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RESEARCH PAPER

Effect of Quinoa Flour Supplementation on Some Properties of Cookies

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A B S T R A C T:

Quinoa has a unique physical-chemical and nutritional characteristics among varied food grains. The objective of this study was to supplement cookies with different levels (20,30 and 40%) of white and black quinoa flour compared to control (100%) wheat flour in terms of their effect on some properties of cookies. The proximate composition of flour and cookies, texture, color, antioxidant activity, total phenol, and reducing sugar content produced by amylase hydrolysis were determined. Also, cookie samples microstructure SEM and sensory evaluation have been done to evaluate the supplemented products. Quinoa flour had a significantly higher proximate composition except for the moisture and carbohydrate content. The cookies' characteristics improved, as by increasing the level of quinoa flour their total phenolic content and antioxidant activity increased but the hardness and reducing sugar percentages were decreased. Scanning electron microscopy (SEM) revealed that by substituting and increasing the level of quinoa flour the starch granule spherical shape was destroyed due to the high content of fiber covering the starch granules. The color of substituted cookies with black quinoa flour was darker than the control and those prepared with white flour quinoa. The highest scores for most attributes were given for cookies that were supplemented by 40% white quinoa and 20% black quinoa. Thus, the results of this study revealed that the black or white quinoa flour and due to the novel ingredients could be used as a good replacement in the bakery and especially for the nutritious cookie.

KEY WORDS: Quinoa; pseudocereal; Cookies; Antioxidants; nutritional value.
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1.INTRODUCTION :

Products from bakeries are widely eaten snack items that may be used at any time. The desire for more nutritionally baked items besides just carbs has increased as a result of rising media focus on better eating options (McIntyre and Schwanke, 2010). A chemically leavened type of food known as a "cookie" or "biscuit". In general, European nations use the phrase "biscuit," whereas Americans use the term "cookie." (Sharif et al., 2009).Due to their high content of sugar (sucrose) and fat, cookies and other sweet baked items were known as high in calories (Lee et al., 2020). The baked good known as cookies are made mostly of flour, fat, and sugar. Low water content (1–5%) and optional secondary additives including yeast, salt, emulsifiers, and leavening agents are required (Pareyt and Delcour,2008).

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Wheat flour lacks some of the essential amino acids and the other micronutrients have to be the most ingredient for making cookies, so the fortification of cookies with products that are rich in protein and fiber could help to increase the nutritional value (Sharif et al., 2009; De Camargo et al., 2014).

Because they provide a great source of fiber, antioxidants, minerals, and phenolic compounds, that offer some protection against obesity, cancer, diabetes, and cardiovascular illnesses, whole grains improve the product's nutritional profile (Pathak et al., 2016).

Furthermore, Because of their greater consumption, ready-to-eat form, longer shelf-life, and superior taste, cookies may be a smarter choice to develop compared to any other (Jan et al., 2018). Pseudo-cereal flours, such as buckwheat, quinoa, and amaranth, can be used for gluten-free goods to enhance their sensory and nutritional characteristics (Lai, 2002). There are a number of researches that have been done on using quinoa flour in biscuits, cookies (Brito et al., 2015; Goyat et al., 2018), and bread (Alencar et al., 2015).

The pseudocereal quinoa (*Chenopodium quinoa Willd*) has been grown for approximately 7000 years, making it one of the Andean region's oldest crops. Due to its great nutritional value, quinoa is now being grown throughout Europe, Asia, and Africa, and these regions see it as a "superfood." In comparison to cereals, quinoa contains a high amount of fiber, high biological-value proteins, essential fatty acids (omega3 and omega6), vitamins, and minerals as compared to other cereals (Stikic et al.,2012) along with a good quantity of essential micronutrients especially calcium, phosphorus, iron, zinc. The quinoa's proximate composition ranges from carbohydrate (55.3-75.82%), fat (4.69-12.4%), protein (11.7-16.4%), and fiber (1.92-3.38%). It's also a rich source of vitamins, minerals, and antioxidants (Arneja et al.,2015).

Additionally, quinoa can also be used in many bakery industries as the starch present in the seeds has properties similar to those found in wheat (Gómez-Caravaca et al. 2011), also, the quinoa flour has revealed positive effects on the rheological and sensory characteristics of bakery products, such as bread and cookies (Harra et al. 2011; Stikic et al. 2012). Since cookies don't require a lot of gluten, this supplementation can also dilute the gluten proteins found in wheat, which reduces the need for a lot of sugar to prevent gluten production during the mixing process (Jan et al. 2018). It is generally recognized that excessive sugar consumption raises calorie intake and causes illnesses like diabetes and obesity (Milievi et al., 2020). According to WHO and FAO recommendations from 2003, fewer sweets and foods that raise blood sugar levels should be consumed overall. Furthermore, considering that cookies have less structural reliance within the product matrix than other baking products do, their dry and dense structure makes them excellent for long-term storage and higher-level substitution.

