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Development of value added products from quinoa using different cooking methods

Supriya Kavali, Shobha D, Shekhara Naik R and Brundha AR

Abstract
The present study was conducted to test the suitability of quinoa for the preparation of value added products with different cooking methods such as boiling (Upma and Kesaribath), roasting (Laddu and Chikki) and frying (Chakli and Nippattu). Different pre-treatment methods (normal water washing, hot water washing, citric acid soaking and sodium bicarbonate soaking) were tried in order to select the best method in terms of bitternness reduction. Among the four different pre treatments, sodium bicarbonate (1%) soaked quinoa was found to be best accepted in terms of bitterness reduction. Using quinoa, different products were standerdized in the following per centages (100, 90 80, 70, 60%) with other ingredients (0, 10, 20, 30, 40%) for Upma, Kesaribth, laddu and chikki. While Nippattu and Chakli in the combination of 90:10, 80:20, 70:30, 60:40 and 50:50 of quinoa with other ingredients. Among the variations tested, Upma, Kesaribath, laddu and chikki were acceptable in the ratio of 60:40 while Chakli and Nippattu were acceptable in the ratio of 50:50 by semi trained judges on a nine point headonic scale.

Keywords: Quinoa, Upma, Kesaribath, Chakli, Nippattu, Laddu, Chikki

1. Introduction
Quinoa (*Chenopodium quinoa Wild*) is a one of the pseudo cereal with starchy dicotyledonous seed. Botanically belongs to the class Dicotyledoneae, family *Chenopodiaceae*, genus *Chenopodium* and species *quinoa*. Quinoa plant is an annual broad-leaved plant with 1-2 m height and having deep penetrating roots. It can be cultivated from sea level up to the height of 4000 m and it can also grown in hot, desert and dry climate. This is able to grow in relative humidity ranging from 40-88% and it can survive in the temperature ranging from -4^{0}C to 38 ^{0}C. In the Andean region, quinoa seed is one of the oldest crops with approximately having 7000 years of cultivation history. This ancient crop was domesticated and conserved in Peru by both Incas and Tiahuanaus culture. The Argentinian, archaeological finding indicated the presence of quinoa around the beginning of the Chrisition era. Plants of the Quinoa was widely cultivated in Pre-Columbian cultures (Sharma *et al*., 2015) [18]. Quinoa plant is tolerant to acidic conditions of the soil (pH 6.0 to 8.5). This plant is drought resistant and can be grown at annual rainfall 200-400 mm. Planting season varies based on the area of cultivation. In Andean highlands it is cultivated during of August extending through December and in some other area of the world it is from January to March. Quinoa is harvested at the physiological maturity i.e when grains become dry and hard and it is difficult to break with finger nail. Yield of quinoa in the range of 45-500 g/m^2 is dependent on both variety and growing conditions (Jancurova., *et al* 2009) [7]. Traditionally quinoa was consumed in the highlands of the Andes in South America and also it attained popularity as health food in North America, Europe, Australia, Japan and India. At present quinoa is cultivated in 95 countries of the world (Shilpi *et al*., 2016). Both Bolivia and Peru are the largest exporter of quinoa accounting for 88% of worldwide production (Janarova *et al.*, 2009) [7]. It is one of the complete food, because it is richest source of good quality protein, lipid and it contains starch, minerals and vitamins such as C and E (Nisar *et al*., 2018) [11]. Quinoa is also good source of amino acids such as lysine (5.1-6.4%) and methionine (0.4-1.0%) which are difficient in other creals and pulses. It is considered as gluten free grain as it contains very little or no prolamin. Quinoa is one of the functional food and is known to lower the risk of various diseases such as celiac disease and exerting health promoting effects (Abdelazim, 2018) [1]. Besides nutrients, Quinoa also contains bitter and toxic compound such as saponins especially it is present on hull part of the grain. Therefore, before using this it must be dehulled or polished and washed (Sharma and Lakhawat, 2017) [17]. Despite all these attributes, still quinoa has little usage as food because of the high cost of the imported grain and also there is little knowledge about its health benefits by most of the consumer.

