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Evaluating Proximate, Antinutrient, and Antioxidant Activity of Raw and Processed Quinoa (Chenopodium Quinoa Willd.) Flour and Developing Food Products by Incorporating Them

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ABSTRACT

Background: This study evaluates the proximate, antinutrient, and antioxidant activities of raw and processed quinoa flour (RQF and PQF). Product development and sensory evaluation were also addressed to provide prospects for human consumption. **Methods:** Quinoa was processed by two methods - soaking and roasting. Some nutrients like moisture, ash, protein, carbohydrate, crude fibre, fat, iron, calcium, vitamin C, phytic acid, saponins, total phenol, and 2,2-diphenylpicrylhydrazyl (DPPH) were analyzed. The recipes were made and conduct acceptability evaluation by a 9-point hedonic scale. The mean, standard deviation, and One-Way Analysis of Variance were utilized as the statistical approach for the analysis of data. **Results:** The study revealed that some nutrient composition of RQF was found to be impressive with moisture (11%), ash (2.1%), protein (16.6%), crude fibre (2%), iron (11.6%), and calcium (76.1%) as compared to PQF; however, carbohydrate (69.9%), fat (9.6%), and vitamin C (9.1%) was increased in PQF, and phytic acid and saponins were decreased in all the PQF. DPPH free antioxidant potential was observed that RQF lowered free radical scavenging activity. In all PQF, the total phenol content was both raised and reduced. Also, proximate and antioxidant activity showed significant differences ($P<0.05$), and antinutrient analysis showed no significant differences ($P>0.05$). The two recipes were prepared as upma (soaked for 48 h), and chakli (roasted at 145 °C). Sample B of upma (50% semolina with 50% soaked quinoa flour) and sample A of chakli (75% refined flour with 25% roasted quinoa flour) were more acceptable. **Conclusion:** This study concluded that the use of domestic processing of quinoa seeds decreases some nutrient value compared with RQF and also infers the dietary importance of quinoa.

Keywords: *Antioxidant; Gluten-free grains; Celiac disease; Nutrition; Quinoa*

Introduction

It is essential to vary the food consumed since a balanced diet should give the required nutrients to the body in sufficient proportions. As a result, possibilities to research this food in several areas are opening up due to the growing demand for nutrient-dense and health-promoting food (Schmidt *et al.*, 2021). Pseudocereals, known for gluten-free grains, are a popular trend in modern human

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diets. They are so nutritious that they have been called “the grains of the twenty-first century”, and have a tremendous amount of promise for addressing the problem of unmet hunger (Pirzadah and Malik, 2020). Furthermore, recent studies have highlighted the potential health advantages of pseudocereals, portraying numerous crops, and when making functional and gluten-free food items, cereal flour can be used instead of the flour found in pseudocereals (Martinez-Villaluenga *et al.*, 2020, Thakur *et al.*, 2021a).

Dicotyledonous plants known as pseudocereals have seeds that resemble actual cereals in their basic nature and starch content. Quinoa (*Chenopodium Quinoa* Willd.), buckwheat (*Fagopyrum esculentum* Moench and *Fagopyrum tataricum* (L.) Gaertn), and amaranth (*Amaranthus* L. spp.) are the most well-known pseudocereals (Graziano *et al.*, 2022). Quinoa protein has a low prolamin content (0.5-7.0%), which means it is devoid of gluten and consequently not allergic (Hans, 2018).

Quinoa is a member of the goosefoot family, *Chenopodiaceae*, along with spinach (*Spinacia oleracea*), lamb’s quarters (*Chenopodium album*), and Swiss chard (*Beta sp*.) Its scientific name is *Chenopodium quinoa* Willd. They may reach heights of 1-3 m and are classified as pseudocereals since they are more like fruits than actual grains. The seeds are 1.5-4.0 mm in diameter, spherical, and flat. They range in colour from white to grey to black with undertones of yellow, red, rose, violet, and purple as shown in **Figure 1**. In soils that are salty, acidic, or alkaline, and in temperatures as low as -5 °C or as high as 35 °C, quinoa has proven to be highly tolerant (Arneja *et al.*, 2015, Contreras-Jimenez *et al.*, 2019, Gordillo-Bastidas and Díaz-Rizzolo, 2016).

