Mysore J. Agric. Sci., 56 (4) : 289-295 (2022)

Formulation and Evaluation of Quinoa Based *Nachos* - A Nutritious Snack

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Authors Contribution

Mounika Patiballa : Conducted the research, interpreted research data and drafted the manuscript.
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Received : September 2022
Accepted : November 2022

Abstract

Quinoa is a pseudo cereal, known as wonder grain and super food with treasure trove of nutrients, low glycemic index and immense potential as functional and neutraceutical ingredients to be explored in various physiological conditions, disease risk reduction and wellness. Hence, the present study was undertaken with an objective to formulate and evaluate quinoa based *nachos* an all time favourite snack. Quinoa *nachos* were developed by replacing corn flour with quinoa flour at 25, 50, 75 and 100 per cent and evaluated for sensory parameters, proximate composition and storage stability by standard procedure. Results indicated that 100 per cent replacement of corn flour with quinoa flour had higher sensory scores of 8.52 (appearance), 8.93 (colour), 8.57 (flavour), 8.68 (taste), 8.76 (texture) and 8.89 (overall acceptability), respectively. Further, it had high protein (13.12g), fiber (8.83g) and ash (3.92g) with low CHO (50.41g) and energy content (396 kcal/100 g). The maximum shelf life of the products was 90 days under the storage conditions studied. Hence, 100 per cent quinoa flour could be replaced with corn flour in developing nutritious *nachos*.

Keywords : *Nachos*, Quinoa flour, Sensory evaluation, Nutritive value, Storage study

Snacks have gained importance and acceptability worldwide in recent years and are now part of the contemporary culture. As deep-fat fried products form the largest group of the marketed snack foods in India and are well known for their crunchy texture and fried aroma (Kulkarni *et al*., 1994). The deep fat fried snacks, which evolved as snacks between meals in India. These have been commercially explored on a wide scale due to improved living standards, urbanization, preference of new generation for fast foods and rise in per capita income. Typically, snacks are calorie dense foods consisting of high carbohydrate and fat content but with respect to the amount of protein content, they have low nutritional value. Because, they traditionally provide less than 2 per cent of the protein requirement and are referred to as foods that provide 'empty calories' (Almeida-Dominguez *et al*., 1990). The current trend in the food industry is to produce more nutritive snacks, rather than try to eliminate snacks from the diet, largely because of their economic value. Incorporating nutrients directly into snacks is an important means of ensuring consumers to have healthy dietary choices. Currently consumer shift their dietary habits towards healthier food options, especially those which convey an adequate intake of nutrients and present therapeutic effects. Recently, the researcher's worldwide shown keen interest towards exploring underutilized grains and pseudo cereals for their health potential and future in the food industry, one among them is quinoa.

Quinoa is a stress-tolerant pseudo cereal was known as the 'golden grain' by the native Andean people and used by the Inca (ruling class) people since 5,000 B.C and has been a source of valuable food over thousands of years. It comprises a treasure trove of nutrients, with high protein content (16-18%) that higher than other cereals with more than 37 per cent of essential amino acids, that can be an alternative to milk proteins (Abugoch *et al.,* 2009). Its protein is exceptionally

high in lysine and good source of methionine and cystine which are low in legumes (Anand *et al.,* 2021). In addition, this 'wonder grain' is gluten free. High dietary fiber, B-vitamins, minerals and bioactive constituents such as phenolic compounds, antioxidants and flavonoids are the other constituents present in this grain. Quinoa is considered as a functional food, that is, a food that promotes human health and longevity beyond the classical understanding of physiological homeostasis offered by sufficient macro and micronutrient intake (Graf *et al.,* 2015). Further, Food and Agricultural Organization has brought quinoa to the world stage for its potentials to address food and nutrition security and even declared 2013 as the 'International Year of Quinoa'. Thus, it can be a boon for today's generation to overcome overweight and obesity. Owing to the therapeutic benefits, variety of food products can be prepared that not only add variety to the diet but also offers numerous desirable nutritional and health benefits. However, no reports are available for incorporation of quinoa flour in deep fat fried snack products like *nachos*. As *nachos* is a novel delicious easy to cook snack. It is an appetizer with great taste and enjoyable by all age groups. So, an attempt was made to replace major ingredients in the preparation of *nachos* with quinoa flour. Hence, the present study was undertaken with objective to formulate and evaluate quinoa based *nachos*.