Accordingly, the objective of this study was to supplement cookies with black and white quinoa seed flour in different percentages. Then investigate their effect on the physicochemical, sensory, color, and nutritional properties of the supplemented cookies.

2. Materials and Methods

2.1. Materials

Quinoa seed (black and white) and other ingredients including bread whole wheat flour, Shortening, milk powder, vanilla essence, baking powder, table sugar, and salt were obtained from Erbil local market.

All chemicals used in the study were of analytical grade and purchased locally.

2. 2. Methods

2.2.1 preparation of Flour and Blends

The quinoa seeds were ground to become flour with a home grinder, whole wheat flour was sieved with a (125-micron sieve), and 14% of the bran was added back to it. The flour was packed in plastic bags and stored at 5^{o}C until further use.

The blends of cookies were prepared with different percentages of wheat (WF): white quinoa (WQ) and black quinoa (BQ) flour.

1. Control 100% wheat flour (100% WF)
2. 20% white quinoa flour (20% WQ)
3. 30% white quinoa flour (30% WQ)
4. 40% white quinoa flour (40% WQ)
5. 20% black quinoa flour (20% BQ)
6. 30% black quinoa flour (30% BQ)
7. 40% black quinoa flour (40% BQ)

2.2.2 Preparation of Cookies

Cookie samples were prepared according to (Jan et al., 2018) with some modifications, by mixing (45g) of shortening and sugar (30g) for about 2 minutes by hand mixer (NWL-3518/ China), until a creamy texture was obtained. Ingredients (vanilla, salt, milk powder) that were mixed before adding, again mixed. The (flour and baking powder) were sieved and added to the mixture and mixed, at the end water was added and kneaded just to get a cohesive dough. Cookie's formulation has been shown in (**Table 1**). The cookie dough was placed between two glass sheets with a thickness of (4 mm) and cut with a round sharp cutter (67.716 mm) diameter. The cookies were then baked at 180 ^{o}C for about 15 minutes. After baking the cookies were left cool to room temperature and put in plastic cookie containers that were stored in the refrigerator until further analysis. The supplemented cookies were produced in different proportions of wheat: quinoa flour (**Table 1**).

Table 1 Formulas of cookies supplemented with two types of Quinoa flour**.**

Ingredients g/100g	100%WF	20%WQ	30%WQ	40%WQ	20%BQ	30%BQ	40%BQ
WF	100	80	70	60	80	70	60
WQ	----	20	30	40	----	----	---
BQ	---	---	---	----	20	30	40
Shortening	45	45	45	45	45	45	45
Sugar	30	30	30	30	30	30	30
Milk powder	5	5	5	5	5	5	5
Baking powder	1	1	1	1	1	1	1
Vanilla	2	2	2	2	2	2	2
Salt	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Water	18	18	18	18	18	18	18

WF=wheat flour, WQ= white quinoa flour, BQ=black quinoa flour

2.2.3. Chemical analysis of cookies (Proximate compositions)

The flours of (wheat and quinoa) and cookies samples were analyzed for moisture (hot air oven), crude protein (micro-kjeldahl, N*5.7), fat (Soxhlet extraction), and ash percentage according to methods of (AACC,2000).

The crude fiber was analyzed by (Weende method) with (Dosi-fiber- Extractor for the determination of cellulose and fiber-Lab plant-England). About 2 grams of flour /cookie samples were weighed in fiber analyzer tubes(W0). Boiling with 100ml acid (H_2SO_4 0.128M) at 80°Cfor (40-45) minutes then washing with distilled water 2-3times. Again, boil with 100ml KOH 0.223M at 80°C for (40-45) minutes then wash with Acetone 2-3 times. Drying the samples in the hot-air oven at 150 °C for 2 hours cooled and weighed (W1), after that the dried samples were turned to ash using a muffle furnace at 550°C for 3 hours, then cooled and weighed (W2). The crude fiber was calculated by the following formula:

$$\text{Crude fiber\%} = \frac{W1-W2}{W0} * 100$$

The carbohydrate is calculated mathematically from the following equations:

Carbohydrate% = 100 - (moisture + ash + fat + protein).

