



Influence of Partial Replacement of Wheat Flour with Quinoa Flour on Physicochemical and Structural Properties of Bread

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ABSTRACT

Background: This study examined the effects of partially substituting wheat flour with quinoa flour at levels of 0%, 5%, 10%, 15% and 20% on proximate composition, colour, texture, sensory quality and microstructure of bread. Quinoa flour, known for its high nutritional value, is incorporated into cereal-based products to enhance health benefits. However, its influence on physical, structural and sensory attributes of bread must be assessed to determine the most suitable substitution level.

Methods: Bread samples were prepared by replacing wheat flour with quinoa flour at substitution levels of 0%, 5%, 10%, 15% and 20%. Analyses were conducted to evaluate proximate composition, colour, texture, overall acceptability and structural changes. Microstructural analysis was performed using scanning electron microscopy (SEM), while molecular changes were studied through FTIR spectroscopy and X-ray diffraction.

Result: Proximate analysis showed significant ($p < 0.05$) increase in moisture (36.28% to 53.48%), ash, fat, protein (12.34% to 16.46%) and crude fibre with higher quinoa flour, while carbohydrate content decreased. Colour analysis confirmed darker loaves, with L^* reducing from 74.99 to 68.66. Texture testing revealed increased hardness and cohesiveness but lower springiness ($p < 0.05$). SEM indicated heterogeneous structures with larger, irregular pores in quinoa-enriched bread. FTIR and X-ray diffraction confirmed modifications in the gluten network and starch-protein interactions due to gluten dilution. Sensory evaluation showed overall acceptability peaked at 10% substitution, whereas higher levels produced darker, bitter loaves with reduced volume. Hence, 10% substitution offered improved nutrition with good consumer acceptance.

Key words: Bread, Colour, Microstructure, Quinoa, Texture, X-ray diffraction.

INTRODUCTION

Bread is one of the most popular staple food worldwide known for its deliciousness and nutritional value. Usually, gluten is the basic ingredient responsible for providing elasticity and texture (Gómez *et al.*, 2013). Quinoa (*Chenopodium quinoa*), a kind of pseudocereal, popularly recognized for its exceptional nutritional worth, complete protein, adequate fiber and also important micronutrients (Anuhya and Dobhal, 2024). Consumer desire for healthier and more nutrient rich diets has led to an increased use of alternative flours in bread-making (El-Sohaimey *et al.*, 2019). Researchers are trying to incorporate quinoa flour instead of wheat flour to improve the nutritional value of bread without losing appetizing flavor and texture. Quinoa grains contain more protein content in between 12-18%, which is higher than that of ordinary wheat and corn. Quinoa provides all the amino acids needed (unlike wheat, which is low in lysine) and is considered a complete protein (Rana *et al.*, 2019). This makes it a great source of plant-based protein for human nutrition. Quinoa is rich in dietary fiber and phosphorus as well, both of which are beneficial for digestion and blood sugar regulation respectively. It is also rich in iron, magnesium and vitamins-B-complex vitamins and vitamin E (El Sohaimey *et al.*, 2018).

In addition, quinoa's anti-inflammatory and antioxidant properties are linked to its rich content of bioactive compounds, like polyphenols, flavonoids and saponins

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(Tang and Tsao, 2017). These properties make quinoa flour a high-quality ingredient (Turkut *et al.*, 2016). Sensory experts enjoy the taste, texture and dye of the bread when quinoa flour is used (Demin *et al.*, 2013). Results from (El-Sohaimey *et al.*, 2019) demonstrated that the nutritional profile and the overall consumer palatability of bread was improved when quinoa flour was blended with wheat flour. Bread's protein and fiber content improves by replacing wheat flour with quinoa flour as discovered by several studies (Gostin, 2019). Surplus substitution can negatively impact the firmness, volume and consumer acceptability of the bread and should thus be used with caution (García-Segovia *et al.*, 2020). The color of the bread changes due to naturally occurring

pigments in quinoa and reactions (Maillard Reaction) that happen while baking (Matsuo *et al.*, 2020).

In comparison to regular wheat bread, quinoa supplemented bread typically produces a darker crust and crumb. Its substantial protein and mineral content promotes non-enzymatic browning reactions, is responsible for this impact (Alencar *et al.*, 2015). Due to its absence of gluten, quinoa may inhibit network formation which may interfere with the development of the texture, structure and elasticity of the crumb (Xu *et al.*, 2019). It has been shown that the incorporation of excess quinoa flour into bread recipes results in a dense texture, reduced loaf volume and increased stiffness due to diluting gluten, thus, lacking viscoelastic properties (Turkut *et al.*, 2016). In the absence of gluten, the structure of the dough results in a rigid crumb that is dense with less air (Sharanagat *et al.*, 2022). However, employing enhanced dough through the use of dough conditioners, adjusting hydration levels and refining baking techniques can significantly improve the microstructure and overall quality of bread. While replacing some of the wheat flour with quinoa flour provides many nutritional benefits, determining the best ratio between the two must also be made in order to preserve the texture of the bread and its consumer acceptability. Therefore, the objective this study was to investigate the influence of substitution of wheat flour with quinoa flour on the proximate composition, color, textural, sensory and microstructural properties of the bread.