Material and Methods

Procurement of Raw Material

Quinoa was procured from Kilaru Naturals Private Limited, Hyderabad, Telangana State. Other ingredients were obtained from local market of Bengaluru.

Processing of Quinoa

Quinoa grains were cleaned and soaked for 4 hrs in 2 per cent salt solution, followed by washing and draining excess water. Then quinoa grains were tied in muslin cloth and germinated for 24 hrs at ambient temperature. Further, germinated quinoa was kept for drying at 50°C for 2 hours. The dried grains were powdered in a flour mill and flour was passed through 300 µ mesh to get uniform particle size flour. It was packed in polyethylene food grade pouches and stored in air tight container for further use.

Product Development

The standardized recipe was used for the replacement of main ingredient with quinoa flour to prepare *nachos* (Fig. 1). Quinoa nachos were developed by replacing corn flour with quinoa flour at 25, 50, 75 and 100 per cent (Moreira *et al.,* 2015). Best accepted formulation was further taken for analysis.

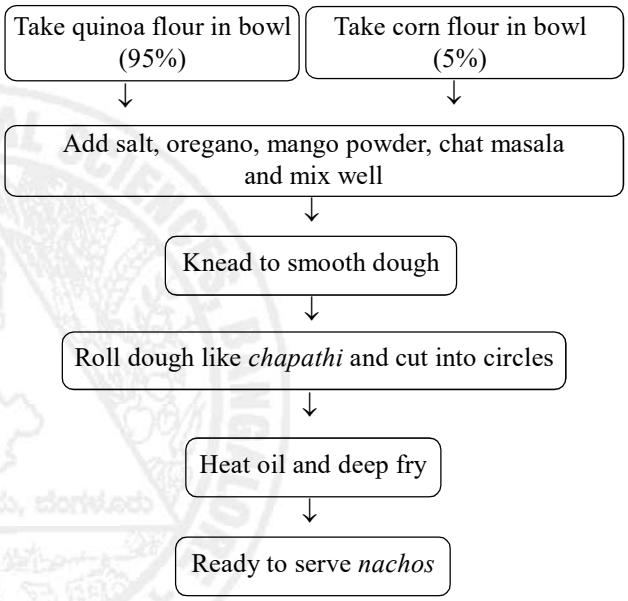

Fig. 1 : Protocol for development of *nachos*

Sensory Evaluation of Developed Products

The organoleptic evaluation was conducted using 9-point hedonic scale (Ranganna, 2002) by 15 trained panel members. The products were evaluated for the appearance, color, texture, taste, flavour and overall acceptability.

Proximate Composition of Quinoa *Nachos*

Best accepted formulation of quinoa *nachos* was analysed for the moisture, protein, fat, fibre and ash using standard protocols (Anonymous, 2005) in triplicates. Further, carbohydrate was computed by difference method and minerals were analyzed by atomic absorption spectroscopy.

Storage Study of Quinoa *Nachos*

Storage stability of best accepted quinoa *nachos* was studied at ambient condition 25-30^{0}C in Department of Food Science and Nutrition (GKVK, Bengaluru) by storing them in Low-density polyethylene (LDPE) pouches for three months. The stored products were analyzed at regular intervals *i.e.,* 0, 30, 60 and 90 days, further evaluated for changes in moisture, free fatty acid (FFA), peroxide value (PV) and sensory parameters.

Statistical Analysis

Mean and standard deviation was calculated using the SPSS 16.0 software (SPSS for Windows, Version 16.0. Chicago, USA, SPSS Inc.). One way ANOVA was used to test the significance of the data.

