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Study on the sensory and nutritional properties of developed food products by the incorporation of Quinoa and Ragi flour

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Abstract

In the present study, the quinoa bar was prepared by combining different proportions of quinoa and ragi flour, as well as various traditional products prepared by incorporating quinoa using various cooking techniques, including baking (cookies), roasting (laddu, khakhara), and frying (mathari). For the various formulations, the quinoa and ragi flour levels varied from 0 to 10, 20, 30, and 40 % for T0, T1, T2, T3, and T4, respectively. In terms of sensory quality, the ratios of 30 % quinoa, 30 % ragi, and 40 % wheat flour or refined flour in khakhara, mathari, and laddu, and 20 % quinoa, 20 % ragi, and 60 % wheat flour in cookies were determined to be acceptable. The sensory features and nutritional content of the manufactured items were examined. It was discovered that quinoa-ragi based products were an excellent source of protein ash, crude fibre, and iron. Thus, ragi and quinoa flour may be effectively exploited as a functional component in the preparation of nutritional quinoa-based food products.

Keywords: khakhara, cookies, laddu, mathari, sensory analysis, nutritional analysis

INTRODUCTION

Due to lifestyle changes, the production and consumption of Ready-to-Eat meals have expanded dramatically in recent years. Attempts are being undertaken to increase the nutritional value of snack foods by altering their nutritive content in response to the rising demand for healthy, natural, and convenient meals among consumers (Kotagi, 2011). Because of busy lifestyles and rising customer demand for short sources of high nutrition and convenience, the food industry has produced products such as nutrition bars (Izzo and Niness, 2001). Multiple components, including cereals, legumes, millets, nuts, sugar, vegetable oil,

and syrups, comprise cereal bars (Lobato et al., 2011). Due to the many health advantages of cereals as a rich source of dietary fibre, antioxidants, and vitamins, the consumption of diets rich in whole grains has increased in recent years. However, the protein quality of grains is poor because they lack lysine. However, the presence of legumes in the diet increases the protein quality of cereals since legumes are high in lysine and because cereal protein is rich in methionine, it complements legume protein (Padmashree et al., 2012). Quinoa is a member of the Chenopodiaceae family and the Chenopodium genus. It is an ancient grain from South America that is considered a "superfood" due to its exceptional nutritional and physiological benefits (Bhathal et al., 2015; James, 2009). Quinoa is recognised as a pseudocereal with a great nutritional value, and its protein quality is exceptional, including all necessary amino acids that are lacking in cereals. Quinoa is recognised as a gluten-free grain because it contains very little or no prolamin (James, 2009). Another distinguishing characteristic of quinoa is that it is ingested by celiac disease patients and utilised in the manufacturing of numerous meals aimed at this demographic (Jacobsen, 2003; Stikic, 2012). Quinoa contains vitamin C, vitamin E, vitamin B complex, minerals including calcium, potassium, iron, magnesium, manganese, and phosphorus, as well as high-quality isoflavones (linoleic and linolenic) and lipids, which provide quinoa with significant antioxidant qualities (Miranda, 2012). The protein content of quinoa ranges between 13.8% and 16.5% (Vega- Gálvez et al., 2010). The amino acid profile of quinoa is comparable to that of rice, with a greater lysine (4.8 g/100 g) and threonine (3.7 g/100 g) protein content, which are the limiting amino acids in traditional cereals such as wheat and maize (Dini et al., 2004). Due to the high-quality protein content of quinoa, it is an ideal diet for treating protein-energy malnutrition on a worldwide scale (Jancurová et al., 2009). Various standard techniques may be used to cook traditional meals that are nutritious, nutrient-dense, and have a longer shelf life. Traditional foods serve an essential role in rural development, especially for small and medium-sized businesses, since they prevent unfair commercial competition (Albayrak and Gunes Erdogan,