2.2.4. Determination of Total phenolic content

The folin-ciocalteu method was used to determine the total phenolic content in cookie samples. The analysis was done spectrophotometrically according to the method described by (Zainol *et al.*,2003) with some modifications. The total phenolic compounds were extracted by mixing 1gm of each sample with 4ml of acidified methanol (HCl/methanol/water) at the ratio of 1:80:10, v/v respectively with shaking using a shaker water bath at (24±1°C) for 30 minutes. The samples were centrifuged at 3000 rpm for 10 minutes. İn a test tube 0.4 ml of the sample extract, 2 ml of folin (diluted with distilled water 1:9), and 1.6 ml of 7.5% Na_2CO3) were mixed by a vortex mixer VM-300P Taiwan. The samples were kept in a dark place for 1hour at room temperature. The absorbance was measured at 765 nm with a (SHIMADZU UV-1280 UV-VIS model) spectrophotometer. The percentage of total phenol was calculated as mg of gallic acid equivalent per 100 gram of sample (Slinkard and Singelton,1977; Gamez-Meza et al.,1999).

2.2.5 Determination of Antioxidant activity

The 2,2-diphenyl-2-picrylydrazyl (DPPH) radical scavenging activity of the cookies was measured according to (Blois,1958; Hatano et al.,1988) procedure with some modifications.

Cookie extract preparation; 1 gram of each sample was mixed with 5 ml of methanol in a screw cub tube, and Shaked for 5 minutes. Then centrifuged for 10 minutes at 4500rpm and left for 30 minutes. For the preparation of the DPPH solution, 0.008g of the DPPH powder was dissolved in 150ml methanol, the mixture was Shaked and left for 24 hours then diluted to a final volume of 200mL using methanol.

The procedure was done by adding 0.3 ml of cookie extract, 2.7 ml methanol, and 1ml DPPH solution in a test tube. The tubes were shacked and left in a dark place. The absorbance was read by spectrophotometer at 517 nm. The percentage of antioxidant activity was calculated by this formula

Antioxidant activity%= $A_{control} - A_{test} / A_{control} \times 100$

2.2.6. In vitro starch digestion analysis for the cookies

The digestibility of cookies samples by amylase was carried out using the method described by Hiran,(2013) with some modifications, 0.5gram of a powdered sample,1 ml pancreatic amylase (0.01g enzyme dissolved in 10ml citrate buffer solution pH=6) and 4ml of the same buffer was mixed until the samples well immersed in the solution. The mixture was incubated at 37°C for 1 hour, boiled at 85°C for minutes 5 for enzyme inhibition then cooled to room temperature. The volume of the mixture was adjusted to 100ml with distilled water and filtered. Reducing sugars in filtrate as a product of starch digestion by amylase was determined by the DNS colorimetric methods and the absorbance values were read at 540 mm using glucose as the standard (Miller, 1959).

2.2.7. Physical analysis of cookies

2.2.7.1. Texture analysis

The hardness of cookies was analyzed by texture analyzer (Technical Services and Supplies) using cylindrical prob and 2mm penetration (N). The weight of cookies was obtained by the sensitive weighing balance in grams.

2.2.7.2. Spread ratio of cookies

The thickness and diameter (mm) of cookies were measured by a vernier caliper just after cooling the cookies. The spread ratio of cookies was calculated mathematically with thickness/ diameter.

2.2.7.3. Color analysis

Freshly made cookies were analyzed for their color by a portable precision colorimeter (Shanzhen 3nh Technology Co.Ltd,China).The measurement was carried out after the colorimeter was calibrated with a white and black calibration interface. The results were expressed in terms of L* (lightness), a* (redness to greenness), and b* (yellowness to blueness) values. The measurement was carried out in triplicate. The whiteness index was (WI) calculated according to the defined formula by (Hsu et al.,2003).

$$WI = 100 - \sqrt{(100 - L^{*})^{2} + a^{*2} + b^{*2}}$$

2.2.8. Scanning electron microscopy (SEM)

The microstructure of cookies samples was determined by scanning electron microscopy (SEM) according to the procedure described by Mamat and Hill., (2014).

2.2.9. Sensory evaluation

Freshly made cookies were evaluated for sensory attributes by twenty semi-trained panelists. The panelists were staff of the Food Technology Department at Salahaddin University. The nine-point hedonic scale was used to score the attributes (appearance, colour, odour, taste, crispiness, and overall acceptability).

2.2.10. Statistical analysis

Data were statistically analyzed using the (SAS, 2002-2003). Duncan Multiple Rang Test within SAS used for comparison between means within each group factors.