A **b** **c**

Figure 1. (a) Quinoa plant; (b) Quinoa seeds; (c) Quinoa flour.

Quinoa is well known for having a protein quality similar to casein, the protein found in milk, having a protein content (16%) higher than that of wheat and maize, a fibre content (2-3% crude fibre; 14-16% total dietary fibre) higher than that of wheat and corn, and an ash content (3-4%) higher than that of wheat and rice. It is a unique complete meal since it includes all nine essential amino acids (Kaur *et al.*, 2016). Polyphenols, flavonoids, phytosterols, and phytoestrogens found in quinoa can help prevent osteoporosis. Moreover, free-radical scavengers such as kaempferol and quercetin are the two primary flavonoids found in quinoa (Bhathal *et al.*, 2017). Quinoa’s mineral concentration is also quite significant. High levels of calcium, iron, magnesium, copper, and zinc are present in the seeds. Quinoa has been shown to benefit consumers in high-risk groups, including kids, the elderly, those who are lactose intolerant, and those who have obesity, diabetes, anemia, dyslipidemia, and celiac disease, in addition to its high nutritional content and gluten-free status. These advantages have been connected to the presence of a wide range of phytochemicals and other nutrients, which provide quinoa a great edge over other grains in aspects of human nutrition and

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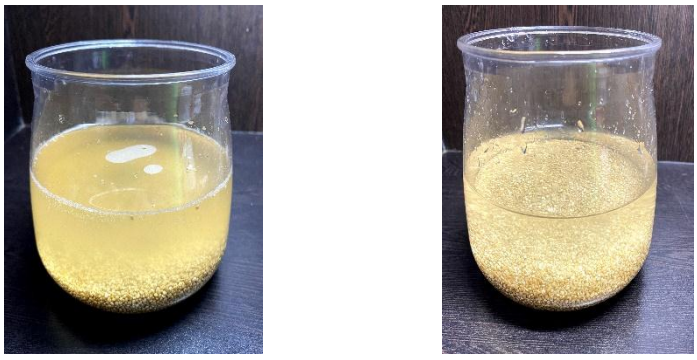
health (Thakur *et al.*, 2021b, Vilcacundo and Hernández-Ledesma, 2017, Zhu, 2020).

Quinoa seeds are used to make baked goods such as cookies, biscuits, bread, crisps, tortillas, pasta, and pancakes, as well as soups, puffed breakfast cereals, and flour. The sprouted seeds are included in salads. Additionally, quinoa seeds can be fermented to produce beers and/or beersemble beverages as well as *chicha*, a classic alcoholic drink from Latin America (Milica and Uma, 2021). Quinoa leaves are eaten in a similar way to spinach. Additionally, the entire plant has been utilized as a nutrient-dense source of food for animals, such as pigs, cattle, and chickens (Hernández-Ledesma, 2019, Navruz-Varli and Sanlier, 2016). The potential of quinoa flour to improve the nutrition and functioning of food items has been indicated by several studies. Quinoa flour's popularity in gluten-free diets is also boosted by the fact that it is a grain that contains no gluten. The product quality is enhanced when quinoa is combined with grains (Gurpreet Kaur *et al.*, 2022). Quinoa flour has been shown to possess a number of useful qualities, including water-holding ability, solubility, foaming, gelation, and emulsifying ability (Collar, 2016).

Quinoa must be first separated from its bitter saponin antinutrients, which are harmful to humans and interfere with protein digestion. A solid-liquid extraction procedure known as "quinoa washing" involves manually swirling quinoa in a strainer while it is being washed to remove saponins. If froth develops while washing, saponins are likely to appear. The washing is deemed finished when the froth vanishes as shown in **Figure 2**. The first step in making a ready-to-eat quinoa snack is to soak the quinoa to increase its volume. The next step is a quick dry-roast step where the quinoa is roasted at high air temperatures while also being stabilized. The quinoa volume must rise during soaking to outpace its shrinking during drying and roasting to produce a final expansion. This process results in lighter, more porous quinoa that is more palatable to consumers (El Hazzam *et al.*, 2020, Irigoyen and Giner, 2017, Kuktaite *et al.*, 2022)



A **B**

Figure 2. Washing of quinoa (A) containing saponin; (B) removal of saponin

The objective of this study was (i) to develop processed flour of *Chenopodium quinoa* using different processing methods like soaking and roasting; (ii) to assess the proximate analysis, antinutrient analysis, and antioxidant activity of raw and processed flour; and (iii) to utilize processed flour as an ingredient in food product development and conduct the acceptability evaluation.