2010). For customary preparations in India, several culinary techniques such as boiling, roasting, frying, and steaming were often used. In boiling, food is cooked consistently, protein is denatured, starch is gelatinized, and collagen is hydrolysed, but in frying, food is cooked extremely quickly, resulting in a higher caloric content, enhanced flavour, and suitability for snack foods. In addition, meals prepared by steaming are cooked slowly, are readily digested, and have an excellent nutritional profile (Srilakshmi, 2007). According to the mentioned literature, experts in many regions of the globe have studied the creation of quinoa salad, porridges, soup, and health beverages, and quinoa has lately been utilised to create morning cereals; granola bars (Garcia et al., 2018). Due of its nutritional value, it is utilised to manufacture healthful snacks (Priyanka et al., 2017). Other processed items, include pasta (Mostafa, 2017), biscuits (Ibrahium, 2015), breads (Salazar et al., 2017), and cookies (Nisar et al., 2018). According to reports of research conducted in various parts of the world, products were developed from cereals and pulses using traditional cooking techniques, including RTC upma mix from quinoa (shaivya, 2016), kesaribath from soy semolina (Yadav et al., 2007), laddu from garden cress seed (Uma Rani and Sucharitha, 2016), chikki from multigrains (Abhir (Saiyed and Sengupta, 2014). However, comparative studies of quinoa-ragi containing items prepared with various cooking techniques have not yet been documented. Considering the overall health benefits of quinoa and ragi, as well as the demand from consumers, the present study aimed to develop quinoa- ragi based traditional products by incorporating quinoa and ragi under different cooking methods and evaluating the effect on nutritional, antinutritional, and consumer acceptability. To determine the product's acceptance, the sensory assessment and nutritional content of quinoa and ragi based samples were analysed.

MATERIALS AND METHODS

A. Materials

Raw materials, such as quinoa and ragi seeds, were acquired at the Lucknow local market. The grains were cleaned to remove any foreign debris, dust, dirt, straw, and immature and broken grains.

Pre-treatment and processing of raw materials

To minimise anti-nutritional elements, the quinoa and ragi seeds were rinsed and steeped in a 2% sodium bicarbonate and 1% citric acid solution. The seeds were emptied, cleaned under running water, and allowed to dry. After the pits were removed from the dates, they were steamed for 20 to 25 minutes until they were soft.

Methods

Preparation of quinoa flour and ragi flour

To eliminate anti-nutritional elements, the quinoa and ragi seeds were soaked for six hours in a solution of 2 % sodium bicarbonate and 1 % citric acid containing 2 % sodium bicarbonate and 1 % citric acid. The grains were emptied, rinsed with running water, and let to dry. After drying, quinoa and ragi were roasted at 140 °C for seven minutes and then ground into fine flour. Ragi was milled into fine flour and defatted at 60°C using a Soxhlet extractor and petroleum ether. The acquired flour was roasted in order to enhance the flavour and sensory qualities of items.

B. Sensory evaluation

The sensory assessment of all products was conducted by ten semi-trained panel members using a nine-point hedonic scale. Scores were determined by comparing the sensory qualities of quinoa and ragi products with those of a control sample, including their appearance, colour, flavour, taste, and texture.

C. Proximate composition

The samples of produced quinoa and ragi products were evaluated for their moisture, protein, fat, carbohydrate, ash, and crude fibre content using conventional procedures (AOAC, 2005).

D. Statistical analysis

Multiple replications of each experiment were conducted. Analysis of Variance (ANOVA) with Duncan multiple range tests was performed at a significance level of 0.05 using the statistical software (Minitab 21 software) to assess whether or not there were significant differences between the mean values of each parameter.

E. Preparation method of different food products

1. Mathari

For the preparation of khakhara100 g of refined wheat flour, 2 g of ajwain seeds, salt to taste, and 10 millilitres of refined oil were carefully combined. Use warm water to help you knead hard dough as needed. Chapatti dough should be looser than this. To cut small spherical mathari, divide the dough in half, sprinkle with flour, and stretch out slightly thicker than a poori. To keep the mathari from inflating up, prick it with a fork. Fry the mathari in medium-hot oil over a low flame until it floats and turns golden brown. Ragi and quinoa seed flour were used in place of 10%, 20%, 30%, and 40% of the refined wheat flour while making the composite flour mathari. The mathari samples with the ragi and quinoa flour substitutions were labelled as T0, T1, T2 and T3, and T4, respectively. The remaining steps in the procedure for creating composite mathari were left unchanged from those used to create the control sample.

