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Formulation of quinoa (*Chenopodium quinoa*) biscuits and evaluation of its physical, textural, sensory and nutritional quality

Vandana and Sarita Srivastava

Abstract
Quinoa (*Chenopodium quinoa* Willd.) is a pseudo cereal that has been cultivated in the Andean region. Quinoa grain is highly nutritious due to its outstanding protein quality as it is rich in amino acids like lysine and methionine that are deficient in cereals and also contain wide range of minerals and vitamins. In the present study, proximate composition of raw and processed quinoa grains have been studied. Biscuits have been formulated using refined wheat flour (RWF) and quinoa flour (QF) in the following ratio RWF:QF, 100:0, 75:25, 50:50, 25:75 and 0:100 and evaluated for physical, textural, sensory and nutritional qualities. Physical characteristics of biscuits show that use of quinoa flour led to increase in product thickness, weight and density while diameter, spread ratio and volume decreased. A change in textural characteristics of the biscuits were also observed. Hardness value of biscuits increased by the replacement of refined wheat flour with quinoa flour. Results on sensory evaluation showed that biscuits upto 75 per cent incorporation of quinoa flour were found to be acceptable by panelists. Nutrient composition of biscuits showed that protein, fat, fibre and energy content of the product increased as the level of incorporation of quinoa increased.

Keywords: Quinoa, biscuits, gluten free, pseudo cereal

Introduction
Quinoa belongs to the class Dicotyledoneae, family *Chenopodiaceae*, genus Chenopodium, and species quinoa. *Chenopodium quinoa* Willd is a native to Andean region of South America. It belongs to the group of crops known as pseudo-cereals. The quinoa grains are considered as potentially gluten-free, has high protein content with abundance of essential amino acids such as lysine, threonine and methionine. This is a valuable source of protein for vegans, as its protein levels are similar to those found in milk and higher than those present in wheat, rice and maize. It is also rich in unsaturated
fatty acids (linoleic and linolenic acids), in vitamins (folate and tocopherol), minerals (iron, copper, manganese, potassium) and other pytochemicals, phenolic acids, flavonoids etc. (Miranda *et al*., 2011; Laus *et al.*, 2012; Lutz *et al*., 2013) [1, 2, 3]. It does not contain gluten, so it can be eaten by people suffering from celiac disease. Furthermore, it is a good source of dietary fibre (Alvarez- Jubete *et al*., 2010) [4]. The Incas credited quinoa with medicinal properties including lowering of blood cholesterol, improving glucose tolerance and reducing insulin requirements (Guzman- Maldonado and Paredes Lopez, 1998) [5]. Due to its excellent nutritional profile, United Nations declared year 2013 as the "International Year of Quinoa".
The nutritional significance of bakery products are well recognized. Biscuits are ready to eat, convenient, inexpensive and widely consumed product in India. However, they lack required nourishment, biscuits are rich in fat, sugar, contain low amount of protein mainly lysine, vitamins and generally lack dietary fibre. Quinoa can be used to develop novel and value added food products. It can be used for bakery products such as biscuits and cookies. So, quinoa is a good alternative to be used in baked products like biscuits.
The study, therefore, was undertaken with the objective of determining proximate composition of quinoa grains, formulating quinoa incorporated biscuits and assessing their physical, textural, sensory and nutritional qualities.

Materials and methods
Source of raw material: Quinoa grains were purchased from Herbs and Crop Overseas, Ahmedabad, India.

Pretreatment: For cleaning, grains of quinoa were manually cleaned to remove stones, grit

and other impurities. Quinoa grains contain saponin which is alkaloid and impart bitter taste to the grain. Therefore, it is important to treat the grains before consumption. The grains were thoroughly washed many times with water to remove saponin until the formation of foam disappeared in the washing water. The saponin free quinoa grains were dried at 50° C for 6 hours. For preparation of biscuits the grains were ground to fine powder in an electric grinder. The flour made was sieved manually through 44 mesh size sieve and packed in airtight container and stored at room temperature for further use.

Proximate composition: Moisture, crude protein, total ash, crude fat and crude fiber were estimated in triplicate by AOAC (1995) [6]. Carbohydrate (%) was calculated as 100-{protein (%) + crude fat (%) + moisture (%) + ash (%) (%) + crude fibre (%)} and energy as (4×protein% + 9×fat% + 4× carbohydrate %).

Preparation of biscuits: For preparation of biscuits different ratio of refined wheat flour (RWF) and quinoa were taken. The ratios were RWF: quinoa 100:0, 75:25, 50:50 and 0:100. Control biscuits contained 100 per cent refined wheat flour.