3. Results and Discussion

3.1. Chemical analysis

3.1.1. Chemical compositions of flours

Error! Reference source not found. shows the results of the analysis of the proximate composition of wheat, white and black quinoa flours. The moisture content of wheat flour was significantly higher than that of the quinoa flour which represented 9.61% compared to white and black quinoa flours with values of 7.68 and 7.52 % respectively. On the contrary, the other chemical compositions except for carbohydrates including (protein, fat, crude fiber, and ash%) were significantly higher in quinoa flour than in wheat flour. Whereas, the highest percentage of carbohydrates, 73.13 %, was found in wheat flour and the lowest value 67.86% in black quinoa flour. Also, it is noticeable that white quinoa was richer in protein content than black quinoa and wheat flour as well as quinoa flour contained more than twice as much fat as wheat flour.

Table 2 Chemical compositions of flour

Sample	**Moisture%**	**Protein%**	**Fat%**	**Crude fiber%**	**Ash%**	**Carbohydrate%**
WF	9.61 ± 0.01 a	13.04 ± 0.52 b	3.09 ± 0.04 b	1.11 ± 0.06 c	1.13 ± 0.01 c	73.13 ± 0.51 a
WQ	7.68 ±0.11 b	15.17 ± 0.5 a	6.96 ± 0.26 a	2.73 ± 0.16 b	2.07 ±0.01 b	68.13 ± 0.5 b
BQ	7.52 ±0.24 b	14.00 ± 0 ab	7.59 ± 0.42 a	7.74 ± 0.26 a	3.02 ± 0.02 a	67.86 ± 0.5 b

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letters are significantly different ($p < 0.05$).
WF=wheat flour, WQ= white quinoa flour, BQ=black quinoa flour

The ash and crude fiber content differed significantly between the wheat flour and quinoa flours, but also between the two quinoa flours. Thus, ash and crude fiber content were significantly higher in black than white quinoa (3.02 % vs. 2.07 % and 7.74 %vs. 2.73 %) respectively.
Similar results were obtained by (Abdellatif, 2018; Tamba-Berehoiu et al.,2019; Godse et al.,2020), with differences in values which might be due to the diversity of variety, maturity, growing region, growing environmental conditions, and method of analysis.

3.1.2. Chemical compositions of cookies

Results concerning the chemical analysis of cookie samples were summarized in **Table *2*.** The moisture content of cookie samples was between (4.03±0.133 and 4.57±0.054) for 40% BQ and 20%WQ respectively. When compared with the control cookie 100%WF, the moisture percentage was decreased with increasing quinoa flour incorporation level. This can be attributed to that quinoa flour's moisture content which is lower than wheat flour.
Regarding the percentage of protein, most of the cookie samples supplemented with quinoa flour had a significantly higher percentage than the control which was made from wheat flour.

Table 2 Chemical compositions of cookies

Sample	Moisture%	Protein%	Fat%	Ash%	Crude fiber%	Carbohydrate%
100% WF	4.38±0.173 ab	8.72±0.263 b	23.56±0.029 g	1.58±0.012 d	0.95±0.003 g	61.75 ±0.130 a
20%White QF	4.57±0.054 a	9.56±0.038 a	24.22±0.009 f	1.64±0.001 d	1.06±0.003 f	59.99±0.083 b
30%White QF	4.50±0.028 a	9.58±0.099 a	26.53±0.032 e	1.96±0.020 b	1.11±0.005 e	57.42±0.120 c
40%White QF	4.32±0.186 ab	9.68±0.042 a	29.89±0.043 b	1.97±0.011 ab	1.52±0.01 c	54.15±0.248 e
20%Black QF	4.28±0.004 ab	8.72±0.197 b	28.20±0.032 d	1.81±0.027 c	1.38±0.006 d	56.96±0.243 c
30%Black QF	4.24±0.067 a	9.52 ±0.066 a	28.91±0.152 c	1.86 ±0.032 c	1.62±0.004 d	55.46±0.082 d
40%Black QF	4.03±0.133 b	9.61±0.082 a	30.62±0.020 a	2.03±0.018 a	1.94±0.006 a	53.71±0.219 e

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letter are significantly different ($p < 0.05$).
WF=wheat flour, WQ= white quinoa flour, BQ=black quinoa flour

The fat content of samples ranged between (23.56±0.029 to 30.62±0.020 for 100%WF and 40% BQ flour respectively). The table shows that there was an increase in the percentage of fat in the cookies samples that were supplemented with both quinoa flours, and that increase was significant when high levels were added. Moreover, the ash content of the control and treatments varied between (1.58±0.012 - 2.03±0.018), Compared to the control cookies, the ash content was significantly affected by substituting wheat with quinoa flour, especially the black one. Substitution of wheat with 40% BQ flour has been given the highest ash percentage (2.03±0.018). The crude fiber content of control cookies was recorded as the lowest value (0.95±0.003) and the significantly highest percentage (1.94±0.006) for the sample 40% containing BQ flour. These results could be described by that quinoa flour seed is higher in fat, protein, minerals and crude fiber content compared with wheat flour as their proximate analysis is revealed previously Error! Reference source not found**..**

It was clear that the cookie samples supplemented with QF had lower carbohydrate% compared to the control cookie 100% WF with value of (61.75 ±0.130). All these traits were in agreement with the previous studies. Many researchers stated that the increase in quinoa seed flour or flaxseed flour at different levels in cookies was led to significant increase in protein, crude fat, ash, and crude fiber with decreasing of carbohydrates contain (Nisar et al., 2018; Jan et al.,2018 and Kaur et al.,2019).