MATERIALS AND METHODS

Refined wheat flour was bought from the Vardhan Foods (Chandigarh, India). Quinoa flour (EC-507741) was procured from ICAR-National Bureau of Plant Genetic Resources-Regional Station, Shimla, Himachal Pradesh, India. Food grade salts, chemicals and reagents were used. Breads were prepared by AAC Method 10-10A standard method with slight modifications. Base formulation (control sample) of bread making comprising 100 g refined wheat flour, 5.3 g yeast, 6 g sugar, 60 ml water, 3 g oil, 1 g gluten,

1.6 g NaCl, 0.5 g bread improver and 0.6 g calcium propionate. The refined wheat flour was partially replaced with quinoa flour at 0, 5, 10, 15 and 20 % levels and the prepared breads using these formulations were named as C, S1, S2, S3 and S4, respectively for further analysis (Fig 1).

Moisture, ash, fat, protein, crude fiber and carbohydrate content were determined using standard AOAC methods ((AOAC), 2016). Color of crumb was determined using chromameter (CR400, Konica Minolta, Osaka, Japan) equipped with D65 illuminant. Average of six measurements of L* = lightness, a* = red/green and b* = yellow/blue were recorded (MALIK *et al.*, 2024). Texture profile analysis (TPA) of bread crumb was performed using texture analyser (Stable Micro Systems TA-XT 2i, Godalming, U.K.) equipped with a 5 kg load cell (MALIK *et al.*, 2024). A cylindrical probe of 25 mm in diameter was attached to the crosshead. The instrument test parameters included: pre-test speed: 1.0 mm/s; test speed: 0.5 mm/s; post-test speed: 0.5 mm/s; distance: 10 mm; contact force: 5 g; return distance: 60 mm and compression: 40%. Crumb cubes (4×4 cm) were prepared to analyze for their hardness, springiness, cohesiveness, resilience, gumminess, chewiness, adhesiveness and resilience. Overall acceptability of the bread samples was assessed through a sensory panel using a 9-point hedonic scale (Dewan *et al.*, 2018). The modifications in the microstructure of breads were explored using a Scanning electron microscope (JSM-7610FPlus, JEOL Ltd., Japan) with a secondary electron detector with few changes as per protocol defined by Dewan *et al.* (2025). Freeze-dried crumb samples were allowed to stick on double-sided sticky tape to secure them on the stubs. The sample's exposed surface was sprayed with gold, employing a sputtering device for 2 min before being kept under microscope. At 5 kV potential, the topographical pattern of samples were scanned. ATR-FTIR spectroscopy was employed to study the secondary structure of lyophilized bread samples. The measurements were recorded at wave numbers ranging from 400 to 4000 cm⁻¹

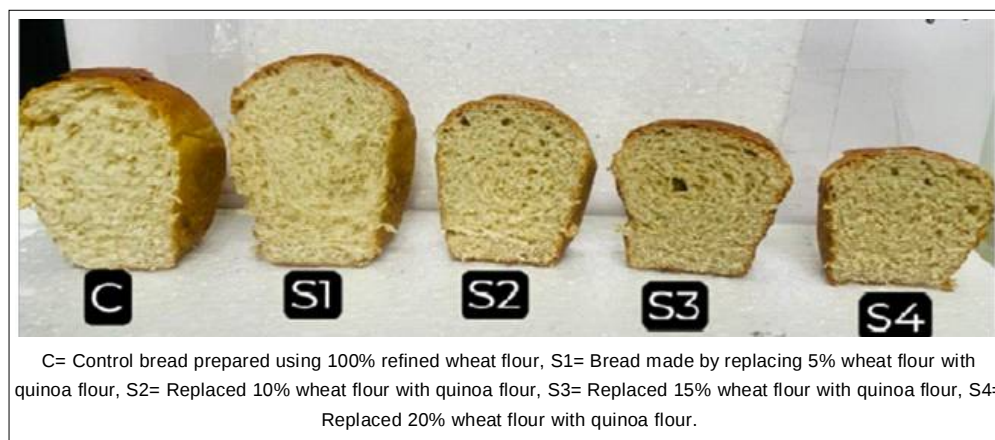


Fig 1: Bread samples.

(Dewan and Khatkar, 2023). The crystalline behaviour of the lyophilized bread samples was investigated using an X-ray diffractometer (Multipurpose Versatile XRD System, Rigaku). The diffraction intensity was recorded from 5 to 40°(2θ) at 4°/min rate and 40 kV and 30 mA testing conditions (Dewan and Khatkar, 2023).