Results and Discussion

Sensory scores of *nachos* prepared with different level of incorporation of quinoa flour are shown in Table 1. Highly significant difference was observed in colour, flavour, taste, texture and overall acceptability of *nachos* with different level of incorporation. As the level of quinoa flour increased, sensory scores also increased. However, scores for appearance, colour, flavour, taste, texture and overall acceptability of *nachos* prepared with 100 per cent corn flour incorporation had low scores (7.04, 7.66, 7.03, 6.72, 7.11 and 6.94, respectively) which was liked moderately by panel of judges. Whereas, *nachos* prepared with 100 per cent replacement of quinoa flour received significantly higher scores for appearance (8.52), colour (8.93), flavour (8.57), taste (8.68), texture (8.76) and overall acceptability (8.89) which was liked very much by the panel of judges. This resulted in raise in acceptability indices from 77.36 at 100 per cent corn flour incorporation to 95.64 at 100 per cent quinoa flour incorporation, which was highly acceptable when compared to control. Similarly, study was carried by Ochoa-Martínez *et al.* (2016) reported that increase in bean flour concentration increased chips taste, texture and crispness, which is a critical parameter for chips quality. The crispness values observed in all the bean incorporated samples were higher than the values for a commercial product (Doritos corn *nachos*).

Similarly, Pritham *et al.* (2021) developed beverage mix by incorporating quinoa flour at four levels (25, 50, 75 and 100%). Researcher found that, flavour, taste, texture and overall acceptability were improved with higher per cent of quinoa incorporation. Inline, Chanu and Shivaleela, 2019 stated that germination and soaking also affects the nutrient content and sensory parameters. It may be due to the germination which increases the sugar levels and decreases

Table 1

Sensory scores of *nachos* developed with quinoa flour

Level of incorporation (CF: QF)	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability	AI
100 : 0	7.04 ± 0.72 ^{c}	7.03 ± 0.31 ^{c}	6.72 ± 0.43 ^{d}	7.11 ± 0.71 ^{d}	6.94 ± 0.51 ^{d}	6.99 ± 0.38 ^{d}	77.36
75 : 25	8.00 ± 0.21 ^{b}	7.62 ± 0.33 ^{b}	7.02 ± 0.71 ^{c}	7.26 ± 0.16 ^{c}	7.32 ± 0.42 ^{c}	7.14 ± 0.41 ^{c}	82.31
50 : 50	8.09 ± 0.25 ^{b}	8.20 ± 0.41 ^{b}	7.62 ± 0.59 ^{c}	7.54 ± 0.49 ^{c}	7.59 ± 0.39 ^{c}	7.89 ± 0.39 ^{b}	83.24
25 : 75	8.15 ± 0.49 ^{b}	8.26 ± 0.22 ^{b}	8.15 ± 0.23 ^{b}	8.24 ± 0.36 ^{b}	8.18 ± 0.38 ^{b}	8.19 ± 0.21 ^{b}	89.78
0 :100	8.52 ± 0.51 ^{a}	8.93 ± 0.43 ^{a}	8.57 ± 0.63 ^{a}	8.68 ± 0.63 ^{a}	8.76 ± 0.48 ^{a}	8.89 ± 0.39 ^{a}	95.64
F Value	13.04	23.28	11.21	19.63	16.12	27.23	
SEM	0.11	0.09	0.12	0.11	0.10	0.09	
CD	0.32 *	0.27 **	0.35 **	0.32 **	0.30 **	0.27 **	

Note : QF- Quinoa flour, CF- Corn Flour, AI- Acceptability Index, *significant @ 5%, ** Highly significant @ 1%.
Average of 15 judges. Means with same superscript do not differ significantly.

The Mysore Journal of Agricultural Sciences

saponins. This further reduced the bitter taste of quinoa. In a comparison study by Diaz *et al*. (2013), the hardness of corn snacks containing 20 per cent quinoa flour was lower than that of snacks of 100 per cent corn flour. This may be due to the presence of other components, reducing the interactions among starch and proteins.