Sweet biscuit: Biscuits were prepared as per recipe given by Rathi and Mogra (2013) [7] with slight modification (Table 1).

Table 1: Ingredients for 100g biscuits are given below

Ingredients	Quantity
Quinoa flour/ refined wheat flour	50 g
Butter (Cholesterol free)	33 g
Powdered sugar	23 g
Baking powder	5g

Method

1. Put flour in a big bowl.
2. Add baking powder, mix it well and sieve the ingredients twice for uniform mixing.
3. Melt the butter and add powdered sugar to it. Stir it continuously for creaming.
4. Flour mix was added in small amounts into the cream and mixed uniformly.
5. Knead it with finger to make the dough soft.
6. Dough was rolled and biscuits were cut into small round shape using biscuit cutter.
7. Preheat the oven to 180°C for 10 minutes.
8. The baking tray was greased and biscuits were arranged in the tray.
9. Bake the biscuits at 180°C for 15 minutes. Biscuits appear little brown from the top.

Physical characteristics of the biscuits: Physical characteristics of the biscuits were determined by the method described by Manohar and Rao (1997) [8]. Diameter was measured by placing 5 biscuits edge by edge and thickness by stacking 5 biscuits one above the other. Spread ratio was measured as the ratio between diameter and thickness. Volume (cm^3) was determined by rapeseed displacement method. Bulk density was expressed as g/cm^3.

Texture of the biscuits: Hardness of biscuits was analyzed in the TA-HD Plus texture analyzer (Stable micro systems, U.K.).The texture analyzer was set to 1mm/sec pre test, 5mm/sec test speed, 5mm/sec post test speed with 75% strain. The hardness values were expressed in Newton.

Sensory evaluation: Formulated food products were evaluated for sensory characteristics by using nine point Hedonic scale. Sensory evaluation was done by 10 semi-trained panelists from department of Foods and Nutrition, GBPUA&T, Pantnagar, Distt. U.S. Nagar, Uttarakhand.

Nutrient composition of formulated food products: Nutrient composition of formulated food products was determined on raw ingredient calculation basis with the help of values as reported by Longvah *et al.* (2017) [9], Gopalan *et al.* (2010) [10] and analyzed value of quinoa grains.

Statistical analysis: The data obtained of formulated food product was analyzed statistically. Paired't' test was employed for the analysis of proximate composition of raw and processed quinoa grains. Completely Randomized Design was used to find out the significant difference between physical attributes of biscuits.

Results and discussion

Proximate composition of quinoa grains

The data presented in Table 2 shows the proximate composition of raw quinoa grains and processed quinoa grains *i.e.* after removal of saponin.

Raw quinoa grains and processed quinoa grains contained moisture content of 9.28 per cent and 9.32 per cent, respectively. There has been non significant difference in moisture content of raw and processed quinoa grains. Repo-Carrasco and Serna (2011) [11] observed moisture in quinoa in the range of 10.78- 12.62 per cent. According to Stikic *et al.* (2012) [12] the moisture content of quinoa whole grains was 10.87. Beniwal *et al.* (2019) [13] reported that raw quinoa flour contain 7.93 per cent moisture.

Significant difference has been found in total ash content of raw (2.84 per cent) and processed quinoa grains (2.66 per cent). The decreased ash content in processed grains might be attributed to the diffusion of minerals into water during washing, soaking and other handlings (Beniwal *et al.*, 2019) [13]. Authors also reported that raw quinoa flour contain 3.5 per cent ash while Alvarez- Jubete *et al.* (2010) [4] reported that processed quinoa grains (washed, centrifuged and dried) contain 2.7 per cent ash. Stikic *et al.* (2012) [12] reported the ash content of quinoa whole grains as 7.06 per cent and dehulled grains as 3.59 per cent.

Non significant difference has been found in the crude protein content of raw quinoa grains (12.8 per cent) and processed quinoa grains (12.03 per cent). Beniwal *et al.* (2019) [13] reported that raw quinoa flour contain 14.5 per cent protein. Alvarez- Jubete *et al.* (2010) [4] reported 14.5 per cent protein in processed quinoa grains (washed, centrifuged and dried).

Significant difference has been observed in the crude fibre content of raw (3.51 per cent) and processed quinoa grains (3.26 per cent). A range of 2.5-3.9 per cent has been reported by Valencia-Chamorro (2003) [14]. Loss in crude fibre content of processed quinoa grains may be attributed to the loss of pericarp that occurs during washing. Stikic *et al.* (2012) [12] reported 10.32 per cent crude fibre in quinoa whole grains and 6.80 per cent crude fibre in dehulled grains. Nisar *et al.* (2018) [15] reported that quinoa contain 3.50 percent crude fibre.