The results obtained from this study were processed using SPSS version 22 (SPSS Inc.). All experiments were conducted with multiple repetitions. Data analysis was carried out using ANOVA and Duncan's multiple range test was employed to compare the means.

RESULTS AND DISCUSSION

Proximate composition

Quinoa flour used in the current study exhibited 8.48% moisture content, 3.06% total ash content, 2.25% crude fat content, 3.59% crude protein content, 6.89% crude fibre and 75.73% carbohydrate. The proximate analysis of the bread samples's is summarized in Table 1. The Bread sample S4 had the highest moisture content, at 53.48%, while the control sample had the lowest, at 36.28%. The proximate analysis of the bread samples revealed that the moisture content of each bread item varied significantly ($p < 0.05$). Higher moisture content was conferred with samples with a higher percentage of quinoa flour. This indicates that the addition of quinoa flour enhances the moisture absorption capacity of dough, leading to an increased moisture retention capacity of the prepared bread. The extra quinoa flour leads to more moisture content in the bread, which can improve the quality of the bread and also can produce a soft firm bread (Moawad *et al.*, 2018). The bread was different because the ash

content of the Sample S4 was of 2.71% whereas it was of 1.58% of control samples' percentages. In the fat level, S4 sample contained 3.13% fat, while the control sample was observed with the lowest value of 1.09% fat. Similarly, the protein content of S4 increased from 12.34% for the control sample to 16.46% for sample S4 bread sample was prepared using 20% quinoa flour and 80% wheat flour. Finally, the crude fibre content also followed the same trend, increasing from 0.54% for the control sample to 1.31% for sample S4. Moreover, although the carbohydrates were declined as the % quinoa flour was increased, the ash, fat, protein and crude fiber contents significantly increased ($p < 0.05$). Some processing variations might have resulted in varying protein content among bread samples prepared with increasing proportion of quinoa flour. Olawuni *et al.* (2024) observed that replacing wheat flour with quinoa flour in cake provided better protein content. The main cause of these variations in proximate composition is the different nutritional profiles of quinoa and wheat flours (Wang *et al.*, 2015).

Color

Table 1 illustrates the observed color evaluation of the bread samples, as well as indicating that the addition of quinoa flour temporally ($p < 0.05$) changed color characteristics (Fig 1). Compared to the control sample, which had L^* values of 74.99, the bread that had the largest amount of quinoa flour (20%) had L^* values of 68.66. While the b^* values increased from 12.37 to 16.82, the a^* values improved from 3.86 in the control sample to 5.59 in the sample S4. As the proportion of quinoa flour increased, the lightness (L^*) of the bread samples significantly decreased ($p < 0.05$). Conversely, it was evident that the

Table 1: Results of proximate, color, textural and sensory evaluation of bread.

Parameter	Control	S1	S2	S3	S4
Moisture, %	36.28±0.29 ^a	40.56±0.31 ^b	42.06±0.11 ^c	46.60±0.33 ^d	53.48±0.37 ^e
Ash, %	1.58±0.09 ^a	2.11±0.12 ^b	2.31±0.13 ^b	2.69±0.19 ^c	2.71±0.05 ^c
Fat, %	1.09±0.02 ^a	1.54±0.02 ^b	1.98±0.04 ^c	2.70±0.03 ^d	3.13±0.02 ^e
Protein, %	12.34±0.06 ^a	14.29±0.01 ^b	15.22±0.02 ^c	15.92±0.02 ^d	16.46±0.05 ^e
Carbohydrate, %	84.45±0.12 ^e	81.40±0.08 ^d	79.64±0.19 ^c	77.66±0.17 ^b	76.42±0.09 ^a
Crude fibre, %	0.54±0.08 ^a	0.66±0.16 ^a	0.85±0.03 ^b	1.06±0.02 ^c	1.31±0.02 ^d
L^*	74.99±0.12 ^e	73.49±0.46 ^d	72.75±0.23 ^c	69.76±0.06 ^b	68.66±0.06 ^a
a^*	3.86±0.09 ^a	3.97±0.08 ^a	4.22±0.18 ^b	4.85±0.06 ^c	5.59±0.04 ^d
b^*	12.37±0.15 ^a	13.69±0.23 ^b	14.42±0.07 ^c	15.88±0.04 ^d	16.82±0.03 ^e
Hardness (N)	6.78±0.12 ^c	5.87±0.10 ^a	6.08±0.04 ^b	8.34±0.07 ^d	8.91±0.03 ^e
Springiness	0.87±0.05 ^b	0.85±0.03 ^b	0.84±0.02 ^b	0.83±0.02 ^b	0.73±0.01 ^a
Cohesiveness	0.45±0.01 ^a	0.50±0.01 ^{ab}	0.57±0.05 ^{cd}	0.59±0.02 ^d	0.53±0.04 ^{bc}
Resilience	0.19±0.02 ^a	0.25±0.03 ^a	0.33±0.05 ^b	0.32±0.02 ^b	0.24±0.04 ^a
Gumminess (Nmm)	3.83±0.06 ^c	2.97±0.07 ^a	3.54±0.07 ^b	4.99±0.04 ^e	4.78±0.03 ^d
Chewiness (Nmm)	2.86±0.05 ^b	2.58±0.10 ^a	3.13±0.03 ^c	4.18±0.04 ^e	3.92±0.04 ^d
Overall acceptability	8.02±0.05 ^c	8.15±0.07 ^d	8.10±0.02 ^{cd}	7.68±0.05 ^b	7.18±0.01 ^a