2. Cookies

Cookies are made by the use of Handa et al. (2012) fundamental formula and procedure were slightly modified to create the control short dough cookies. Using a hand mixer with a whip attachment, 40 g of refined sugar powder (or 250 mg) was combined with 32 g of shortening. The mixture was vigorously whipped for 10 minutes. The cream was then blended once more for two minutes before being added to butylated hydroxy toluene (0.02 g) and flavour (0.5 mL). 100 g of refined wheat flour, 0.8 g of sodium chloride, 0.4 g of sodium bicarbonate, and 0.2 g of ammonium bicarbonate were added to this cream. The dough was kneaded for 7 minutes before 14 millilitres of distilled water was added gradually for a minute. The dough was sheeted with a rolling pin to a thickness of 0.60×0.05 cm after 5 minutes of resting, and it was then cut with a round cookie cutter that had an interior diameter of 4.5 cm. The cut cookies were put on a greased baking sheet and cooked in a commercial oven at 190 °C for 13 minutes. In preparation for further studies, the baked cookies were cooled for two hours at room temperature (RT, 27.2 °C), packed in biaxially oriented polypropylene pouches, and

kept at 4 °C. Ragi and quinoa seed flour was used in place of 10%, 20%, 30%, and 40% of the refined wheat flour while making the composite flour biscuits. The ragi and quinoa flour substitution cookie samples were categorized as T0, T1, T2 and T3, and T4, respectively. The rest of the procedure for making composite cookies followed the same guidelines as those used to make the control sample.

3. Ladoo

Dehulled wheat flour was used to make ladoo, which was made by roasting the flours separately over a low flame while stirring constantly until a pleasant aroma arose, then removing and setting aside to cool. The toasted flour was well combined with the powdered jaggery. After melting, the ghee was set aside to cool. Melted ghee was added before rolling the flour and jaggery mixture into balls. Ragi and quinoa seed flour were used in place of 10%, 20%, 30%, and 40% of the wheat flour in the composite flour ladoo, respectively. The ragi and quinoa flour substitution ladoo samples were categorised as T0, T1, T2 and T3, and T4, respectively. The remainder of the procedure for creating the composite ladoo was followed just as it was for creating the control sample.

4. Khakhara

For the preparation of the khakhara, 100g of wheat flour were used. After sieving the flour, the other ingredients such as salt, red chilli powder, turmeric, and amchur—were weighed. The dough preparation process was then completed by adding one tablespoon of oil and water. Now make equal-sized dough balls, shape them into rounds, and roast them on a flat tawa. Ragi and quinoa seed flour were used in place of 10%, 20%, 30%, and 40% of the wheat flour in khakhara to make the composite flour. The ragi and quinoa flour substitution khakhara samples were categorised as T0, T1, T2 and T3, and T4, respectively. The remainder of the procedure for creating the composite khakhara followed the same steps as those used to create the control sample.

F. Standardization of recipe

Recipe for khakhara, mathari, laddu, and biscuits prepared according to Table 1 formulation.

(khakhara and laddu made from wheat flour and mathari or cookies made from refined flour) Wheat flour,quinoa flour, and ragi flour are used in the manufacture of khakhara, mathari, laddu, and cookies in proportions of100:0:0, 80:10:10, 60:20:20, 40:30:30, 20:40:40 and coded as T0, T1, T2, T3 and T4 respectively. The addition of quinoa flour and ragi flour to the list of ingredients boosted the nutritional value and flavour of the finished product. The pitted soft dates and dry ingredients were placed to a mixer grinder and blended until a uniform consistency was achieved.

Table 1: Formulation of khakhara, mathari, laddu, cookies by using different level of wheat, quinoa and ragi flour

Ingredients	T_0	T_1	T_2	T_3	T_4
Wheatflour (Ladoo and khakhara)/ Refined flour (mathari and cookies) (g)	100	80	60	40	20
Quinoaflour(g)	-	10	20	30	40
Ragi flour(g)	-	10	20	30	40

T0 (Control) –Without addition of quinoa and ragi flour; T1 – With addition of 10% quinoa and 10% ragi flour; T2 – With addition of 20% quinoa and 20% ragi flour; T3 – With addition of 30% quinoa and 30% ragi flour; T4 – With addition of 40% quinoa and 40% ragi flour.

