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Proximate, Physical and Sensory Properties of Wheat-Quinoa Flour Composite Bread

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Abstract

This study investigated the proximate analysis, physical properties, and sensory evaluation of the composite bread of wheat and quinoa. In addition, the quinoa flour's functional qualities were evaluated. The bulk density was 0.71g/cm^3, swelling index of 2.0%, foam capacity of 6.0g/cm3, foam stability of 1.0g/cm2, and oil and water absorption capacities of 2.19g/g and 3.10g/g. Four formulations, ranging from 0% to 30%, substituted quinoa flour (QF) for wheat flour. (100: 0, 90: 10, 80: 20, and 70: 30, respectively). Quinoa flour replacement resulted in an increase in the bread's moisture content (34.22 to 36.21%), ash (1.66 to 2.08%), protein (10.34 to 12.76%), fats (2.16 to 3.38%), and crude fiber (1.31 to 4.61%) while the carbohydrate content ranged from 50.36 to 40.95%. Weight increased from 302 to 321 grams, height decreased from 70.00 to 60.00 millimeters, loaf volume decreased from 800.00 to 740.00 cubic centimeters, and specific volume decreased from 2.65 to 2.31 cm^3 grams^{-1} when wheat flour was substituted with 0%, 10%, 20%, and 30% quinoa flour. In addition to having excellent sensory acceptance, the bread produced by substituting 10% QF has the basic nutrients that can help in solving the health needs of the consumers.

Keywords
Proximate, Physical properties, Wheat, Quinoa, Bread, Sensory acceptability

INTRODUCTION

The fundamental objective of eating is to give the body the energy and/or nutrition it needs to perform at its best. However, in order to achieve the minimal nutritional requirements, particular foods must be incorporated in goods and dietary components must be given extra consideration due to Nigeria's high rate of malnutrition (Ofoedu, et al., 2021).

Quinoa, also known as Chenopodium quinoa Wild, is a pseudo-cereal grain and a member of the Chenopodiaceae family. In the South American Andes, quinoa was first cultivated and produced between 5000 and 3000 BC (Gonzalez et al., 2015). On the other hand, quinoa fruits are called achenes and contain a single seed enclosed in an external pericarp (FAO, 2011). Despite having cereal-like traits, it is categorized as a "pseudocereal" and even an oleaginous "pseudoseed" because it does not belong to the Gramineae family and has botanical characteristics like the presence of panicle-type inflorescence, exceptional nutritional balance of protein and lipids, high protein content, sulfur amino acids, and lysine (Farro, 2008). The seeds have been cooked and eaten in many different ways, such as as rice, in soups, puffed to produce breakfast cereal, or ground to flour to make toasted and baked items (cookies, breads, biscuits, noodles, flakes, tortillas, and pancakes.

Quinoa seeds may also be used in the fermentation process to create the traditional South American alcoholic beverage "chicha" (FAO, 2011). Linolenic (18:2n-6: 52%) and linoleic (18:3n-6: 40%) oleic acids, two important fatty acids, are highly concentrated in quinoa seeds. The amino acid profile of quinoais similar to that of rice, but with higher levels of lysine (4.8 g/100 g protein) and threonine (3.7 g/100 g protein), which are frequently the limiting amino acids in conventional cereals like wheat and maize (Dini et al., 2004). Quinoa seeds, which range in starch content from 58 to 68% to 5% sugar, have a high fibre content, making them a superior source of slowly-releasing energy.

However, the absence of gliadins (gluten-forming proteins found in wheat) and protein fractions similar to gliadin (found in oats, barley, rye, and malt) makes quinoa appropriate for the preparation of food items commonly referred to as "gluten-free," which is essential for enabling a greater variety and supply of more nutrient-rich food appropriate for patients with celiac disease (Nwokenkwo, et al 2020).

Some quinoa cultivars have celiactoxic epitopes, a region on an antigen that interacts with antibodies, which may cause certain persons with celiac disease to have immunological reactions to them. Quinoa is considered to be a glutenfree grain since it has very little to no prolamin (Ofoedum, et al., 2023). Due to its nutritional profile, this seed can be used with other cereals to significantly increase their protein, dietary fiber, and mineral levels (Dini, et al, 2009).