3.2. Total phenol contains and antioxidant capacity of cookies

The total phenol contents (TPC) and antioxidant capacity assay results of cookies were shown in

Table *3*. The results indicate that there were significant differences in the TPCs of cookies samples. Cookies made by substituting and increasing the quantity of quinoa flour compared to that of control, also by comparing the results of the substitution of wheat flour with white or black quinoa flour the latter recorded highest total phenolic content. The TPCs were between ranged from (570.38± 7.865 to 980.54±20.560) for control and 40%BQ respectively.

The antioxidant capacity assay of cookies is shown in

Table 3 Total phenol and antioxidant activity of cookies, a significant increase of antioxidant activity was observed in blended cookies when compared with the control in which the maximum value was recorded for 40% BQ flour (87.87± 0.195) but no significant increase was observed between the substituted samples. Similar findings were reported by Watanabe et al., (2013) who suggested that the antioxidant capacity of quinoa flour was high compared to wheat flour. Also, Goyat et al.,(2018) found a significant increase in bioactive compounds and higher antioxidant activity with increasing the amount of quinoa and chia seed flours in cookies. Due to their effective antioxidative potential quinoa and chia seeds could be used in cereal-based products (Demir and Kılınç ,2017).

Table 3 Total phenol and antioxidant activity of cookies

Sample	Total phenol (mg/100g)	Antioxidant activity%
100% WF	570.38± 7.865 d	86.25± 0.462 b
20%White QF	703.05±0.883 bc	87.43±0.883 a
30%White QF	605.23±0.883 cd	87.50±0.195 a
40%White QF	763.25±15.506 b	87.43±0.074 a
20%Black QF	630.57±21.387 cd	87.58±0.000 a
30%Black QF	938.43±16.492 a	87.87± 0.195 a
40%Black QF	980.54±20.560 a	87.21±0.074 a

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letter are significantly different ($p < 0.05$).

WF=wheat flour, WQ= white quinoa flour, BQ=black quinoa flour

3.3. In vitro starch digestion analysis for the cookies

The reducing sugar released during starch digestion by pancreatic α-amylase in vitro for control and quinoa flour incorporated cookies is presented

Figure *1*. It can be seen from the results that the percentage reducing sugar in cookies was significantly decreased with increasing of quinoa flour substitution. The maximum percentage was found for control cookie 100%WF and significantly the lowest value was recorded for the 40%BQ.

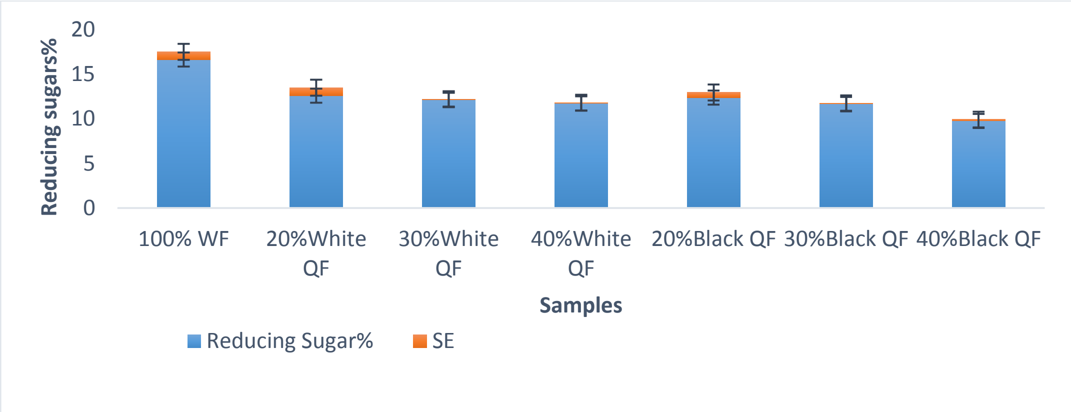

Figure 1 Effect of substitution of wheat flour with quinoa flour at different percentages on the reducing sugar contents of cookies.

The reason might be due to the fact that quinoa flour incorporated cookies contain a higher percentage of dietary fiber and phenolic substances, as is evident from the results of the previous Error! Reference source not found.