Materials and Methods

Collection of quinoa

Quinoa of the good brand was purchased from Amazon for proximate, antinutrient, antioxidant analysis of raw and processed flour, and sensory evaluation of the developed food product.

Processing of quinoa

The processing of quinoa by two methods:

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soaking and roasting. The quinoa was split into five equal portions; one portion (100 g) was left uncooked and acted as a control sample, while the other four portions (100 g each) underwent soaking and roasting.

Soaking: Quinoa seeds in a determined quantity (100 g) were steeped in 1000 ml of distilled water in a glass container. The quinoa was soaked for 24 h and 48 h at room temperature. After 24 and 48 h, samples were taken out of the glass container, and the quinoa was washed twice with water after being soaked. The soaked quinoa seeds were then dried, processed in the laboratory using a mixer grinder (Bajaj model, India origin, and used at low speed) and were then sieved. After that, the flour was utilized for additional testing.

Roasting: Whole quinoa seeds were put in a petri dish and baked for 30 minutes in a hot air convection oven at a temperature of 145 °C and 190 °C. The seeds were roasted and then allowed to cool in a desiccator at room temperature. The roasted seeds were then processed in the laboratory using a mixer grinder (Bajaj model, India origin, and used at low speed) and were then sieved; the resulting flour was employed for further investigation.

Nutrient analysis

Proximate analysis: The proximate analysis of raw and processed quinoa flour (RQF and PQF) was done by moisture, ash, crude fibre by acid and alkali treatment method, fat by soxhlet method, and protein by micro-kjeldahl method. The mineral composition included iron by wong's method, and calcium and vitamin C by titrimetric method. The amount of total carbohydrate was calculated by deducting the sum of the contents of the moisture, ash, protein, fat, and crude fibre from 100 (Raghuramulu *et al.*, 2003, Sharma, 2007).

Antinutrient analysis: The antinutrient analysis of RQF and PQF was carried out by phytic acid and saponins. Phytic acid method as ferric ions complexed with phytate at pH 1-2 cannot react with thiocyanate ions; this method is based on the determination of a pink-coloured complex precipitate. Phytate phosphorus content is calculated from this value under the assumption that the precipitate contains a constant 4Fe:6P molecular ratio. A graph of the standard was plotted and results were expressed as mg phytic acid/100 g dry weight (Davies NT and Reid, 1979).

Saponins, which were named so because they can create stable, soap-like foams in aqueous solutions, were a complicated and chemically varied class of substances; they were partially dissolved in water during soaking, and blanching, were and lost in the soaking, washing, and blanching liquors (Obadoni and Ochuko, 2002, Shi *et al.*, 2004).

Antioxidant analysis: The antioxidant analysis of RQF and PQF was performed by total phenols and DPPH free radical scavenging activity. Before both analyses, methanol extract was prepared. Moreover, total phenols were determined using the Folin-Coicalteu reagent (Slinkard and Singleton, 1977) and DPPH free radical scavenging activity was measured by an established method (Alessandra *et al.*, 2002).

Food product development and its acceptability evaluation

The recipes were made using homemade ingredients with different proportions of quinoa flour. The recipes were selected based on easy availability and low cost of ingredients.

Sensory evaluation: Sensory evaluation consists of judging the quality of food by a panel of judges. The evaluation deals with measuring, analyzing, and interpreting the qualities of food as they are perceived by the senses of smell, taste, touch, and hearing. Acceptance of the food depends upon the 9-point hedonic scale performa. It was done formally by the laboratory and semi-trained panel members with the help of a triangle test (Yadav *et al.*, 2018).