C= Control bread prepared using 100% refined wheat flour; S1= Bread made by replacing 5% wheat flour with quinoa flour; S2= Replaced 10% wheat flour with quinoa flour; S3= Replaced 15% wheat flour with quinoa flour; S4= Replaced 20% wheat flour with quinoa flour.

redness (a^*) and yellowness (b^*) values rose as the quinoa flour content increased. These color changes are consistent with earlier studies' conclusions (Wang *et al.*, 2015).

Textural characteristics

The bread samples' textural characteristics, as displayed in Table 1, demonstrate the noteworthy influence of the addition of quinoa flour. The hardness fluctuated from 5.87 N (S1) to 8.91 N (S4) which is the most important quality indicator in the bakery products and it is greatly correlated with consumers' perception of freshness (Moawad *et al.*, 2018). In terms of textural analysis of the bread samples, the hardness and cohesiveness after storage of formulations increased ($p < 0.05$) with increasing proportion of quinoa flour; however, cohesiveness slightly decreased at the highest levels of substitution. These findings are consistent with previous studies, reporting that the higher proportion of quinoa flour leads to firmer textured bread (Moawad *et al.*, 2018).

As the concentration of quinoa flour increased, springiness decreased from 0.87 to 0.73, mainly because there were fewer gluten proteins present, which are necessary for an elastic and airy bread structure. Although quinoa is high in protein and has many nutritional

advantages, its absence of wheat gluten's viscoelastic qualities makes for a denser crumb (Xu *et al.*, 2019). Initially, resilience, gumminess and chewiness increased, but they showed a slight decline at higher levels of quinoa flour incorporation. The alteration in texture arises from the weakening of gluten proteins, which are essential for maintaining the structure of bread and trapping gas (Xu *et al.*, 2019). In contrast to traditional wheat bread, some research indicates that adding modest amounts of quinoa flour (up to 20%) may actually improve particular textural qualities, like resilience (Föste *et al.*, 2014).

Overall acceptability

The overall acceptability of bread, as shown in Table 1, reveals that the addition of quinoa flour had a substantial ($p < 0.05$) impact. The control sample achieved an overall acceptability score of 8.02, which saw a slight improvement with the incorporation of 10% quinoa flour. Nevertheless, when the amount of quinoa flour surpassed 10%, the acceptability score dropped, with sample S4 scoring 7.18. Research indicates that the addition of quinoa flour affects the bread's flavor, texture and appearance (El-Sohaimy *et al.*, 2019; Xu *et al.*, 2019). Because quinoa flour is