Table 2 of this study. Many researchers reported that the incorporation of quinoa into wheat flour decreased the reducing sugar as a result of lowering starch digestion rate by inhibiting the enzymes responsible for starch hydrolysis due to their high phenolic and dietary fiber content (Zhu,2015; Abderrahim et al.,2015; Hui et al.,2020; Sun and Miao,2020; Jia et al.,2020).

3.4. Physical analysis of cookies

3.4.1. Texture analysis

Table *4* shows the results of the physical analysis that has been done for cookies. The weight of cookies ranged between (13.39±0.092g for 100%WF) and (14.4±0.235 for %20 BQ). When control and test cookies are compared, it is noted that the weight was slightly increased in most quinoa flour-supplemented samples. Similar findings have been stated by Azuan et al., (2020).

Table 4 Physical analysis of cookies

Sample	Weight(g)	Hardness(N)	Diameter(mm)	Thickness (mm)	Spread Ratio (D/T)
100% WF	13.39±0.092 b	42.7±1.354 a	60.8±0.342 d	5.3±0.054 b	11.5±0.103 a
20%White QF	13.9±0.140 ab	42.1±0.857 a	62.7±0.229 c	5.6±0.120 ab	11.2±0.274 a
30%White QF	13.7±0.162 b	41.1±0.811 a	63.02±0.077 c	5.8±0.110 a	10.9±0.204 a
40%White QF	13.99±0.179 ab	31.9±0.394 c	63.8±0.009 a	5.5±0.097 ab	11.6±0.204 a
20%Black QF	14.4±0.235 a	34.80.501± b	63.1±0.108 bc	5.6±0.138 ab	11.3±0.289 a
30%Black QF	13.9±0.135 ab	34.7±0.974 b	62.8±0.138 c	5.8±0.010 a	10.9±0.024 a
40%Black QF	13.95±0.281 ab	34.6±0.154 b	63.6±0.161 ab	5.7±0.181 a	11.1±0.338 a

Results of three (n=3) replications were expressed as mean± standard error, values with different superscript letter are significantly different ($p < 0.05$).

WF=wheat flour, WQ= white quinoa flour, BQ=black quinoa flour

Concerning the cookie’s hardness, as shown in **Table *4*** the hardness decreased by increasing the quinoa flour in the blends. The values range between (31.9±0.394 and 42.7±1.354 N) which stands for 40%WQ and 100%WF, this was in agreement with the previous studies. Due to the high level of fat and fiber and lack of gluten in the quinoa flour, the hardness decreased as the level of quinoa flour increased in the blends (Azuan et al.,2020).

Once the diameter of the control was compared with the treated samples, it was observed that the supplemented samples scored higher diameter than the control, and a significantly highest value was found for 40% WQ (63.8±0.009 mm) compared to (60.8±0.342mm) for the control of (100% WF). The thickness of the control cookie with 100% WF was recorded (5.3±0.054mm) which was significantly lower than the treated samples, but no significant increase was detected by increasing the level of substitution from 20 to 40%.

Similar results were obtained by Ganorkar and Jain, (2014) who stated that the thickness and diameter of cookies increased as flaxseed flour was increased, and they reported that Protein influences the dough viscosity. This is because the expansion of protein gluten is not resumed in the making of cookies.

3.4.2. Spread ratio of cookies

Table *4* showed the results of the spread ratio that was calculated mathematically and the minimum amount was for 30%WQ and 30%BQ which was (10.9). White and black quinoa flour caused insignificant differences in the supplemented cookies. It has been reported that by substitution and with increasing levels of quinoa flour spread ratio was decreased and the highest spread ratio was seen for control cookies (Jan et al.,2018).

3.4.3. Color analysis

The color parameters are illustrated in

Table *5*, the L*(lightness) value of the cookie's samples decreased with increasing the substitution of quinoa flour in the blends mainly in black ones, the maximum value of 68.8±0.718 was noted for100%WF which was significantly higher than that of 43.8±0.331 for 40%BQ. The highest a* (represented the greenness to redness) value that was observed for the 20 and 40%WQ flour. The values of b* (blueness to yellowness) were highly represented at 30.2±0.317 for 20%WQ and less value of 14.3±0.113 was obtained for 30%BQ which was significantly lower than of cookies made using white quinoa and wheat flours.

Table 5 Physical analysis (color attributes) of cookies.