Criteria for doing sensory evaluation: Sensory examination took place between 10 AM and 12 PM in a quiet laboratory environment. Each panel member was given a meal sample individually, and after each sample was tested, water was provided. To ensure that each panellist made an impartial decision, the panellists were not permitted to communicate with one another. Judges who were contagious or unwell were prohibited from

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evaluating.

Selection of semi-trained panel members using the triangle test: 30 researchers from the Department of Food Science and Nutrition took the triangle test. They had a semi-trained panel and were in good health. Additionally, they had some fundamental knowledge of sensory evaluation. In this test, three samples of Paratha were presented to panel members in which two samples were identical, and one was different with little use of flavour in the dough. These three samples were coded as A, B, C and were presented to the panel. The screening numbers were asked to pick out from each triangle set, the sample that is different from others (Kemp, 2008, Mian Kamran *et al.*, 2017).

The triangle difference test was applied to all of the researchers who received a thoughtfully crafted triangle test questionnaire. Following the assessment, the performance was gathered and analyzed based on the researchers' capacity for discriminating. 25 researchers were chosen to serve on a semi-trained panel that would analyze food products using quinoa flour on a 9-point hedonic scale performance. The panellists judged the acceptability and measured the pleasurable and unpleasable experiences of food products ranging from extremely like to extremely dislike. The participants were asked to rate the new products on a scale of 1-9 based on their hedonic evaluation of appearance, taste, texture, colour, flavour, and overall acceptability. Performa was gathered, and the outcomes were recorded (Lim, 2011).

Data analysis: The mean, standard deviation, and One-Way ANOVA test were utilized as the statistical approach for the analysis of the data for the current study. The means of the three sample analyses' values were determined, and at a 5% probability level, a significant difference was found (Steel and Torrie, 1980).

Results

Nutrient analysis

Proximate analysis: The proximate analysis of RQF and PQF is shown in **Table 1**. In both the samples RQF and PQF showed a significant difference (P<0.05) in moisture, ash, protein, carbohydrate, crude fibre, fat, iron, calcium, and vitamin C. The moisture, ash, protein, crude fibre, iron, calcium, and vitamin C was higher in RQF compared to PQF, and the carbohydrate content increased in both PQF, respectively. The fat content was higher in RQF except for roasted flour at 145 °C.

In soaked quinoa flour, some proximate content like moisture, ash, protein, fat, and iron were increased when soaked for 48 h in comparison with the time they were soaked for 24 h that included moisture, ash, protein, fat, and iron respectively. The other proximate content like carbohydrate, crude fibre, calcium, and vitamin C were decreased when soaked for 48 h compared to the time, they were soaked for 24 h that included carbohydrate, crude fibre, calcium, and vitamin C, respectively.

Table 1. Proximate analysis of raw and processed flour of *Chenopodium quinoa*

Proximate (100 g)	Raw	Soaked (24 h)	Soaked (48 h)	Roasted (145 °C)	Roasted (190 °C)	P-value[b]
Moisture (g)	11.0±0.40[a]	8.8±0.19	9.7±0.19	8.2±0.22	5.4±0.35	<0.001
Ash (g)	2.1±0.20	0.9±0.12	1.0±0.23	1.9±0.12	1.6±0.19	<0.001
Protein (g)	16.6±0.26	15.8±0.40	16.1±0.15	13.7±0.25	14.8±0.25	<0.001
Carbohydrate (g)	59.3±0.10	65.8±0.20	62.8±0.40	65.6±0.15	69.9±0.15	<0.001
Crude fibre (g)	2.0±0.24	1.7±0.19	1.6±0.24	1.0±0.01	0.7±0.19	<0.001
Fat (g)	9.0±0.19	7.0±0.16	8.8±0.16	9.6±0.23	7.6±0.16	<0.001
Iron (mg)	11.6±0.40	7.0±0.01	9.0±0.40	10.03±0.04	8.5±0.29	<0.001
Calcium (mg)	76.1±0.40	71.1±1.2	70.1±0.50	56.0±0.81	51.1±0.81	<0.001
Vitamin C (mg)	5.2±0.38	9.1±0.16	7.8±0.03	2.6±0.23	4.3±0.19	<0.001

[a]: Mean±SD; [b]: One-Way ANOVA test.