Gluten-free quinoa flour can be used with wheat flour to make composite flour-based items like bread, which will increase the nutritious content of those foods (Ameh et al., 2007). One of the major health challenges facing developing nations like Nigeria today is malnutrition, which has contributed to high birth mortality, inadequate physical and cognitive development in the infant and low disease resistance. To boost its nutritional content and use in baking processes, quinoa flour may be used with wheat flour.

The material presented here will show how quinoa flour is created from quinoa seeds and how quinoa flour can boost bread's nutritional content by being added as a composite. This would encourage Nigeria to use quinoa more frequently and minimize malnutrition because bread prepared simply from wheat won't be as nutrient-dense as bread made with quinoa flour. The usage of quinoa seeds in the food business will, however, open up a new market or frontier for their production. This project's main objective is to create bread from quinoa and wheat flour combinations and evaluate the sensory, practical, and physical characteristics of the finished product.

MATERIALS AND METHODS

Materials

Given how difficult it is to find quinoa seeds and how expensive they are, this study's quinoa seeds were bought from Jumia Nigeria. The wheat flour, yeast, salt, and other ingredients used for the bread production were sourced from Relief main market in Owerri, Imo State. While the analytical-grade chemicals and other laboratory equipment were obtained from the Food Science and Technology laboratory, FUTO.

Place of the Research: The research was conducted in the Department of Food Science and Technology in **Federal University of Technology, Owerri**, Imo State, Nigeria.

Duration/Year of Research: The duration of the research covered a period of eight months, from September, 2022 to April, 2023.

Production of flour from Quinoa seeds

The method of Nwokenkwo, et al (2020) and Olawuni, et al., (2023) was adopted for the production of quinoa seed flours, with slight modifications. The quinoa seeds underwent a thorough sorting procedure to remove unwanted components and damaged seeds and subsequently washed and rinsed with clean water. The quinoa seeds were spread out on metal trays and dried in the oven at 185°C for 45 minutes. The seeds were roasted, then ground into a powder using a blender and sieved with a 177-mesh screen to produce flour with a consistent size. The flow chart for the process is shown in Fig. 1.