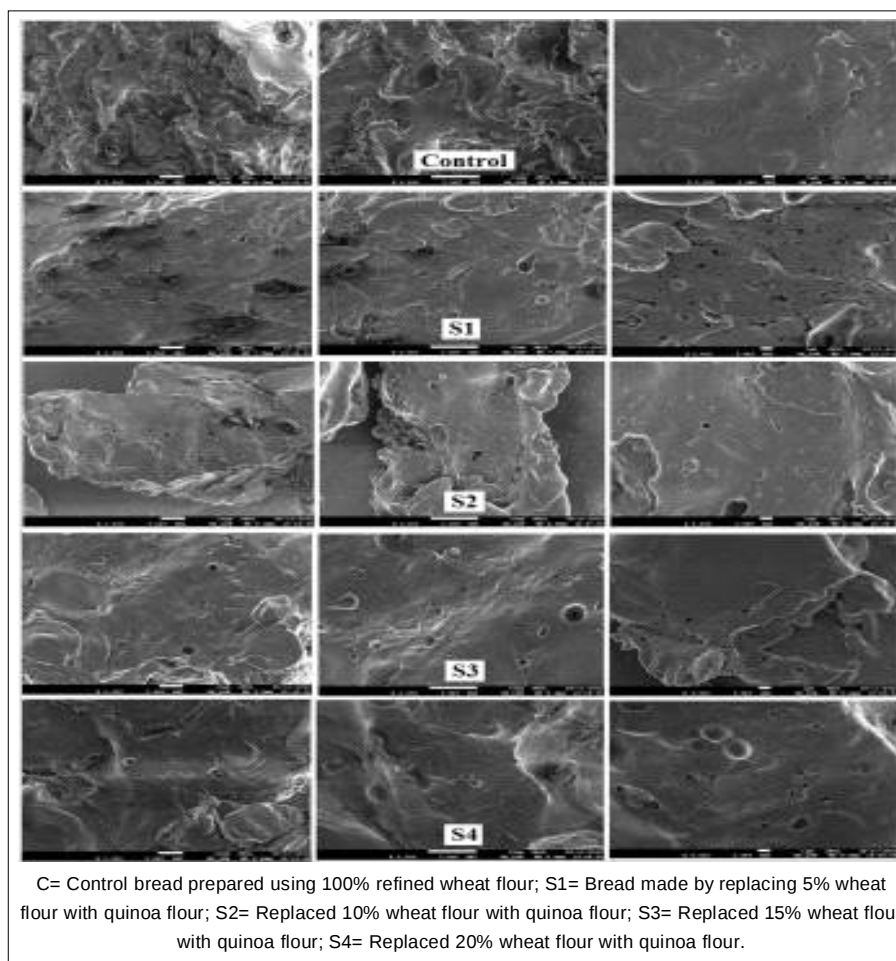


Fig 2: Microstructure of bread samples using scanning electron microscopy (SEM).

naturally gluten-free, incorporating it to wheat-based bread changes the overall structure and rheological characteristics of the dough. This impact is mainly due to the reduced levels of gluten proteins which are essential for bread structure and gas retention. Higher proportion of quinoa flour in bread formulation has yielded lower loaf size and a denser texture than wheat bread. Quinoa flour is best added in small amounts, generally accepted to be 10% to 20% of the total weight of flour, so that enhances the nutritional profile of the bread without affecting the texture and its overall acceptability. Quinoa flour has a unique nutty, mildly bitter taste, although the flavor depends on the consumer. However, as the amount of quinoa flour increases, the flavor becomes stronger and may be likely to be negatively perceived (Turkut *et al.*, 2016). Overall improved nutritional value of the bread is upgraded by quinoa flour, but the content should be optimally balanced to maintain satisfactory sensory properties for consumers.

Microstructure (SEM)

The scanning electron micrographs for each bread sample are shown in Fig 2, illuminating the microscopic architecture and how quinoa flour impacted wheat bread's formation. In the control sample, a dense gluten network is clearly visible, together with evenly shaped small sheets of starch. But as the proportion of quinoa flour grew, the structure of the gluten collapsed, leaving visible bubbles. The starch granules began to separate as quinoa concentrations spiked which further facilitated the formation of these holes. Quinoa flour modifies the gluten structure, it causes a more broken and less cohesive protein matrix (Mu *et al.*, 2023). Lessening the protein gluten leads to this alteration in texture and since it is the main responsible for keeping the bread well-formed as well as its ability to hold gas (Collar and Angioloni, 2014). SEM micrograph additionally revealed that, in comparison to conventional wheat bread, quinoa-enriched bread had a more diversified

structure, with larger and more irregular holes. When quinoa and wheat were combined to produce bread, the starch molecules were less embedded in the protein matrix, creating a more porous while widening crumb structure (Föste *et al.*, 2014).

Secondary structure (FTIR)

It has been demonstrated that incorporating quinoa flour into bread recipes alters the secondary structure. FT-IR spectra of the quinoa breads were recorded across the infrared region from 4000 to 400 cm^{-1} , as shown in Fig 3. The FT-IR analysis between 4000 and 2000 cm^{-1} revealed several noteworthy absorption bands common to all samples. The characteristic peak between 1022 and 1079 cm^{-1} associated with the C-O vibration in carbohydrates. Further analysis of the spectra detected several additional informative peaks. Specifically, the peak detected at 1547 cm^{-1} linked to variations in the protein composition of the diverse flours used in bread production. In terms of secondary structure assessment, the broad peaks in this range arose from O-H stretching vibrations, indicating the presence of water within the breads. Two additional peaks in the same region originated from the symmetric and asymmetric stretching of C-H groups in the predominant carbohydrates, such as glucose, fructose, sucrose and arabinose, as well as various lipids contained within the formulations. The simple spectra highlighted the similarities between the chemical compositions of the plain and fortified breads compared to those containing additional quinoa.