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In roasted quinoa flour, some proximate content like moisture, ash, crude fibre, fat, iron, and calcium were increased when roasted at 145 °C as compared to the time roasted at 190 °C which included moisture, ash, crude fibre, fat, iron, and calcium respectively. Some proximate content like protein, carbohydrate, and vitamin C were decreased when roasted at 145 °C as compared to the time roasted at 190 °C which included protein, carbohydrate, and vitamin C, respectively.

Antinutrient analysis: The antinutrient analysis of RQF and PQF is shown in **Table 2**. After different processing, the phytic acid and saponin content was decreased.

Table 2. Antinutrient analysis of raw and processed flour of *Chenopodium quinoa*

Antinutrient	Raw	Soaked (24 h)	Soaked (48 h)	Roasted (145 °C)	Roasted (190 °C)	P-value[b]
Phytic acid (g/100 g)	0.0004±0.0002[a]	0.0003±0.0002	0.0002±0.0001	0.0003±0.0001	0.0003±0.0002	0.72
Saponins (g/100 g)	1.90±0.10	1.50±0.50	1.20±0.25	1.70±0.20	1.80±0.10	0.06

[a]: Mean±SD; [b]: One-Way ANOVA test.

In both the samples RQF and PQF there were no significant differences (P>0.05) regarding phytic acid, and saponins. The phytic acid range in PQF was almost the same 0.0003 g/100 g in soaked for 24 h and in both roasted forms at 145 °C and 190 °C. The only range that varied in soaked quinoa flour for 48 h was a maximum reduction. All the samples' ranges were decreased compared to RQF. The saponin content was decreased in both soaked quinoa flours as compared to both roasted quinoa flours. All the samples' ranges were decreased compared to RQF, but soaked quinoa flour was better than roasted quinoa flour.

Antioxidant activity: The significant antioxidant activities were found in all the five samples of RQF and PQF at a higher concentration of 200 µg/ml. RQF showed the lowest IC_{50} value compared to other PQF, which indicated that raw quinoa extracts had a strong proton donating ability, which could serve as a free radical scavenger and could neutralize the reactive oxygen species originate due to prolonged oxidative stress in living organisms.

The antioxidant analysis of RQF and PQF is shown in **Table 3**. The total phenol content of RQF and PQF extracts was expressed as gallic acid equivalent (GAE). The total phenol content in RQF and PQF varied with different solvents. Both the RQF and PQF showed significant differences (P<0.05) regarding total phenols, and DPPH.

The total phenol content was increased when soaked for 48 h as compared to the time soaked for 24 h quinoa flour. In the period roasted at 145 °C, the total phenol content was increased compared to the time roasted at 190 °C quinoa flour. Therefore, data revealed that roasted quinoa flour at 145 °C contained a higher number of total phenols. DPPH IC_{50} value was increased in both conditions (soaked and roasted) as compared to the RQF. In this regard, it was observed that RQF had lowered free radical scavenging activity other than PQF.

Table 3. Antioxidant activity of raw and processed flour of *Chenopodium quinoa*

Antioxidant	Raw	Soaked (24 h)	Soaked (48 h)	Roasted (145 °C)	Roasted (190 °C)	P-value[b]
Total phenols (mg GAE/100 g)	87.3±1.1[a]	73.6±0.5	82.6±0.4	91.3±0.5	78.0±0.6	<0.001
DPPH IC_{50} value (µg/ml)	28.0±0.0	54.0±0.0	50.0±0.0	35.0±0.0	38.0±0.0	<0.001

GAE: Gallic acid equivalent; **DPPH:** 2,2-diphenylpicrylhydrazyl, and IC_{50} is half of maximal inhibitory concentration. This means IC_{50} value was the concentration of the sample which can scavenge 50% of DPPH free radical in DPPH free radical scavenging method; [a]: Mean±SD; [b]: one-way ANOVA test.