Non significant difference has been observed in the crude fat content of raw and processed quinoa grains which was 5.13 and 5.30 per cent, respectively. USDA (2005) [16] reported average oil content of quinoa around 6 per cent**.** Alvarez-Jubete *et al.* (2010) [4] reported that processed quinoa grains (washed, centrifuged and dried) contain 5.2 per cent fat.

Non significant difference has been observed in the carbohydrate content of raw (66.43 per cent) and processed

quinoa grains (67.43 per cent). Nisar *et al.* (2018) [15] reported that quinoa grains contain 65.10 per cent carbohydrate content.

Physiological energy value of raw quinoa grains has been found to be 363 kcal per 100g which was significantly lower from value of processed quinoa grains which was 366 kcal per 100g. USDA (2015) [17] reported 368 kcal energy per 100g of quinoa.

Table 2: Proximate composition of raw and processed quinoa grains

Proximate composition	Values of raw quinoa grains	Values of processed quinoa grains	't' value
Moisture (%)	9.28±0.02	9.32±0.02	1.81^{ns}
Total ash (%)	2.84±0.01	2.66±0.04	9.04*
Crude protein (%)	12.8±0.26	12.03±0.3	3.29^{ns}
Crude fibre (%)	3.51±0.10	3.26 ±0.05	8.66*
Crude fat (%)	5.13±0.03	5.30 ±0.02	3.92^{ns}
Carbohydrate by difference (%)	66.44±0.19	67.43±0.33	3.65^{ns}
Physiological energy value (Kcal/100g)	363±0.26	366±0.12	18.09*

*significant at 5% ns- non significant mean ± S.D.

The values are mean of triplicate observations

Physical characteristics of the biscuits

The results on the physical characteristics of the biscuits prepared from refined wheat flour (RWF) and quinoa flour (QF) blends have been shown in (Table 3). The mean thickness of the RWF and QF biscuits ranged from 5.81 mm in control sample to 6.43 mm in 100% quinoa flour incorporated biscuits. The diameter decreased from 46.10 mm in control sample to 44.09 mm in 100% quinoa flour incorporated biscuits. The biscuits thickness increased steadily with increased concentration of quinoa flour in the blends while the diameter decreased. Demir and Kilinc (2017) [18] also reported that use of quinoa flour led to a slight increase in thickness and decrease in diameter of the cookies as the level of quinoa flour increased. Nisar *et al.* (2018) [15] also reported gradual increase in thickness of cookies with increase in quinoa flour.

The changes in diameter and thickness reflected the spread ratio which consistently decreased from 7.93 in control sample to 6.87 in 100% quinoa flour incorporated biscuits. Reduced spread ratio of quinoa flour incorporated biscuits were due to the fact that composite flours form aggregates with increased numbers of hydrophilic sites available that compete for the limited free water in biscuits dough (Baljeet *et al*., 2010) [19]. Similar results were also observed by Demir and Kilinc (2017) [18] and they further reported that replacement of wheat flour with quinoa flour influence characteristics of cookie dough and formed more compact cookies. Nisar *et al*. (2018) [15] also observed decrease in spread ratio with increase in quinoa flour.

The weight increased from 7.69 in control sample to 8.63 in 100% quinoa incorporated biscuits. Nisar *et al.* (2018) [15] reported increase in weight of cookies from 10.5 to 11.7 g with increase in levels of quinoa seed flour due to property of quinoa flour to absorb more water and retain it.

The biscuits volume decreased steadily from 15 cm^3 to 10 cm^3 with increased concentration of quinoa flour in the blends. Zucco *et al*. (2011) [20] and Gupta *et al*. (2010) [21] reported a correlation between an increase in the protein content and a decrease in the expansion rate of cookies. Brito *et al.* (2015) [22] also reported decrease of volume in the cookies with higher amount of quinoa flour.

Table 3: Effect of quinoa flour addition on physical characteristics of biscuits

Biscuit sample	Thickness (t) (mm)	Diameter (d) (mm)	Spread ratio (d/t)	Weight (g)	Volume (cm^3)	Density (g/ cm^3)
100%RWF	5.81^a	46.10^a	7.93^a	7.69^a	15.00^a	0.51^a
25%QF+75%RWF	5.99^b	46.73^b	7.67^b	8.35^b	12.33^b	0.68^b
50%QF+50%RWF	6.03^b	45.10^c	7.50^c	8.50^c	12.00^b	0.71^b
75%QF+25%RWF	6.23^c	45.37^c	7.26^d	8.60^c	10.00^c	0.86^c
100%QF	6.43^d	44.09^d	6.87^e	8.63^c	10.00^c	0.86^c
S.E.±	0.03	0.11	0.05	0.04	0.35	0.02
C.D. at 5%	0.09	0.35	0.16	0.14	1.11	0.05