RESULT AND DISCUSSION

A. Sensory evaluation of food products

The acceptability of khakhara, mathari, laddu, and cookies was determined based on factors including colour & odour, body & texture, taste & flavour, and overall acceptability. The data analysis of the sensory assessment (Table 2 a, b,c,d respectively) demonstrated statistically significant differences ($P<0.05$) in colour & odour, body & texture, taste & flavour, and overall acceptability between the control product and the blend of quinoa and ragi-based product. Texture of quinoa and ragi including khakhara, mathari, and laddu (T3, 60:20:20) was more palatable than the control (T0) This may be because quinoa and ragi have a higher water-holding capacity than wheat, which improves consistency and, therefore, the texture of the final product (Inglett et al., 2015). Due to the existence of natural pigment colour and flavour in quinoa and ragi, the colour and flavour of quinoa and ragi-incorporated khakhara, mathari, and laddu (30 and 30 %) were substantially more acceptable ($P<0.05$) than those of

wheat cookies (T0, control). The results are corroborated by the findings of Elsohiamy et al. (2015); Bawachkar et al. (2021), who stated that quinoa absorbs water and oil better than wheat and similarly to ragi, which contributes to the product's superior flavour. In addition, the findings suggested that as the ratio of quinoa and ragi integration increased, so did the panellists' ratings for colour, texture, flavour, and taste of the quinoa and ragi-based products.

For khakhara, mathari, and laddu, the combination (T3) of 40% wheat flour, 30% quinoa flour, and 30% ragi flour produces a product that is extremely acceptable and desired in terms of colour & odour, body & texture, taste & flavour, and overall acceptability. The findings are reinforced by Bahaduri and Navder (2014), who proved that the addition of quinoa flour in baked food items improves sensory properties and customer acceptance. In the instance of cookies, a mixture (T2) of 60% wheat flour, 20% quinoa flour, and 20% ragi flour produced a product that was both extremely acceptable and desired. Higher levels of quinoa and ragi flour were determined to be unacceptable for all metrics, including colour & odour, body & texture, flavour & aroma, and general acceptability of aftertaste. The average sensory score result is shown in table 1.

Table 2. Complete sensory evaluation table of prepared products

a) Sensory evaluation of khakhara

Product	Characteristics	Colour and odour	Body and texture	Taste and flavour	Overall acceptability
Khakhara	To	7 ± 0.6^{a}	6.9 ± 0.8^{ab}	7.2 ± 0.9^{b}	7.2 ± 0.8^{b}
	T1	7.3 ± 0.5^{b}	7.2 ± 0.6^{b}	7.4 ± 0.1^{b}	7.4 ± 0.3^{a}
	T2	7.9 ± 1^{a}	7.5 ± 0.7^{a}	7.8 ± 0.7^{a}	7.7 ± 0.7^{b}
	T3	8.4 ± 0.7^{ab}	8.5 ± 0.9^{ab}	8.5 ± 0.7^{ab}	8.8 ± 0.5^{b}
	T4	8 ± 0.7^{b}	8 ± 0.7^{ab}	7.9 ± 0.7^{b}	8 ± 0.8^{b}

All values shown are means±SD and superscript with different alphabets in a row were significantly different from each other

b) Sensory evaluation of mathari

Product	Characteristics	Colour and odour	Body and texture	Taste and flavour	Overall acceptability
Mathari	To	8.1 ± 0.6^{a}	7.8 ± 0.8^{abc}	7.5 ± 1^{bc}	7.4 ± 0.8^{bc}
	T1	6.7 ± 0.5^{c}	6.9 ± 0.6^{c}	7 ± 0.1^{c}	7 ± 0.5^{c}
	T2	7 ± 0.7^{bc}	7.4 ± 0.7^{bc}	6.9 ± 0.6^{c}	7.4 ± 0.7^{bc}
	T3	8.4 ± 1^{a}	8.5 ± 0.7^{a}	8.4 ± 0.7^{a}	8.7 ± 0.7^{a}
	T4	7.7 ± 0.7^{ab}	7.9 ± 0.9^{ab}	7.9 ± 0.6^{ab}	7.9 ± 0.6^{ab}