Food and Agriculture Organization selected quinoa has one of the crop destined to offer food security in the 21st century, because it is tolerant to conditions like drought, stress, salinity and can also grown on marginal region. The United Nations (UN) had declared 2013 as the International year of quinoa, with an aim to focus global attention on food security, nutrition and poverty eradication (Sharma and Lakhawat, 2017) [17].

Traditional Indian foods are very nutritious and tasty and help to effective utilization of natural resources and minimize the waste. Majorly rice and wheat are used as a traditional foods followed by coarse grains such as sorghum, maize, finger millet and many more millet family members. Some of the ingredients used in the traditional foods which known to be considered as functional includes dietary fiber, vitamins and minerals, oligosaccharides, lignins, essential fatty acids, flavonoids, miscellaneous phytochemicals, and lactic acid bacterial cultures. The Indian traditional foods impart beneficial effects on human physiology beyond providing adequate nutrition. The health benefits of traditional foods thus derived may range from ensuring normal physiological functions in the body such as improving gastrointestinal health, enhancing the immune system, weight management and providing better skeletal health, among others in order to reduce blood cholesterol level, oxidative stress and reduce the risk of cardiovascular diseases, inflammatory diseases, various types of cancer and possible prevention of diabetes and neurodegenerative diseases (Srinivasan, 2010) [21]. Many traditional foods from coarse grains such as sorghum, maize, millets are already popular among larger mass. However, pseudo cereal like quinoa needs attention of consumers beacause of its superior nutritious quality in terms of protein, esssential amino acids and minerals such as calcium and iron which lends itself a gluten free nutritious alternative for routein dietary alternative. Many researchers around the world have reported majorly on quinoa based confectionaries such as cookies (Nisar *et al*., 2018) [11] pasta (Mostafa, 2017) [10] beverages (Kaur and Tanwar, 2016) [8] bread (Salazar *et al***.,** 2017) [15] snack items (Priyanka *et al.,* 2017) [20]. However still there is a lot of scope exists for testing of quinoa incorporation in traditional products. Hence, study was undertaken to assess the suitability of quinoa in preparation of traditional food items under different cooking methods.

2. Materials and Methods

2.1 Procurement of Raw materials

Good quality quinoa were procured from Dhatu organics and naturals, organic food store Mysore and other ingredients were purchased from local market in a single lot.

2.2 Processing of raw materials

Quinoa grains were cleaned by manual method to remove the dust and other unwanted materials and were subjected to different pre-treatments to reduce the bitter component present in the grain. The different treatments were followed below:

a) Hot water treatment: Quinoa were washed in hot water (84.4^0C) and drained followed by sun drying for 12-18 hours (Garsa, 2016) [5].

b) Normal water treatment: Quinoa were washed in normal water ($24.4\ ^0$C) and drained followed by sun drying for 12-18 hours (Garsa, 2016) [5].

c) Citric acid treatment: Quinoa grains were soaked in 0.5 and 1% citric acid for 6 hours followed by draining, washing with running tap water for 2-3 times and sun drying until completely dried (Nisar *et al*., 2018) [11].

d) Sodium bicarbonate treatment: Quinoa grains were soaked in 0.5 and 1% sodium bicarbonate for 6 hours, drained and grains were washed with running tap water for 2-3 times followed by sun drying. This is modification of Nisar *et al* (2018) [11] method.

After drying, pre-treated quinoa grains were milled to get fine flour of 250 µm (60 BS mesh sieve) using domestic flour mill. Chapathis were prepared from above pre treatment flours to test the level of bitterness reduction. To check the bitterness reduction chapathis were prepared and served to 15 panel members and instructed them to mark +++ for good reduction in bitterness, ++ for moderate bitterness and + for slight bittterness.

2.3 Formulation of products

Product were developed by incorporation of quinoa using different cooking methods, under boiling method Upma and Kesaribath were standardized at different ratios 100:0, 90:10, 80:20, 70:30, 60:40 (quinoa: semolina), while under frying method, Chakli and Nippattu were standardized at ratios 90:10, 80:20, 70:30, 60:40, 50:50 (quinoa flour: rice flour) in roasting method laddu and chikki were standardized at different ratio 100:0, 90:10, 80:20, 70:30, 60:40 as shown below.