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Product development: In this study, products namely upma and chakli were prepared with a variation.

Upma: There was a standard (S) and its four variants were made by incorporating the soaked quinoa flour (48 h) in different variations. The four variations of the recipes were standard, 100% semolina, A: 75% semolina with 25% soaked quinoa flour, B: 50% semolina with 50% soaked quinoa flour, C: 25% semolina with 75% soaked quinoa flour, and D: 100% soaked quinoa flour.

Chakli: There was a standard (S) and its four variants were made by incorporating the roasted quinoa flour (145 °C) in different variations. The four variations of the recipes were standard: 100% refined flour, A: 75% refined flour with 25% roasted quinoa flour, B: 50% refined gram flour with 50% roasted quinoa flour, C: 25% refined gram flour with 75% roasted quinoa flour, and D: 100% roasted quinoa flour.

Sensory evaluation: In this study, the sensory evaluation of both recipes was carried out using a triangle test for the selection of the panel, and for judging formulated recipes, a 9-point hedonic scale with various attributes was used. The mean and standard deviation for different attributes of both products is shown in **Table 4**.

Table 4. Acceptability score of upma and chakli in terms of sensory attributes

Sensory attributes	S	A	B	C	D
Upma					
Appearance	8.8±0.36[a]	8.3±0.47	8.0±0.44	7.4±0.51	3.9±0.22
Taste	8.8±0.41	7.8±0.41	7.7±0.88	5.1±0.45	4.6±1.01
Texture	8.6±0.50	8.0±0.56	7.8±0.48	6.6±0.50	5.8±0.50
Colour	8.9±0.30	8.1±0.44	7.8±0.87	6.8±0.41	4.4±0.40
Flavour	8.5±0.51	7.6±0.58	7.4±0.50	4.8±0.91	3.7±0.67
Overall acceptability	8.5±0.51	7.6±0.51	7.8±0.40	4.6±0.56	3.8±0.77
Chakli					
Appearance	8.0±0.40	7.2±0.22	6.6±0.22	5.5±0.81	3.5±0.32
Taste	7.4±0.32	7.4±0.32	7.1±0.54	5.2±0.44	4.6±0.78
Texture	7.7±0.22	7.7±0.22	7.1±0.48	6.2±0.34	5.2±0.31
Colour	8.0±0.36	7.4±0.36	7.8±0.40	5.5±0.41	4.4±0.35
Flavour	7.8±0.30	7.6±0.30	6.8±0.32	5.2±0.67	3.4±0.56
Overall Acceptability	8.4±0.60	7.1±0.54	7.2±0.22	5.8±0.32	3.2±0.24

[a]:Mean±SD; **Upma:** Standard (S): 100% semolina, **A**: 75% semolina+25% soaked quinoa flour, **B**: 50% semolina+50% soaked quinoa flour, **C**: 25% semolina+75% soaked quinoa flour, and **D**: 100% soaked quinoa flour.
Chakli: Standard (S): 100% refined flour, **A**: 75% refined flour+25% roasted quinoa flour, **B**: 50% refined gram flour+50% roasted quinoa flour, **C**: 25% refined gram flour+75% roasted quinoa flour, and **D**: 100% roasted quinoa flour.

According to **Table 4** regarding both of the recipes, the score of standard 8.5±0.51 in upma, and in chakli 8.4±0.60 was more acceptable in overall acceptability than all other variations made with different variations. But, with different variations, the result showed that in upma sample B i.e., 50% semolina with 50% soaked quinoa flour was more acceptable (7.8±0.40); and in chakli, sample A i.e., 75% refined flour with 25% roasted quinoa flour was more acceptable (7.1±0.54) in comparison to other variants by descriptive panels.

Discussion

The current study focused on two processing methods of quinoa which were soaking and roasting. Both processing methods affect the nutritional analysis of RQF. Different cultivation environments, extraction solvents, and quinoa types with coloured testa may be the cause of the considerable variance in nutritional content observed by several other authors.