The study found that the gluten network gradually weakens as the proportion of quinoa flour increases, reducing the structural integrity of the bread over time. Moreover, the FTIR spectra revealed that the bands pertaining to starch were also impacted by the percentage of quinoa flour substituted, altering the functionality of this complex carbohydrate within the dough. According to previous research conducted by Föste *et al.* (2014) as well

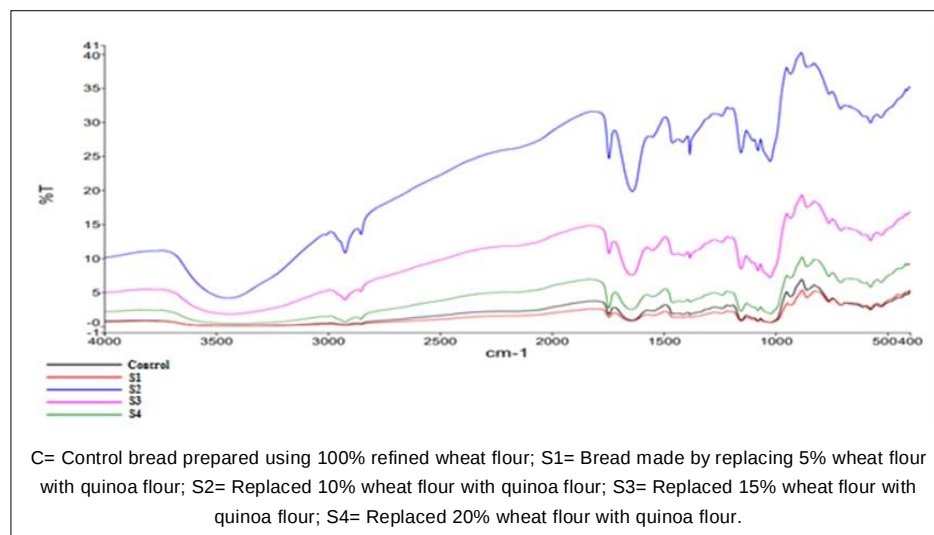


Fig 3: Secondary structure of bread samples using fourier-transform infrared spectroscopy (FTIR).

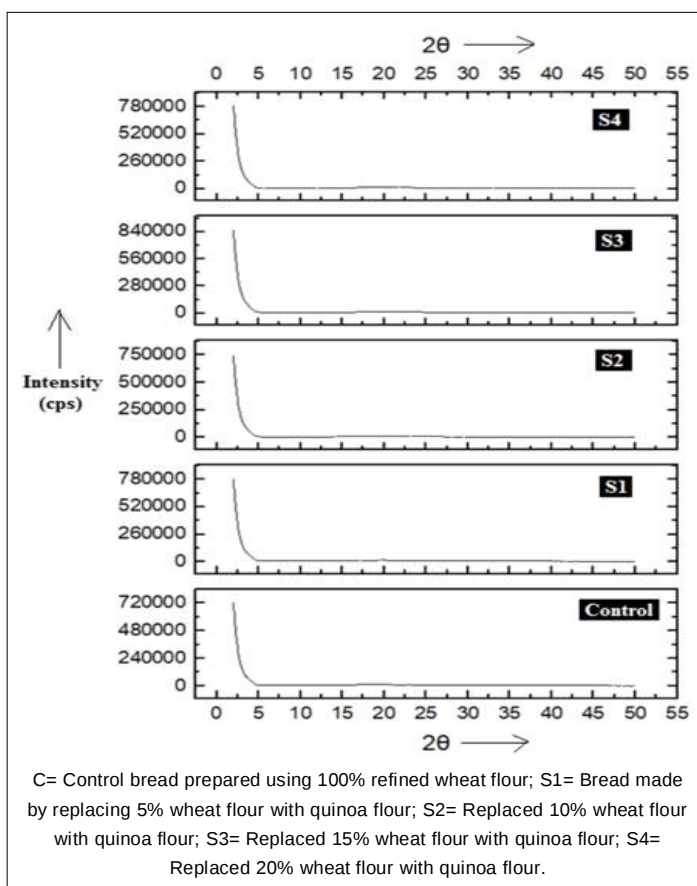


Fig 4: X-ray diffraction of bread samples using XRD.

as Collar and Angioloni (2014), the incorporation of quinoa flour modified the biochemical composition and associated functional properties of the resulting bread product. With an increase in the portion of quinoa starch granules incorporated within the gluten matrix system, these characteristic starch peaks could be observed (Wang *et al.*, 2015). Microstructural study also manifested that increasing quinoa starch granules influenced and diluted the gluten network which further corroborated with these FTIR spectroscopic results. This division was responsible because of the varied bread structure and the formation of holes.