Table 1: Formulation of boiled products (Upma and Kesaribath) and fried products (Chakli and Nippattu)

Upma and Kesaribath			Chakli and Nippattu		
Variations	**Wheat semolina**	**Quinoa semolina**	**Variations**	**Rice flour**	**Quinoa flour**
T0	100	0	T0	100	0
T1	0	100	T1	10	90
T2	10	90	T2	20	80
T3	20	80	T3	30	70
T4	30	70	T4	40	60
T5	40	60	T5	50	50

Table 2: Formulation of roasted products (Laddu and Chikki)

Laddu			Chikki		
Sample	**Besan flour**	**Quinoa flour**	**Sample**	**Groundnut**	**Quinoa**
T0	100	0	T0	100	0
T1	0	100	T1	0	100
T2	10	90	T2	10	90
T3	20	80	T3	20	80
T4	30	70	T4	30	70
T5	40	60	T5	40	60

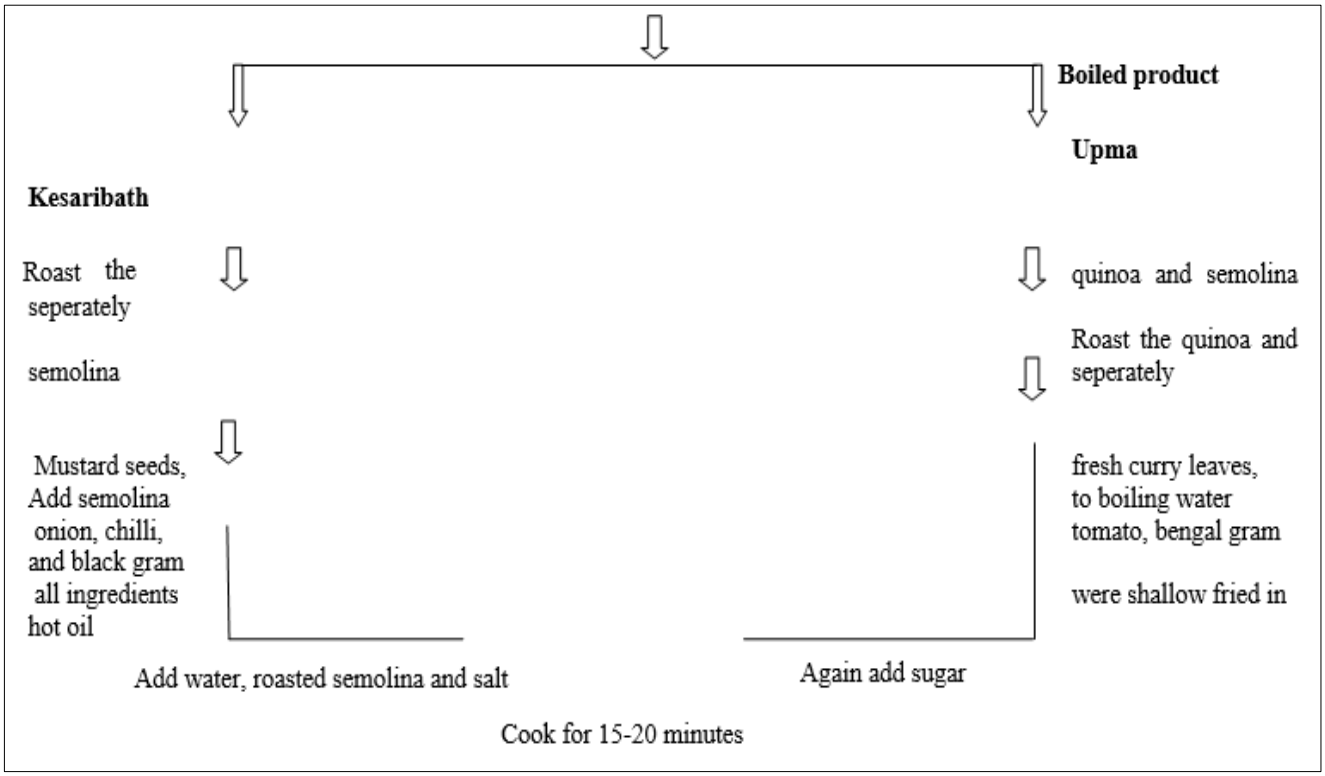

Fig 1: Flow chart for prepation of quinoa Upma and Kesaribath

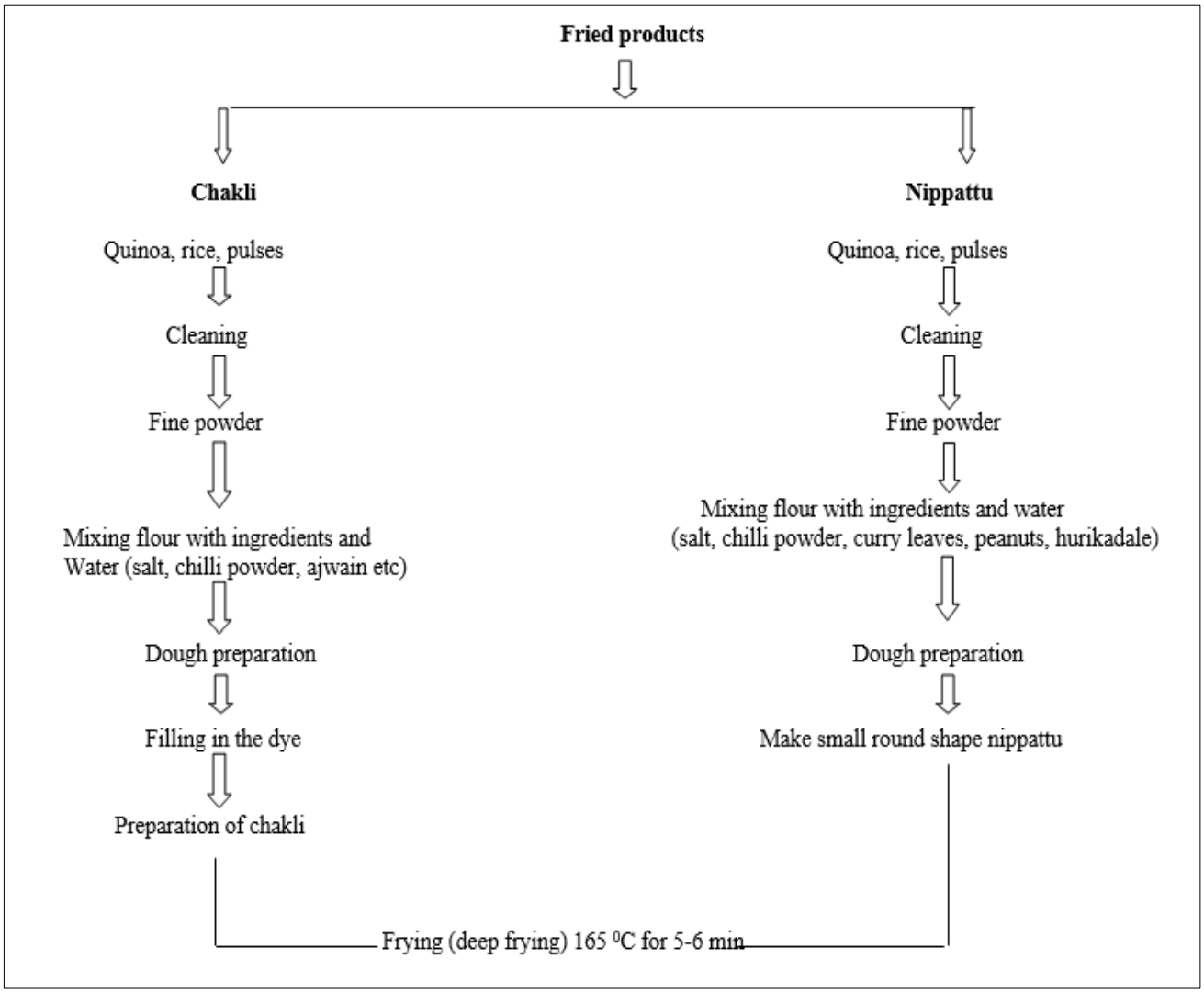

Fig 2: Flow chart for preparation of quinoa Chakli and Nippattu

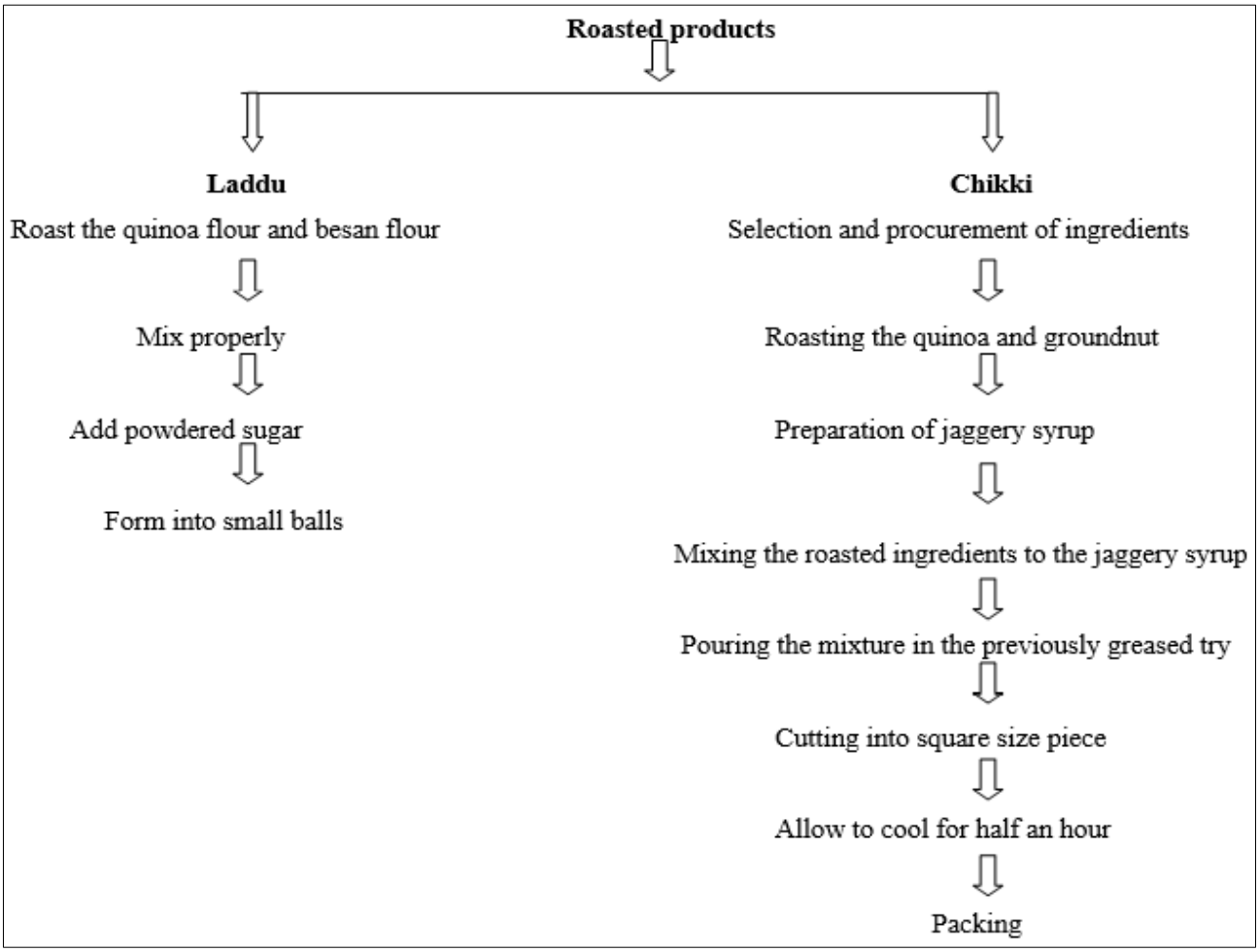

Fig 3: Flow chart for preparation of quinoa laddu and chikki

2.4 Sensory evaluation of developed products

Developed products were evaluated by 21 semi trained panel members. Parameter consider for evaluation were appearance, colour, texture, flavour, taste and overall acceptability on 9 point hedanic scale, where 9 indicates extreme liking, 8 - very much liking, 7 - moderate liking, 6 - like slightly, 5 - neither like nor dislike, 4 - dislike slightly, 3- dislike moderately, 2 - dislike very much, and 1 - dislike extremely (Shobha and Neena, 2016) [3]