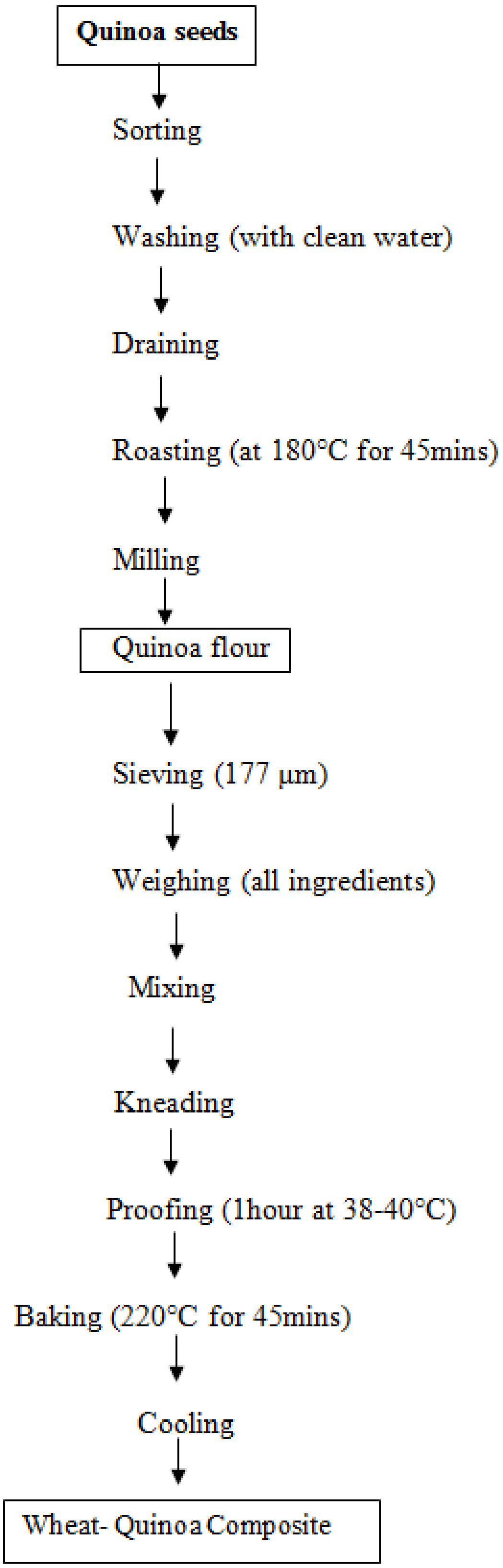

Fig. 1 Flowchart of wheat quinoa composite bread

Bread preparation

With a few minor modifications, this preparation used the methodology from Feili *et al.* (2013). Wheat flour and quinoa flour were substituted in three different proportions (10, 20, and 30%), indicated as Q10, Q20, and Q30, to make the breads. The dry were measured into a bowl. Following a 15-minute rest period, the yeast was activated by being given a little amount of water and sugar (from the amount to be used). A planetary mixer was used to combine all the ingredients for two minutes at 214 rpm. The ingredients were blended together in the mixer to create silky, homogeneous, and elastic dough. Following this, the dough was repositioned, shaped, and proofed for a further 30 minutes before being baked for about 45 minutes at 220°C. After baking and cooling for around two hours, the bread loaves were cut and packaged. The different ingredients and their proportions are stated in Table 1.

Table 1 Wheat-quinoa composite bread formulation

Ingredients	T0 (Control)	T1 (Q10)	CT2(Q30)	T3(Q30)
Quinoa flour (g).	0	20	40	60
Wheat flour (g)	200	180	160	140
Sugar (g)	12	12	12	12
Fat (g)	4	4	4	4
Yeast (g)	4	4	4	4
Salt (g)	4	4	4	4
Milk (g)	4	4	4	4
Egg (ml)	2	2	2	2
Improver (g)	1	1	1	1
Water (ml)	120	120	120	120

T0 = 100% wheat flour (WF); T1 (Q10) = 10%QF + 90%WF; T2 (Q20) = 20%QF + 80%WF; T3 (Q30) = 30%QF + 70%WF

Evaluation of the Physical Characteristics of the Bread

The Height, loaf volume and specific volume index and Weight (g) were all determined using a method described by Feili et al. (2010).

(i) Determination of the Height

The heights of about three bread slices that were positioned edge to edge and taken from the centre of the loaf were measured. For duplicate reading, the bread pieces were turned at a 90° angle. While measuring the average heights, the process was done three times.

(ii) Calculating the volume of the loaf and the specific volume index

The approach given by Feili et al., (2010) was used to calculate the loaf volume and specific volume of bread samples.

(iii) Weight (g)

The weight of the bread was measured by placing the bread samples on the measuring scale and readings were noted and recorded.

Proximate Composition of Bread

The processes used to determine the proximate analyses (Moisture contents, Ash, crude fibre, Protein, fats and oil, and Carbohydrates) followed the procedures outlined by A.O.A.C. (2006).

Functional Properties of the Quinoa Flour

The Bulk Density, Foaming Capacity, Foaming Stability, Swelling Index, Oil and Water Absorption Capacity were determined by a method described byOlawuni et al., (2023) and Nwosu, 2011).

Sensory Evaluation

The sensory evaluation was conducted by twenty (20) semi-trained panelists composed of bread consumers, including 10 men and 10 women. The various quantitative traits were rated using a 9-point hedonic scale according to a method described by (Odimegwu, et al, 2020).

Statistical Analysis

Using Microsoft Excel 2007 software, the data produced by the laboratory analyses were submitted to one-way analysis of variance, and means were separated using Fisher's least significant difference (LSD) at $P<0.05$.

RESULTS AND DISCUSSION

Functional Properties of Quinoa Flour

Table 2 displays the flour sample's functional characteristics. It was discovered that the bulk density was 0.71g/ml. The capacity of the quinoa flour to absorb water and oil was found to be 3.10ml/g and 2.19ml/g, respectively. Oil flavoring results in a velvety feel in food. Therefore, oil absorption by food items is the reason the mouth feel and taste retention improve. The swelling index of the quinoa flour was calculated and found to be 2.0%. The swelling index is acknowledged as a quality indicator in some food compositions, such as bread goods.