All values shown are means±SD and superscript with different alphabets in a row were significantly different from each other

c) Sensory evaluation of Laddu

Product	Characteristics	Colour and odour	Body and texture	Taste and flavour	Overall acceptability
Laddu	To	7.7±0.9 ^{c}	7.5±0.9 ^{c}	7.5±0.8 ^{b}	7.1±0.8 ^{b}
	T1	6.9±0.7^{bc}	6.9±0.6^{bc}	6.9±0.7 ^{b}	6.8±0.8 ^{b}
	T2	7.9±0.6 ^{ab}	7.4±0.5^{bc}	7.3±0.6 ^{ab}	7.5±0.8 ^{b}
	T3	8.6±0.5 ^{a}	8.6±0.5 ^{a}	8.9±0.5 ^{a}	8.8±0.4 ^{a}
	T4	7.9±0.7 ^{ab}	7.8±0.7 ^{ab}	7.8±0.7 ^{ab}	7.8±0.7 ^{ab}

All values shown are means±SD and superscript with different alphabets in a row significantly different from each other

d) Sensory evaluation of cookies

Product	Characteristics	Colour and odour	Body and texture	Taste and flavour	Overall acceptability
Cookies	To	8.1±0.5 ^{b}	7.7±0.5^{bc}	7.3±0.5 ^{b}	7.4±0.7^{bc}
	T1	6.7±0.3 ^{c}	6.9±0.7 ^{c}	7±0.3 ^{c}	6.9±0.6 ^{c}
	T2	8.4±0.3 ^{b}	8.5±0.5^{bc}	8.4±0.5^{bc}	8.7±0.5^{bc}
	T3	7.6±0.5 ^{a}	7.7±0.5 ^{a}	7.7±0.3 ^{a}	7.6±0.4 ^{a}
	T4	7.1±0.3 ^{b}	7.6±0.4 ^{b}	7±0.4 ^{b}	7.6±0.4 ^{b}

All values shown are means±SD and superscript with different alphabets in a row were significantly different from each other

B. Nutritional composition of food products

The nutritional compositions of selected khakhara (T3), mathari (T3), laddu (T3), and cookies (T2), including moisture, protein, fat, total carbohydrate, ash, and crude fibre, were determined and the results are discussed below:

1. Proximate composition of khakhara

The proximate constituents of khakhara are listed in Table 3. Total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, and calcium were determined to be 3.7±0.%1, 7.8±0.3%, 7.9±0.2g/100g, 9.6±0.2%, 70.6±0.1g/100g, 401.9±1.1Kcal, 4.1±0.2g/100g, 2.6±0.1mg/100g, 170.5±0.2mg/100g respectively, in control khakhara. Total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, and calcium were found to 2.8±0.3%, 8.6±0.4%, 12.4±0.2g/100g, 8.2±0.2%, 68.1±0.1g/100g, 396.2±1.3 Kcal, 4.1±0.3g/100g, 6.4±02mg/100g, 210.2±0.3mg/100g respectively in the acceptable khakhara. In this research, the control khakhara had a lower moisture content than the acceptable khakhara (T3, mixture of quinoa and ragi; 30:30). Moisture content of control khakhara (T0, wheat 100%) and acceptable khakhara (T3, quinoa