2.5 Statistical analysis: data were analysed in triplicates for calculation of mean and standard deviation.

3. Result and Discussion

Table 3: Effect of pre-treatments on the level of bitterness reduction in quinoa

Pre- treatment	Normal water washing	Hot water washing	Citric acid soaking		Sodium bicarbonate soaking	
			(0.5%)	(1%)	(0.5%)	(1%)
Bitterness reduction	+	+ +	-_	+	+ +	+ + +

(n=15)
No reduction in bitterness
+: Slightly bitter
+ + Moderately bitter
+ + +: Good reduction in bitterness

The different pre treatment methods (hot water, normal water, 0.5 and 1% citric acid, 0.5 and 1% sodium bicarbonate) were employed for the quinoa grains to remove the bitterness, among the tested pre treatments, 1% sodium bicarbonate soaked grains showed more reduction of bitterness in chapathis prepared out of quinoa flour.

3.1 Development of Quinoa product with different cooking methods

Different quinoa incorporated products were standardised with different cooking methods such as boiling, frying, roasting and steaming.

Table 4: Sensory evaluation scores of quinoa incorporated boiled products with different level of Quinoa incorporation

Product Name	Parameters	Control	100:0	90:10	80:20	70:30	60:40
Upma	Appearance	8.3±0.67	7.16±0.95	7.4±0.96	7.8±0.56	7.98±0.59	8.0±0.81
	Colour	8.2±0.78	7.46±0.66	7.63±0.96	7.55±0.95	7.99±0.65	8.0±0.81
	Texture	8.05±0.83	7.55±0.76	7.54±0.69	7.52±0.94	7.89±0.98	7.9±0.87

	Flavour	8.5±0.52	7.15±0.66	7.15±0.81	7.08±0.95	7.34±0.98	7.8±0.63
	Taste	8.15±0.66	7.57±0.63	7.7±0.92	7.9±0.87	8±0.94	8.0±0.59
	OAA	8.1±0.99	7.61±0.94	7.78±0.79	7.7±0.95	7.76±0.86	7.8±0.91
Kesaribath	Appearance	8.02±0.76	7.11±0.70	7.16±0.95	7.15±0.57	7.45±0.72	7.9±0.88
	Colour	8.23±0.80	7.15±0.8	7.03±0.81	7.11±0.86	7.49±0.57	7.7±0.89
	Texture	7.83±0.96	7.16±0.6	7±0.94	7.36±0.86	7.45±0.52	7.52±0.81
	Flavour	8.02±0.90	7.09±0.94	7.02±0.78	7.21±0.84	7.22±0.75	7.89±0.80
	Taste	7.87±0.90	7.06±0.94	7.02±0.71	7.25±0.87	7.40±0.49	7.6±0.98
	OAA	7.83±0.81	7.04±0.74	7.02±0.66	7.36±0.90	7.5±0.67	7.7±0.90

Value are mean ± SD of 21 panel members
Ratio of quinoa semolina: wheat semolina (100:0, 90:10, 80:20, 70:30, 60:40)