Nutritive Value of *Nachos*

Data presented in Table 2 shows that nutrient composition of *nachos*. Carbohydrate content was reported to be high in corn *nachos* (66.08 g/100g) and low in quinoa *nachos* (50.41 g/100g). Maximum amount of protein (13.12g) and fat (20.17g) was recorded in quinoa *nachos* compared to corn *nachos*. However, quinoa *nachos* provided higher amount of fiber and ash (8.83 and 3.92 g/100g) than corn *nachos* (4.03 and 1.67 g/100g). The energy content of *nachos* was 489 kcal (corn *nachos*) and 396 kcal (quinoa *nachos*). Results were on par with the study reported by Lopez-Martinez *et al*. (2019), where legume mixture incorporation in *nachos* increased protein, fiber and ash content and decreased the CHO content. Present data on macro and micro nutrients in processed quinoa highlighted superiority of nutrients which are comparable to pulses. Hence, quinoa could be used as a functional ingredient to avoid occurrence of chronic diseases which are associated with CHO rich diets, as it is well known that diets high in carbohydrates are associated with chronic diseases. An energy-restricted, low-fat and low-carbohydrate but high-protein diet provides nutritional and metabolic benefits that are equal to or sometimes greater than those observed with a high-carbohydrate diet (Noakes *et al*., 2005).

Mean sensory scores of *nachos* stored at ambient condition are represented in Table 3. It shows that a significant difference was found among two variations. As the storage period increased gradual decrease in the sensory scores was observed from initial to the 90th day. While, no significant difference ($p<0.05$) were observed in appearance and colour from initial to 90 days of storage. However, T1 sample had mean sensory scores of 5.76, 5.98, 5.32 and 6.32 for flavour, taste, texture and overall acceptability respectively. Conversely, T2 had scores of 6.78 (flavour), 6.46 (taste), 6.32 (texture) and 7.12 (overall acceptability) after 90 days of storage. It was evident from sensory evaluation that even after 90 days of storage period T2 was liked moderately, whereas T1 was liked slightly by the panel members. Sensory score for flavor, taste, texture and overall acceptability (OAA) was significantly reduced as the storage period increased; this was significantly evident in corn *nachos*as against to quinoa *nachos*. This may be due to rancid flavor that was reported in products after 90 days of storage. Rancid flavor may be due to increase in FFA (%) during storage, similar trend was reported by Tiwari *et al*. (2011).

It is observed from the Table 4 that, moisture content ranged between 4.08 and 9.06 for T1 (Corn *nachos*), while 3.06 to 7.98 per cent for T2 (Quinoa *nachos*) from initial to 90 days of storage, respectively. However, moisture gain for both samples was linearly

TABLE 2

Proximate composition of *nachos* (per 100g)*

Nachos	Moisture (%)	Protein (g)	Fat (g)	Fiber (g)	Ash (g)	CHO (g)	Energy (K cal)
T1	4.18 ± 0.43	5.08 ± 0.42	19.02 ± 0.32	4.03 ± 0.09	1.67 ± 0.14	66.08 ± 0.61	489.21 ± 0.96
T2	3.02 ± 0.50	13.12 ± 0.22	20.17 ± 0.21	8.83 ± 0.51	3.92 ± 0.56	50.41 ± 0.42	396.32 ± 0.21
F value	*	*	*	*	*	*	*
SEM	0.04	0.12	0.02	0.06	0.12	0.14	0.17
CD at 5% level	0.21	1.32	0.30	0.62	0.49	0.32	0.61

Note : T1 - Corn *nachos*, T2 - Quinoa *nachos*, * - Significant at 5% level

TABLE 3
Sensory evaluation of *nachos* on storage

Product	Duration	Apperance	Colour	Flavour	Taste	Texture	OA
	Initial	7.56	7.98	7.97	7.68	7.76	7.92
	30th day	7.43	7.63	7.31	7.02	7.29	7.37
	60th day	7.49	7.44	6.42	6.32	6.20	6.49
T1	90th day	7.32	7.24	5.76	5.98	5.32	6.32
	F value	NS	NS	*	*	*	*
	SEm±	0.32	0.35	0.14	0.13	0.10	0.12
	CD at 5%	-	-	0.31	0.49	0.32	0.38
	Initial	8.58	8.78	8.62	8.73	8.89	8.91
	30th day	8.47	8.63	7.92	7.63	7.58	7.80
	60th day	8.32	8.45	7.03	7.32	7.02	7.49
T2	90th day	8.16	8.11	6.78	6.46	6.32	7.12
	F value	NS	NS	*	*	*	*
	SEm±	0.30	0.32	0.13	0.12	0.16	0.12
	CD at 5%	-	-	0.42	0.40	0.41	0.34