Table 2 Results of the Functional properties of Quinoa Flour

Properties	Readings
Bulk density (BD)	0.71 g/cm^3
Water Absorption Capacity (WAC)	3.10 ml/g
Oil Absorption Capacity (OAC)	2.19 ml/g
Swelling Index (SI)	2.0%
Foam Capacity (FC)	6.0 cm^3
Foam Stability (FS)	1.0 cm^3

The foam stability after 30 minutes was found to be 1.0 cm^3, and the quinoa flour's foam capacity was found to be 6.0 cm^3. Good foam capacity and stability are desired properties for flours intended for the production of a variety of baked goods, including cookies, angel cakes, muffins, akara, etc. These traits also operate as functional agents in other food compositions (El-Adawy, 2001).

Proximate Composition of Bread Samples

The results of the proximate analysis (Table 3) showed that there were significant differences in the moisture, ash, crude protein, crude fat, crude fiber, and crude carbohydrate contents of the bread samples (P> 0.05).

Table 3 Proximate Composition of Wheat Quinoa Bread

Sample	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Fat (%)	CHO (%)
A	34.22 ± 0.06^d	1.66 ± 1.82^d	10.34 ± 0.01^d	1.31 ± 0.01^d	2.16 ± 0.07^d	50.36 ± 0.01^a
B	35.02 ± 0.01^c	1.85 ± 0.01^c	10.98 ± 0.01^c	2.61 ± 0.014^c	2.72 ± 0.14^c	46.93 ± 0.07^b
C	35.63 ± 0.01^b	1.86 ± 0.01^b	11.75 ± 0.01^b	4.11 ± 0.01^b	3.17 ± 0.01^b	43.52 ± 0.01^c
D	36.22 ± 7.06^a	2.08 ± 0.01^a	12.76 ± 0.01^a	4.61 ± 0.01^a	3.38 ± 0.01^a	40.95 ± 0.01^d
LSD	**0.015**	**0.015**	**0.015**	**0.02**	**0.15**	**0.076**

The '*abc Means'* with different superscript within the same column are significantly different ($p\leq0.05$)

Quinoa starch granules are better at absorbing water than wheat starch flour, as evidenced by the fact that the moisture content of bread with supplements steadily increased from 35.01% to 36.21%. The ash level of the bread samples significantly increased (p >0.05) when more quinoa flour was used instead of more wheat flour, going from 1.65% to 2.09% compared to 1.65% for the control sample, which served as the reference. When quinoa flour was substituted because it has more dietary fiber and lipids, Table 3 demonstrated that the crude fiber and fat content increased significantly (p>0.05) as the substitution level rose The amount of crude fiber and fat increased significantly (p >0.05) as the degree of substitution increased, from 1.30% to 4.60% and 2.16% to 3.39%, respectively, due to the substitution of quinoa flour, which has a higher concentration of lipids and dietary fiber. Given the importance of fiber in food items, this suggests that quinoa flour could be a useful addition. The samples' protein content ranged from 10.34% to 12.75%, and there were noticeable differences between them (P>0.05). The highest mean value of 12.75% was discovered for the quinoa flour substitute of 30% (Q30), while the sample (WFB) with the lowest value was found to be the control (10.34%). Carbohydrate content, or nitrogen-free extract (NFE), dropped sharply from 50.37% to 40.96% (p >0:05).

Physical Evaluation of Bread

Table 4 demonstrated that the weight of composite bread increased from 312g to 321g as the degree of QF (10–30%) was raised. This is owing to QF's strong capacity to absorb water and the heavy dough that is produced as a result of its minimal air entrapment (Ameh et al., 2007). By adding non-gluten flour to wheat flour reduces its gluten content and, in turn, the volume of the bread, the loaf's volume and its specific volume drastically fell with increasing quinoa flour concentrations.

Table 4 Physical Properties of Wheat Quinoa Bread

Sample	Weight	Height	Loaf volume	Specific volume
A	301.50 ± 0.7^d	70.5 ± 0.7^a	800.5 ± 0.7^a	2.65 ± 0.007^a
B	312.5 ± 0.7^c	64.5 ± 0.7^b	774.5 ± 0.7^b	2.47 ± 0.007^b
C	317.5 ± 0.7^b	62.5 ± 0.7^c	751.5 ± 0.7^c	2.41 ± 0.01^c
D	312 ± 0.7^a	60.5 ± 0.7^d	740.5 ± 0.7^d	2.32 ± 0.01^d
LSD	**1.31**	**1.51**	**1.51**	**0.015**

Means '*abc…'* with different superscript within the same column are significantly different ($p\leq0.05$).

