH/100g) during storage (Days)			
Control (MF 100%)	43.36±0.18	46.46±0.23	48.70±0.50	0.68
Type I (MF:QF::60:40)	41.19±0.06	44.21±0.18	46.92±0.53	0.65
't' value	19.91**	13.43**	6.66**	

Values are mean±SE of three independent determinations.

MF = Maize Flour; QF = Quinoa flour.

*Significant at 5% level of significance.

**Significant at 1% level of significance.

muffins was 4.39 mg per 100 g which was significantly higher than the control muffins *i.e*. 1.31 mg/100 g. The zinc content of quinoa muffins 2.65 mg was also significantly higher than that of control (1.21 mg per 100 g). The phosphorus content of quinoa supplemented muffins 269.7 mg/100 g was also significantly higher than the control (186.8 mg/100 g). Ascheri *et al* (2002) 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 is concluded that since quinoa flour has higher levels of many nutrients, so it can find the application in various processed foods.

Lysine and methionine content

Lysine content of control muffins was 1.25g/100 g and in 40 per cent quinoa supplemented muffins it was 2.78 g/100 g (Table 4). Significant increase was observed in lysine content of supplemented muffins compared to control. Similarly, it was found that methionine content of quinoa supplemented muffins was 1.78 g/100 g, respectively, which was significantly higher (p≤0.05) than control. Bhathal and Kaur (2018) also observed an increase in the amount of amino acids by the addition of quinoa to the cookies, particularly essential amino acids.

Mineral availability

Control muffins possessed 27.40 and 62.95 per cent available iron and calcium, respectively and in 40 per cent quinoa supplemented muffins the values were i.e 24.73 and 59.83 per cent, respectively (Table 5). However total amount of available minerals in quinoa muffins was higher. The lower digestibility of maize-quinoa muffins was explained to supplementation of quinoa in maize flour which might have led to increase in polyphenols and interference with digestibility (Schlemmer *et al.* 2009).

Storage stability

During storage (upto 3 days) the mean overall acceptability scores of maize flour muffins ranged from 8.5 (liked extremely) to 5.80 (liked slightly) (Table 6). Whereas quinoa incorporated muffins scores were 8.1 to 5.60 during storage. The mean overall acceptability scores of supplemented fresh muffins ranged from "liked very much" to "liked slightly". Fat acidity content of maize (control) and quinoa flour muffins significantly increased during storage (Table 6). Maize flour muffins' fat acidity values varied between 43.36 to 48.70 mg KOH/100 g during storage. While the values for 40 per cent control muffins were 41.19 mg KOH/100 g on 0 day which amplified to 46.92 mg KOH/100 g on 3rd day of storage (room temperature). The higher fat acidity of control muffins during storage might be due to their higher fat content than quinoa supplemented muffins. Enhancement in the fat acidity in baked products with storage was possibly due to moisture gain and the commencement of fat break down with time passage and creation of free fatty acids. This also explains the descend in the acceptability scores of stored products (Saharan and Jood 2020; Godase *et al.* 2020). A high acidity of extracted fat indicates rancidity and as per the Food Safety and Standards Regulations, a fat acidity more than 1.5 per cent is not desirable. In present study the fat acidity in all types of muffins stored ranged from 41.19-48.70 KOH/100 g and the values were within the acceptable limit.

CONCLUSION

Quinoa muffins had a higher proximate composition, lysine and methionine, mineral content and dietary fibre compared to the maize muffins. They can serve to the nutritional needs of celiac patients. Quinoa based processed food intervention can be taken up as a strategy to assuage the problem of malnutrition and hidden hunger in vulnerable population. Utilization of quinoa flour for formulation of different types of healthy food can be undertaken by food industries to develop products rich in lysine and methionine, calcium, dietary fibre and protein which is the need of the hour.

Conflicts of interest

No conflicts of interest.

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