Proximate analysis: Regarding RQF, Thakur reported a moisture content of 10.84%, 2.15% ash, 14.94% protein, and 6.39% fat (Thakur *et al.*,

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2021a). Nowak reported a carbohydrate content of 59.9%, crude fibre of 3.3%, 9.47 mg/100 g iron, and 87 mg/100 g calcium (Nowak *et al.*, 2016). Kaur reported a vitamin C content of 13 mg/100 g (Kaur *et al.*, 2016), Ogungbenle reported a moisture content of 11.20 g/100 g, 1.20g/100 g ash, 13.50 g/100 g protein, 9.50 g/100g crude fibre, 58.3 g/100 g carbohydrate, 2.6 mg/100 g iron, and 86.0 mg/100 g calcium (Ogungbenle, 2003).

In soaked quinoa flour (24 h), Thakur reported a moisture content of 10.54%, 2.04% ash, 15.74% protein, 59.09% carbohydrate, 6.59% crude fibre, 6.28% fat, and vitamin C content of 15.09 mg/100 g (Thakur *et al.*, 2021a).

Regarding roasted quinoa flour (at 67 °C), Bhathal reported a moisture content of 0.77%, ash content of 2.44%, protein content of 8.61%, carbohydrate content of 80.18%, crude fibre content of 2.23%, and fat content of 3.46% respectively (Bhathal *et al.*, 2017).

In the current study, the moisture, fibre, iron, and calcium contents were higher in RQF. The protein content was similar in both raw and soaked quinoa flour with a small difference. Vitamin C content was higher in soaked quinoa flour compared to other processing methods. The difference may be due to environmental and storage conditions, as factors like light intensity, frequency or irrigation, and temperature of the region strongly affect the vitamin C content in crops. Therefore, both processing methods led to a decrease in the nutritional value of quinoa flour compared to RQF. Similar results were supported in other studies like the ones by others (Bhathal *et al.*, 2017, Marmouzi *et al.*, 2015, Thakur *et al.*, 2021a), which found that the processing method decreased the nutritional value of quinoa compared to RQF.

Antinutrient analysis and antioxidant activity: In other studies, the result of antinutrient and antioxidant analysis of raw quinoa flour reported a phytic acid content of 971 mg/100 g (Demir and Bilgicli, 2021), total phenols content of 43.2 mg GAE/100 g, and DPPH IC_{50} content of 37.3 Trolox equivalent antioxidant capacity (TEAC) respectively (Kaur *et al.*, 2016). In other studies, the result of antinutrient and antioxidant analysis of soaked quinoa flour (24 h) reported a phytic acid of 0.97% (Thakur *et al.*, 2021a), total phenols of 31.1 mg/100 g, and DPPH IC_{50} value of 34.99 TEAC respectively (Kaur *et al.*, 2016). In the current study, the findings of antinutrient and antioxidant activity of RQF and PQF were not similar to other studies. This may be due to the use of other extraction processes and measures in other units. In addition, few studies were done regarding PQF of antinutrient and antioxidant activity (Arendt and Zannini, 2013).

This study had some strengths like the availability of the equipment and other sources and panel members for sensory evaluation in addition both the processing methods help to detach antinutrient compounds which are indigestible contents. Both quinoa-based food products were acceptable, and the results were easily interpreted. However, the study had some limitations. It was expensive because of quinoa and was time-consuming because of lab experiments. Only two processing methods were used, and closed rooms were required for sensory evaluation. Furthermore, gluten-free ingredients with quinoa were not used for food product development (that is good for celiac people).

Conclusion

Quinoa must be treated before consumption since the grains were coated in saponin (indigestible). As a result, quinoa grains were rinsed in flowing water beneath the faucet until the grains stopped foaming. According to the current analysis, soaking and roasting and conventional domestic food processing techniques save time and energy. The quinoa flour's pre-treatments, such as soaking and roasting, had a substantial influence on nutritional analyses d with the raw sample. According to the sensory evaluation of the upma and chakli, quinoa flour additions with less grain and more of the other ingredients were preferred.

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Author's contributions

Chauhan ES. designed research; Panwar B. conducted it; Chaudhary M. analyzed data and wrote the draft of the manuscript, and Singh R. evaluated the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

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