Similar to this, Sanz-Panella et al. (2013) proposed that this phenomenon was brought about by high water content, which results in gluten dilution, physical interactions, and chemical reactions among fiber components, and as a result, the gluten matrix formation is impacted during mixing, fermentation, and baking steps.

Sensory Evaluation of Bread

The average sensory evaluation scores for the bread samples were provided in Table 5. Sensory evaluation is a key component in assessing whether quinoa bread is of a high enough standard to satisfy client requests (Alagbaoso, et al; 2019). The mean scores for the color and texture of the bread significantly decreased when quinoa flour was added. The control group obtained the highest mean score (color: 8.00 and texture: 7.66) and was followed by 10%, 20%, and 30% substitution of quinoa flour. The best bread crust and crumb textures were found to be achieved using 10% quinoa flour. The symmetry of the bread decreased linearly with an increase in quinoa flour concentration. The evaluations for aroma and taste decreased from 7.33 to 6.00 and 8.00 to 7.02 with additional quinoa flour, respectively. This may be so because some bakery goods may find the nutty flavor of composite bread produced at high temperatures repulsive. An observation in this vein was published by Olawuni et al. (2019). The samples of the bread produced were shown in Fig. 2.

Table 5 Sensory Characteristics of Wheat Quinoa Bread

Sample	Colour	Texture	Taste	Aroma	Appearance	Overall Acceptability
T1 (Q0)	8.00^{a}	7.66^{a}	8.00^{a}	8.00^{a}	8.00^{a}	7.80^{a}
T2 (Q10)	7.66^{b}	7.66^{a}	7.00^{a}	7.33^{c}	8.00^{a}	7.53^{a}
T3 (Q20)	7.00^{a}	7.00^{b}	7.31^{b}	7.33^{b}	7.00^{b}	7.06^{b}
T4 (Q30)	6.66^{d}	6.66^{c}	7.00^{c}	7.00^{c}	6.66^{c}	6.66^{c}
LSD	**0.50**	**0.70**	**0.69**	**0.40**	**0.70**	**1.20**

The "*abc…. Means*" with different superscript within the same column are significantly different (p≤0).
Keys:
T0 = 100% wheat flour (WF);
T1 (Q10) = 10%QF + 90%WF;
T2 (Q20) = 20% QF + 80%WF;
T3 (Q30) = 30%QF + 70%WF.

Fig. 2 Appearance of wheat quinoa composite bread

The investigation revealed that the general palatability of supplemented bread was good at 10% supplementation in terms of a number of physical characteristics. It eventually results in the rejection of 30% quinoa-based bread as it reduces linearly as quinoa flour concentration increases.

CONCLUSION AND RECOMMENDATION

Conclusion

The nutritional contents of bread might be increased by using quinoa flour for wheat flour while making the bread. In order to assess the changes in the physic-chemistry, physical parameters, and sensory characteristics of wheat quinoa bread, two different flours, namely wheat flour and quinoa flour (up to 30%), were replaced in this study. According to the findings, the bread baked with 10% quinoa flour had higher moisture content, protein, ash, fats, and fibre contents than the control. Overall, making quinoa-based breads with two distinct flours can result in superior goods with more nutrients. The research done to create quinoa-based wheat flour bread shows that acceptable bread that is comparable to wheat bread can be generated at 10% level of quinoa flour substitution, which explains why the panelists preferred T1 (90: 10) treatment in terms of organoleptic qualities.

Recommendation

Given that quinoa is extremely nutritious, gluten-free, and has a lower carbohydrate content than wheat, this study suggests that it be widely cultivated and used as a supplement for the creation of composite bread.

CONCURRENT INTEREST

The authors have affirmed that there are no conflicts of interest.

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CONTRIBUTIONS FROM WRITERS

The protocols and the first draft of the article was planned and designed and conceptualized by Authors **OIA** and **UAE**. Data interpretation and statistical analysis were carried out by author **OAF and NOE**. Authors **AEJ and ILN** conducted literature research, participated in data gathering, and oversaw study analysis, Author **AEJ and OAF** did reviews**,** while **ASO and UNC** were involved in laboratory analysis and data curation. The final draft was read by all authors and got their approval.

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