QF= quinoa flour RWF= refined wheat flour

Values in each row with different superscripts are significantly different at $p \leq 0.05$

Results showed that density increased from 0.51 g/ cm^3 to 0.86 g/ cm^3 in control sample and 100% quinoa incorporated biscuits, respectively. The results are consistent with results reported by Atef, *et al.* (2012) [23] who reported that density of biscuits consistently increased from 0.40 g/cm^3 in control sample to 0.49 g/cm^3 in 100% quinoa meal biscuits.

Texture analysis of biscuits

Table 4 shows the amount of breaking force in Newton that the texture analyzer performed on each biscuit. The hardness of biscuits ranged from 70.92 N in control biscuits to 84.83 N in 100 per cent quinoa incorporated biscuits. The texture differences may also have been due to the absence or presence of the differing amounts of quinoa flour. Bilgicli and Ibanoglu (2015) [24] reported that quinoa flour increased hardness of bread samples. Nisar *et al.* (2018) [15] reported that with increase in proportion of quinoa flour the hardness of cookies gets increased. Several studies reported that inclusion of flour with high fibre and protein content increased hardness in bakery products (Brenaan and Samyue, 2004; Sudha *et al*., 2007; McWatters *et al*., 2003; Pareyt *et al*., 2011) [25, 26, 27, 28]. Considering the fibre and protein content present in quinoa might have influenced hardness of biscuits.

Table 4: Hardness of biscuits with different ratio of refined wheat flour and quinoa in Newton

Amount of quinoa (%)	Avg ± SD
0	70.92± 6.39
25	74.58±8.33
50	83.73±2.55
75	84.34±7.93
100	84.83±4.36

Each value an average of three determinations

Sensory evaluation of biscuits

Organoleptic evaluation is important in judging the suitability of the product from consumer point of view. In order to study the effect of quinoa flour incorporation on sensory quality characteristics different ratios of quinoa flour was undertaken. It was found that biscuits containing quinoa flour upto 75 per cent were acceptable to the panelists. Data pertaining to organoleptic evaluation of biscuits by nine point hedonic scale have been presented in Table 5.

Table 5: Effect of different ratio of quinoa flour on sensory characteristics of biscuits

RWF: Quinoa	Liked extremely	Liked Very much	Liked Moderately	Liked Slightly	Neither liked nor disliked	Disliked slightly	Disliked Very much	Disliked moderately	Disliked extremely
100:00 (Control)	50%	10%	10%	30%	-	-	-	-	-
75:25	20%	40%	40%	-	-	-	-	-	-
50:50	20%	40%	30%	10%	-	-	-	-	-
25:75	20%	40%	30%	10%	-	-	-	-	-
0:100	-	30%	20%	10%	40%	-	-	-	-

RWF: Refined wheat flour

Nutrient composition of quinoa incorporated biscuits

Nutrient composition of biscuits revealed that protein, fat, fiber and energy content of the product increased as the level of incorporation of quinoa increased (Table 6). Nisar *et al*. (2018) [15] reported that with increase in quinoa flour at different level in cookies there was a increase in protein, ash, crude fat, crude fibre and decrease in carbohydrate content. Demir and Kilinc (2017) [18] also found that ash, crude protein and crude fat content increased with addition of quinoa flour. According to Alvarez- Jubete *et al*. (2010) [4] crude protein, ash and crude fat contents in quinoa are generally higher than in common cereals such as wheat.

Table 6: Proximate composition of quinoa incorporated biscuits (per 100g)

RWF: Quinoa	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (g)	Energy (kcal)
100:0	11.94	5.2	27.11	0.15	0.26	61.25	511
75:25	11.68	5.42	27.71	0.52	0.52	60.39	513
50:50	11.44	5.62	28.29	0.90	0.80	59.54	516
25:75	11.19	5.84	28.89	1.26	1.06	58.68	518
0:100	10.93	6.04	29.47	1.63	1.33	57.83	520

Conclusion

Thus from the present study it is concluded that quinoa grains are excellent source of nutrients. The incorporation of quinoa flour results in increasing nutritional quality of biscuits. The quinoa incorporated biscuits showed a good sensory acceptability, revealing their potential for consumption by the general population and as an interesting option for individuals suffering with CVD and diabeties. It is suggested that quinoa is a nutritious and functional substitute for wheat and can be used in daily dietary forms for adopting a healthy lifestyle.

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