Sample	L*	a*	b*	Whiteness Index
100% WF	68.8±0.718 a	9.4±0.290 b	28.95±0.406 b	56.31±0.750 a
20%White QF	66.5±0.642 b	10.5±0.178 a	30.2±0.317 a	53.7±0.541 b
30%White QF	68.0±0.314 a	9.0±0.234 b	28.3±0.170 b	56.35±0.368 a
40%White QF	66.2±0.180 b	10.5±0.185 a	28.93±0.191 b	54.3±0.043 b
20%Black QF	54.7±0.485 c	5.4±0.197 d	18.0±0.426 c	50.97±0.568 c
30%Black QF	48.0±0.419 d	4.5±0.204 e	14.3±0.113 e	45.92±0.415 d
40%Black QF	43.8±0.331 e	6.5±0.354 c	16.3±0.347 d	41.2±0.231 e

Results of three (n=3) replications were expressed as mean± standard error, values with the same superscript letter are significantly different ($p < 0.05$).

WF=wheat flour, WQ= white quinoa flour, BQ=black quinoa flour

The whiteness index (WI) value was obtained mathematically and has been shown in

Table *5*. In comparison between the control and substituted cookies, the whiteness index of the cookies decreased significantly from (56.31 for %WF+T to 41.15 40%BQ+T). Substitution of wheat with quinoa flour affected the whiteness of cookies significantly, especially those with black quinoa flour. This is due to the quinoa flour's chemical composition which contains more fiber and phenolic compounds that made the supplemented cookies darker than the control as reported by (Jan et al.,2018). Also, Maillard reaction, with a consequent increase of melanoidin formation, resulting in a darkening of the product (Secchi et al. 2011; Zucco, et al. 2011).

Furthermore, oxidation of phenolic compounds present in quinoa flour and quinoa flakes with consequent formation of dark pigments may also have an effect (Brito et al. 2012).

3.5. Scanning electron microscopy (SEM)

SEM helped to visualize and understand the interaction between the wheat and the level novel **Figure *2***.

SEM of cookies with 20%WQ replacement revealed that starch granules were gelatinized and starch particles could be recognized. However, increasing the percentage of 40% WQ adversely affected the gelatinization and starch granules are less swollen and the starch outlines can barely be determined. The spherical shape was distorted due to replacing wheat with quinoa flour and the high content of fiber in quinoa flour covered the starch granules. Thus, slow releasing sugar compared to the control (100%WF) as confirmed quinoa flour (white and black) and their effect on starch granules and starch-protein matrix.

SEM results showed that the starch particles of the cookies without the novel ingredients were less visible and the outlines could be not obviously recognized when compared to the increased quinoa flour substitution

by the enzymatic digestion. Our results are in agreement with a previous study which concluded that cereal products supplemented with different types of dietary fibers decreased starch gelatinization and consequently reduced releasing sugar (Galali et al.,2022).

Another study which has been done by Wang et al., (2021) determined the occurrence of 2 different digested starch types (slowly digestible and rapidly digestible starches) that work on slowing down the digestion rate by adding whole quinoa flour to wheat bread.