The scores of sensory evaluation of quinoa incorporated Upma and Kesaribath prepared with different ratios (100:0, 90:10, 80:20, 70:30, 60:40) along with control is depicted in Table 4. Among the different variation tested, 60 per cent quinoa incorporated Upma and Kesaribath were accepted with highest scores by panel members. While 60% quinoa incorporated Upma and Kesaribath had sensory scores for appearance (8.0, 7.9) colour (8.0, 7.7) texture (7.9, 7.5) flavour (7.8, 7.8) taste (8.0, 7.6) overall acceptability (7.8, 7.7). Control Upma and Kesaribath received high score for colour but in 100% and 90% quinoa incorporated Upma and Kesaribath had received low score which may be beacause of dull colour. Similar study conducted by Shaivya and Sunita, (2016) [16] on Quinoa Upma mix with 75% Quinoa as a basic ingredient found to be acceptable in sensory parameters. However, another study conducted by Sajeev *et al*., (2015) [14] revealed that south Indian recipes such as idli, dosa, puttu, Kolukattai, Idiyappam, Adai, Upma were developed by incorporation of tribulus terrestris fruit powder in various levels (10, 20, 30%) indicated that incorporation of 10% was accepted by panel members. Instant Upma mix was developed by foxtail millet semolina and garden cress semolina at various level 80:5, 75:10, 70:15, 65:20 indicated that 75:10 was found to be accepted as discribed by Rodge *et al*., (2018) [20].

Table 5: sensory evaluation scores of quinoa incorporated fried products with different level of Quinoa incorporation

Product Name	Parameters	Control	90:10	80:20	70:30	60:40	50:50
Chakli	Appearance	8.28±0.71	5.1±0.56	5.14±0.85	5.97±0.98	7.1±0.73	7.14±0.79
	Colour	8.38±0.80	5.±0.66	5.09±0.94	5.80±0.99	6.2±0.78	6.95±0.92
	Texture	8.14±0.72	5.1±0.56	5.19±0.87	6.09±0.94	6.5±0.84	6.77±0.93
	Flavour	8.04±0.86	5.2±0.63	5.23±0.88	6.2±0.93	7±0.66	7.19±0.96
	Taste	8.23±0.83	4.9±0.56	4.97±0.98	6.19±0.91	6.6±0.51	6.88±0.89
	OAA	8.33±0.73	5.1±0.87	5.23±0.93	6.02±0.92	7±0.81	7.14±0.79
Nippattu	Appearance	8.38±0.74	6.5±0.52	6.76±0.87	6.97±0.90	7.2±0.63	7.77±0.83
	Colour	8.40±0.86	6±0.47	6.11±0.97	7.16±0.92	7.3±0.67	7.59±0.94
	Texture	8.42±0.87	6.1±0.56	6.25±0.95	6.87±0.93	6.9±0.73	7.01±0.73
	Flavour	8.14±0.85	6.2±0.42	6.37±0.92	7.05±0.98	7.4±0.51	7.50±0.96
	Taste	8.47±0.92	6.4±0.69	6.57±0.95	7.15±0.98	7.5±0.97	7.74±0.96
	OAA	8.59±0.66	6.5±0.52	6.7±0.83	7.22±0.93	7.7±0.48	7.88±0.95

Value are mean ± SD of 21 panel members
Ratio of quinoa flour: rice flour (90:10, 80:20, 70:30, 60:40, 50:50)

The overall sensory score for fried product (Chakli and Nippattu) were shown in Table 5. Quinoa flour and rice flour were used to develop products in different ratio (90:10, 80:20, 70:30, 60:40, 50:50) along with control. Among different level of incorporation, 50 per cent quinoa incorporated was found to be accepted by 21 panel members compared to control ratios. Sensory scores for 50 per cent quinoa incorporated Chakli and Nippattu received better sensory score for Appearence (7.14, 7.77) colour (6.95, 7.59) texture (6.77, 7.01) flavour (7.19, 7.50) taste (6.88, 7.74) and overall acceptability (7.14, 7.88). In both fried products quinoa incorporation leads to hard in texture which may be because, low starch content in quinoa and incorporation of quinoa severely affected the textural properties even the quinoa incorporated products were dark brown in colour due to its natural colour of the grains. This is supported by study Veena *et al*., (2003) they reported as the incorporation of millet increases the colour of the product and decreases texture. Even chavan *et al*., (2016) [22] developed sorghum Chakli at different variation 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90, 0:100. In all the variation 40:60 (Chakli mix: sorghum flour) exibited best crispiness and addition of pulses improves the appereance and extrusion quality due to its water and fat binding capacity. Banka *et al*., (2017) [2] iron rich Chakli was prepared by incorporation of underutilized leaves (5, 10, 15%). Incorporation of 5% was most acceptable and more than 5% leaf powder shows not accepted by panel members due to dark colour.