X-ray diffraction of bread

X-ray diffraction (XRD) has been used to study the molecular properties of bread. The XRD spectra confirmed the semi-crystalline structure of the bread (Fig 4). The intensity of X-rays scattered at different angles is plotted in each line graph, providing useful information about the physical structure, chemical composition and crystallographic properties of the bread. The y-axis shows the intensity (Cps), with values ranging from about 260,000 to 780,000 Cps, while the x-axis likely reflects the diffraction angles from 0 to 55 degrees. In each sample, clear peaks can be seen at almost the same position (2°) on the x-axis, indicating the presence of comparable crystalline components. The bread appears to be composed mainly of a dominant crystalline

phase, as no other prominent peaks are present. The different peak intensities of the bread samples are most likely due to the different proportions of quinoa flour. In terms of XRD analysis, quinoa flour differs substantially from traditional wheat flour in its constituent makeup, featuring distinctive protein structures and starch granules that imbue unique textural properties (Connolly, 2023). As studies have demonstrated, incorporating quinoa flour into good baked formulations initiates a stepwise transition in the XRD pattern signature. Most notably, emerging diffraction signatures concordant with quinoa starch grains progressively overshadow the characteristic Type A crystallization of wheat starch as it dissipates away (Collar and Angioloni, 2014). Moreover, the unusual amino acid profile of quinoa-especially its elevated lysine levels-could catalyze shifts in the XRD pattern by reshaping starch-protein intermingling during dough preparation and the heat of the oven. Thus, the partial replacement of quinoa flour with wheat flour influenced the nutritional composition as well as the functional and microstructural characteristics of the bread.

CONCLUSION

In conclusion, the experimentation with varying amounts of quinoa flour inclusion (0%, 5%, 10%, 15% and 20%) within

the bread recipes yielded notable impacts across diverse quality metrics. The composition was altered as quinoa flour raised moisture, ash, fat, protein and crude fiber levels while carbohydrates decreased. Visually, the loaves darkened and colors warmed with greater quinoa flour usage. Texturally, while cohesiveness and hardness elevated in general, springiness observed reduction. The molecular properties and microstructure varied significantly as well. Some slices exhibited softer centers surrounded by outer sections with stronger chew, an unevenness traditional wheat bread typically lacks. Overall, the modified formulations delivered nutritious breads with intriguing variations in properties depending on the quinoa proportion implemented. Microstructural tests revealed that the crumb of quinoa-enriched bread turned into more porous and heterogeneous, with fewer embedded starch granules and a more fragile gluten structure. FTIR spectroscopy and X-ray diffraction assessment revealed variations in crystalline structures and starch-protein interactions, which further confirmed molecular-level alterations. Higher amounts of quinoa impaired the bread's overall acceptability, therefore establishing the ideal quantity of substitution is crucial to maintain customer satisfaction even though quinoa flour increased the bread's nutritional worth. Based on these results, it is advised to manufacture quinoa-enriched bread with acceptable textures and nutritional advantages by substituting 10% wheat flour with quinoa flour. This information helps create bread products with added nutrients that keep consumers interested.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