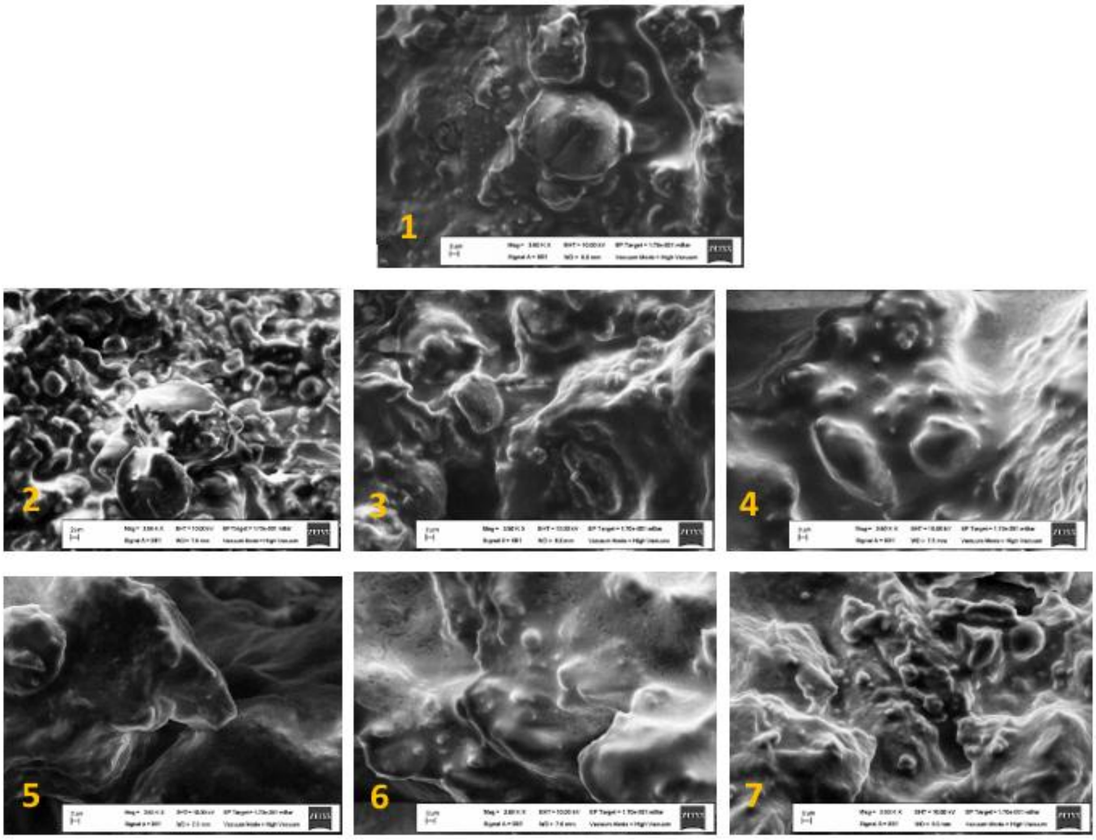

Figure 2 Scanning electron microscopy for cookies
1(100%WF), 2(20%WQ), 3(30%WQ), 4(40%WQ), 5(20%BQ), 6(30%BQ), 7(40%BQ).

3.6. Sensory evaluation

The results of the sensory analysis of cookie samples are given in

Table 6. The results were obtained from scoring on five attributes of control and treated cookies on the 9-hedonic scale by 20 panelists.

Table 6 Sensory evaluation for cookies

Sample	Appearance	Colour	Odour	Taste	Crispiness	overall acceptability
100% WF	8.1 ab	7.6 bc	8.0 ab	7.7 b	7.9 bc	8.0 b
20%White QF	8.2 ab	8.05 ab	8.2 a	8.8 a	8.1 abc	8.6 ab
30%White QF	8.6 ab	8.2 ab	8.0 ab	8.6 a	8.6 ab	8.4 ab
40%White QF	8.9 a	8.6 a	8.0 ab	8.6 a	8.8 a	8.7 a
20%Black QF	7.8 bc	7.8 ab	8.1 ab	8.9 a	8.8 a	8.9 a
30%Black QF	8.05 abc	7.7 abc	7.8 ab	8.8 a	8.7 ab	8.7 ab
40%Black QF	7.2 c	6.9 c	7.2 b	7.2 b	7.7 c	7.2 c

Results of three (n=3) replications were expressed as mean± standard error, values with the different superscript letters are significantly different ($p < 0.05$).
WF=wheat flour, WQ= white quinoa flour, BQ=black quinoa flour.

The sensory score for the appearance of cookies minimum and maximum ranges from 7.2 to 8.9 score. The sample 40% WQ, represented a significantly highest score than the 30% WQ sample which had the lowest score. Data from Table 7 revealed that sample 40% WQ was mostly accepted and preferred by the panelists which obtained a significantly higher score (8.6) for color compared to control cookies. With sample 40% BQ was found to record the lowest value of (6.9).

As has been shown from the results of odor, the highest degree (8.2) was found for the 20%WQ cookie sample while sample 40%BQ obtained less score for odor (7.2). regarding the taste of cookies, the maximum score of (8.9) was given for 20% BQ. Statistically, no significant differences were seen in the results of (20%WQ, 30%WQ, 40%WQ, and 30%BQ).

The crispiness of 40%WQ and 20%BQ obtained the highest score and was mostly preferred by the panelists. The maximum score was given for 20%BQ and followed by 40%WQ which were liked very much on the attribute of overall acceptability. The lowest scores were given for 40%BQ which represented (7.2). The results of sensory evaluation revealed that a significant reduction in sensory scores for all attributes of cookies was observed when supplemented with black quinoa flour at a high level.

The results obtained by Jan et al., (2018) showed that the panelists gave maximum scores for the cookies with 10 percent substitution in all attributes and a lower score of 50 percent. The panelists commented on the later sample which has bitterness taste and nutty flavor.

Conclusion

From the present study it was concluded that the for cookies supplemented with quinoa flour, especially the black type, had highest value of protein, fat, fiber and ash %. The hardness and whiteness index decreased as the level of quinoa flour increased. Furthermore, it could be noted that the substituted cookies samples were characterized by the best nutritional quality as were contain more total phenolic content, and antioxidant activity. It was decided that cookies supplemented with 40% white quinoa flour and 20% black quinoa flour were more acceptable by the panelists. Eventually, it can be concluded that quinoa flour could be a good replacement for producing novel snacks (cookie).

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