Table 6: Sensory evaluation scores of quinoa incorporated roasted product with different level of Quinoa incorporation.

Product Name	Parameters	Control	100:0	90:10	80:20	70:30	60:40
Laddu	Appearence	8.58±0.66	7.57±0.94	7.6±0.69	7.66±0.74	7.79±0.78	8.2±0.78
	Colour	8.58±0.51	7.25±0.85	7.2±0.63	7.47±0.73	7.51±0.54	7.7±0.48
	Texture	8.33±0.65	7.31±0.91	7.5±0.52	7.54±0.58	7.66±0.53	8±0.47
	Flavour	8.33±0.77	7.33±0.94	7.7±0.48	7.91±0.68	7.83±0.57	8.1±0.56
	Taste	8.41±0.66	7.5±0.86	7.8±0.42	7.87±0.60	7.9±0.54	8.12±0.73
	OAA	8.45±0.78	7.55±0.78	7.8±0.63	7.91±0.63	7.85±0.71	8.1±0.56
	Appearence	8.4±0.51	7.05±0.79	7±0.39	7.1±0.90	7.2±0.94	7.4±0.51

Chikki	Colour	8.7±0.48	7.15±0.33	7.2±0.63	7.2±0.78	7.37±0.73	7.5±0.70
	Texture	8.8±0.42	7.1±0.56	7.1±0.56	7.15±0.74	7.2±0.78	7.6±0.84
	Flavour	8.5±0.52	7.3±0.67	7.4±0.69	7.4±0.96	7.45±0.76	7.7±0.67
	Taste	8.41±0.58	7.1±0.87	7.1±0.56	7.2±0.78	7.3±0.82	7.4±0.84
	OAA	8.7±0.48	6.97±0.8	7.2±0.63	7.3±0.71	7.48±0.63	7.6±0.51

Value are mean ± SD of 21 panel members
Ratio of quinoa: Besan flour (100:0, 90:10, 80:20, 70:30, 60:40) for laddu
Ratio of quinoa: groundnut (100:0, 90:10, 80:20, 70:30, 60:40) for chikki

The value of sensory evaluation of quinoa incorporated laddu and chikki prepared with different variations (100:0, 90:10, 80:20, 70:30, 60:40) along with control is depicted in Table 6. Among different level of incorporation, 60 per cent incorporation was best accepted by 21 panel members. Quinoa incorporated laddu and chikki had sensory score for appearence (8.2, 7.4) colour (7.7, 7.5) texture (8.08, 7.6) flavour (8.1, 7.7) taste (8.1, 7.4) and overall acceptability (8.19, 7.67). Similar study was conducted by Sharma, (2017) they stated that laddu prepared by using multigrain atta and flax seed at different combination 50:50, 60:40, 70:30, 80:20 (multigrain atta: flax seed). Laddu prepared from 60:40 ratio was better accepted compared to rest of the variation. Even Fatima, (2019) [4] developed laddu by incorporation of foxtail millet and it was acceptable by judges. Developed chikki by the incorporation of the 20% flaxseed reported to be best accepted compared other variations and addition of flaxseed showed increase in colour score of the product reported by Chethana and Sunkireddy, (2011) [13]. Garden cress seeds at 25% level of incorporation was found to be acceptable by semi trained judges as reported by Jain and Grover, (2017) [6].

Under steaming method idli and Kadabu were developed at different ratios 90:10, 80:20, 70:30, 60:40, 50:50 (quinoa: rice) but it was not accepted by panel members.

4. Conclusion

The results of the study indicated that soaking of the quinoa grains in 1% sodium bicarbonate solution and drying was found be best pre-treatment for reduction of bitterness in quinoa products. Among the different cooking Mathods, results of the study indicated that pre treated quinoa grains were found to be suitable for preparation of value added products such as Chakli and Nippattu (fried) at 50% level of quinoa incorporation, in roasting and boiling methods the level of incorporation was up to 60%. Hence study indicated that quinoa can be used as major ingredient in the preparation of break fast and snack food items.

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