- (AOAC), A.O.A.C. (2016). Official Methods of Analysis of the Association of Official Analytical Chemists. USA: The Association.
- Alencar, N.M.M., Steel, C.J., Alvim, I.D., de Moraes, E.C. and Bolini, H.M.A. (2015). Addition of quinoa and amaranth flour in gluten-free breads: Temporal profile and instrumental analysis. *LWT-Food Science and Technology*. **62(2)**: 1011-1018.
- Anuhya and Dobhal, N. (2024). Evaluation of physical characteristics and impact of germination on functional properties of Quinoa (*Chenopodium quinoa Willd.*). *Asian Journal of Dairy and Food Research*. doi: 10.18805/ajdfr.DR-2148.
- Collar, C. and Angioloni, A. (2014). Nutritional and functional performance of high β -glucan barley flours in breadmaking: Mixed breads versus wheat breads. *European Food Research and Technology*. **238**: 459-469.
- Connolly, D. (2023). Impact of quinoa and food processing methods on the human gut microbiome through *in vitro* fermentation. Washington State University.
- Demin, M., Vučelić-Radović, B., Banjac, N., Tipsina, N.N. and Milovanović, M.M. (2013). Buckwheat and quinoa seeds as supplements in wheat bread production. *Hemijaska Industrija*. **67(1)**: 115-121.
- Dewan, A., Chaudhary, N., Malik, P.D., Malik, M., Singh, N., Khatkar, B.S., Rustagi, S. and Pandiselvam, R. (2025). Concentration-dependent functional impact of high molecular weight (HMW) and low molecular weight (LMW) glutenins on dough rheology and instant noodle quality in distinct wheat varieties. *Journal of Cereal Science*. **123**: 104135.
- Dewan, A. and Khatkar, B.S. (2023). Wheat polymeric proteins isolation and characterization: Microstructural, thermal, configurational and spectroscopic approach. *European Food Research and Technology*. **249(7)**: 1797-1806.
- Dewan, A., Meena, G., Upadhyay, N., Barapatre, R., Singh, A. and Rana, J. (2018). Formulation of non-gluten pasta from the optimized levels of dairy and non-dairy ingredients. *Madridge J. Food Technol.* **3(1)**: 91-97.
- El-Sohaimy, S., Shehata, M., Mehany, T. and Zeitoun, M. (2019). Nutritional, physicochemical and sensorial evaluation of flat bread supplemented with quinoa flour. *International Journal of Food Science*. **2019(1)**: 4686727.
- El-Sohaimy, S., Mohamed, S., Shehata, M., Mehany, T. and Zaitoun, M. (2018). Compositional analysis and functional characteristics of quinoa flour. *Annual Research and Review in Biology*. **22(1)**.
- Föste, M., Nordlohne, S.D., Elgeti, D., Linden, M.H., Heinz, V., Jekle M. and Becker, T. (2014). Impact of quinoa bran on gluten-free dough and bread characteristics. *European Food Research and Technology*. **239**: 767-775.
- García-Segovia, P., Igual, M. and Martínez-Monzó, J. (2020). Physicochemical properties and consumer acceptance of bread enriched with alternative proteins. *Foods*. **9(7)**: 933.
- Gostin, A. (2019). Effects of substituting refined wheat flour with wholemeal and quinoa flour on the technological and sensory characteristics of salt-reduced breads. *LWT*. **114**: 108412.
- Gómez, M., Talegón, M. and De La Hera, E. (2013). Influence of mixing on quality of gluten free bread. *Journal of Food Quality*. **36(2)**: 139-145.
- Malik, M., Tomar, D., Singh, N. and Khatkar, B.S. (2024). Selection of salt level in noodle making using technique for order of preference by similarity to ideal solution. *Journal of Food and Nutrition Research*. **63(4)**: 344-351.
- Malik, M., Tomar, D., Singh, N. and Singh, B. (2024). Application of compensatory topsis-based multiple criteria decision-making system for selecting appropriate salts in noodle production. *Annals of Agri Bio Research*. **29**: 151-157.
- Matsuo, H., Noguchi, Y., Miyano, R., Higo, M., Nonaka, K., Sunazuka, T. and Nakashima, T. (2020). Thioporiols A and B: Two new sulfur compounds discovered by molybdenum-catalyzed oxidation screening from *Trichoderma polyperi* FKI-7382. *Antibiotics*. **9(5)**: 236.
- Moawad, E., Rizk, I., Kishk, Y. and Youssif, M. (2018). Effect of substitution of wheat flour with quinoa flour on quality of pan bread and biscuit. *Arab Universities Journal of Agricultural Sciences*. **26(Special issue (2D))**: 2387-2400.
- Mu, J., Qi, Y., Gong, K., Brennan, M.A., Ma, Q., Wang, J. and Brennan, C.S. (2023). Effects of quinoa flour (*Chenopodium quinoa willd*) substitution on wheat flour characteristics. *Current Research in Food Science*. **7**: 100556.

- Olawuni, I.A., Uzoukwu, A.E., Ibeabuchi, J.C., Ofoedum, A.F., Nwakaudu, A.A., Alagbaoso, S.O., Anaeke, E.J. and Ugwoezuonu, J.N. (2024). Proximate, functional and sensory analysis of quinoa and wheat flour composite cake. *Asian Journal of Dairy and Food Research*. **43(1)**: 59-64. doi: 10.18805/ajdfr.DRF-340.
- Sharanagat, V.S., Singh, L. and Nema, P.K. (2022). Approaches for development of functional and low gluten bread from sorghum: A review. *Journal of Food Processing and Preservation*. **46(11)**: e17089.
- Rana, G.K., Singh, N.K., Deshmukh, K.K. and Mishra, S P. (2019). Quinoa: New light on an old superfood: A review. *Agricultural Reviews*. **40(4)**: 319-323. doi: 10.18805/ag.R-1927.
- Tang, Y. and Tsao, R. (2017). Phytochemicals in Quinoa and Amaranth grains and their antioxidant, anti inflammatory and potential health beneficial effects: A review. *Molecular Nutrition and Food Research*. **61(7)**: 1600767.
- Turkut, G.M., Cakmak, H., Kumcuoglu, S. and Tavman, S. (2016). Effect of quinoa flour on gluten-free bread batter rheology and bread quality. *Journal of Cereal Science*. **69**: 174-181.
- Wang, S., Opasathavorn, A. and Zhu, F. (2015). Influence of quinoa flour on quality characteristics of cookie, bread and chinese steamed bread. *Journal of Texture Studies*. **46(4)**: 281-292.
- Xu, X., Luo, Z., Yang, Q., Xiao, Z. and Lu, X. (2019). Effect of quinoa flour on baking performance, antioxidant properties and digestibility of wheat bread. *Food Chemistry*. **294**: 87-95.