Note : T1- Corn *nachos*, T2 - Quinoa *nachos,* NS-Non significant, *-Significant at 5% level

correlated with storage period which might be due to storage conditions and packaging material used. Wherein, moisture absorption during storage leads to quality degradation in terms of hydrolytic rancidity and sensory attributes such as texture. Crispiness is lost if excess moisture is absorbed (aw>0.35–0.50) for crisp snack foods such as chips and popped popcorn (Katz and Labuza, 1981). Crispiness of snack foods is desirable, but due to moisture absorption, it causes sogginess, ultimately leading to rejection of the product (Taoukis *et al*., 1988). Moisture absorption by the product reduces its shelf life, as it gives medium for microbial growth, acceptability of the product and development of off-flavor due to hydrolytic rancidity (Labuza and Schmidl, 1985).

Similar to moisture, FFA was found to be increased with storage period for T1 (0.18 to 0.92) and T2 (0.14 to 0.81), respectively. Free fatty acids significantly increased during storage period, but remained in safe level, making *nachos* acceptable till the end of 3 months. When compared, corn *nachos* reported significantly higher FFA value than quinoa *nachos* sample over a period of 0-90 days. However, in both the samples, free fatty acid content increased on storage. This may be due to hydrolysis of triglycerides, mainly because of lipase enzymes or non-enzymatic reactions at high temperatures (Camire *et al*., 1990). Products were acceptable till 3 months of storage as FFA value was below 1 per cent. As it is generally accepted that, when FFA content >1 per cent in fried product is not fit for consumption (Erickson and Frey, 1994). Inline, high levels of FFA directly correlate to off-colours, off-odours and off-flavours in fried product.

Peroxide value is an important quality attribute. It measures the amount of hydro peroxides and used as indicator of lipid oxidation (Gray, 1978). Peroxide value (PV) of the products increased from 0, 30, 60 and 90 days of storage for T1 (0.56, 1.62, 2.73 and 3.04) and T2 (0.50, 1.21, 2.26 and 3.02) samples, respectively. Throughout the storage period, an increasing trend was observed for PV in the products.

TABLE 4
Storage stability of *nachos*

Nachos	Storage days											
	Moisture (%)				FFA (as oleic acid %)				PV (meq/kg of fat)			
	0	30	60	90	0	30	60	90	0	30	60	90
T1	4.08 ± 0.43	6.12 ± 0.19	7.48 ± 0.21	9.06 ± 0.32	0.18 ± 0.14	0.39 ± 0.15	0.64 ± 0.31	0.92 ± 0.07	0.56 ± 0.12	1.62 ± 0.02	2.73 ± 0.26	3.04 ± 0.12
T2	3.06 ± 0.50	5.02 ± 0.24	6.38 ± 0.38	7.98 ± 0.50	0.14 ± 0.05	0.31 ± 0.06	0.52 ± 0.22	0.81 ± 0.41	0.50 ± 0.16	1.21 ± 0.31	2.26 ± 0.11	3.02 ± 0.11

Note : T1- Corn *nachos*, T2 - Quinoa *nachos.* OA-Overall acceptability, NS-Non significant, *-Significant at 5% level

This may be due to the development of primary oxidation products. It has been shown that, products can be consumed if the peroxide level is <5 meq/kg of oil (Tiwari *et al.*, 2011). Henceforth, both the stored samples were found to be having less peroxide value and considered safe at the end of 90 days storage.

From the present study, it could be concluded that quinoa *nachos* developed from 100 per cent of quinoa flour had better organoleptic properties. Conversely, it is highly nutritious snack with low CHO, high protein, fiber and mineral content. Quinoa *nachos* are very much suitable for children, adolescents and elders. The snack can be stored for three month at ambient temperature, when packed in LDPE pouches. Hence, quinoa flour can be successfully used in snacks such as *nachos* with high nutritional value and nutraceutical benefits. Thus, it can be encouraged in processing industry.

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