and ragi combination; 30:30) were significantly different (P<0.05). Similar research published in 2013 by Khouryeih and Aramounn reveals that CB and QB have a longer shelf life. Ash, fat, carbohydrate, and calorie content of acceptable khakhara (T3, combination of wheat:quinoa:ragi; 40:30:30) were considerably (P<0.05) lower than those of the control khakhara (T0, wheat 100%). The carbohydrate content of crackers was observed to decrease as the percentage of quinoa integration increased. This might be a result of the observed rise in fat and protein levels. The results are consistent with those of Ibrahium (2015), who observed a larger carbohydrate content in wheat cookies than in biscuits using 20 or 40 % quinoa flour. In this research, the protein content of acceptable khakhara (T3, combination of wheat:quinoa:ragi; 40:30:30) was considerably (P<0.05) greater than the protein content of control khakhara (T0, wheat 100%). The observed increased protein content of quinoa seeds compared to other typical cereals such as wheat supports the findings (Arneja et al., 2015). Enriquez et al. (2003) also observed that the addition of quinoa into wheat flour improved the protein quality of food items. The crude fibre content of acceptable khakhara (T3, combination of wheat:quinoa:ragi; 40:30:30) and control khakhara (T0, wheat 100%) did not vary substantially (P>0.05). The results are corroborated by Slinkard's (2014) findings that pasta made with a mix of quinoa and chickpea flour has a higher nutritional value than pasta made with quinoa flour alone.

2. Proximate composition of Mathari

Table 3 displays the proximate constituents of mathari. Total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, and calcium were determined to be 3.6±0.2%, 23.8±0.1%, 10.5±0.1g/100g,24±0.1%, 38.4±0.2g/100g, 411.4±0.9Kcal, 1.6±0.3g/100g, 3.3±0.2mg/100g, 170.6±0.2mg/100g respectively, in control mathari. The acceptable mathari exhibited total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, and calcium concentrations of 44.8±0.1%, 2.8±0.1%, 7±0.2g/100g, 22.1±0.2%, 63.4±0.2g/100g, 480.±0.6Kcal, 2.1±0.2g/100g, 3.8±0.1mg/100g,

159.9±0.3mg/100g respectively. Accepted mathari (T3, combination of wheat:quinoa:ragi; 40:30:30) had considerably (P<0.05) less moisture than control mathari (T0, wheat 100%). According to Owusu et al. (2011), the findings are in according with the stated moisture content of several varieties of crackers. Similar research published in 2013 by Khouryeih and Aramounn reveals that CB and QB have a longer shelf life. The protein and fat content of acceptable mathari (T3, combination of wheat:quinoa:ragi; 40:30:30) was considerably lower (P<0.05) than that of the control mathari (T0, wheat 100%). It was discovered that the crackers' protein and fat content decreased as the %age of quinoa integration increased. This might be a result of the observed rise in carbohydrate and fibre content. Ash, carbohydrate, energy, and crude fibre content of acceptable mathari (T3, combination of wheat:quinoa:ragi; 40:30:30) were considerably (P<0.05) greater than control mathari (T0). The observed increased protein content of quinoa seeds compared to other typical cereals such as wheat supports the findings (Arneja et al., 2015; Ibrahium, 2015). Enriquez et al. (2003) also observed that the addition of quinoa into wheat flour improved the protein quality of food items. The results are consistent with the findings of Jancurova et al. (2009), who revealed that quinoa contains more crude fibre than wheat.

3. Proximate composition of Laddu

The proximate ingredients of laddu are shown in Table 3. Total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, and calcium were determined to 1.4±0.2%, 25.5±0.2%, 8.4±0.3g/100g, 11.2±0.3%, 53.7±0.3g/100g, 369.9±0.7Kcal, 1.6±0.1g/100g, 2.5±0.1mg/100g, 169.3±0.2mg/100g respectively, in control laddu. Total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, calcium in accepted laddu are 1.7±0.1%, 12.8±0.1%, 2.1±0.2g/100g, 7.8±0.1%, 65.6±0.3g/100g, 381.4±0.8Kcal, 2.4±0.1g/100g, 4.8±0.2mg/100g, 210±0.1mg/100g respectively. Accepted laddu (T3, combination of wheat:quinoa:ragi; 40:30:30) had considerably (P<0.05) less moisture than control laddu (T0, wheat 100%). According to Owusu et al. (2011), the

findings are in according with the stated moisture content of several varieties of crackers. Similar research published in 2013 by Khouryeih and Aramounn reveals that CB and QB have a longer shelf life. Accepted laddu (T3, combination of wheat:quinoa:ragi; 40:30:30) had considerably less fat ($P<0.05$) than control laddu (T0, wheat 100%). The fat level of laddu decreased as the proportion of quinoa integration increased. This may be attributed to the reported increase in the amount of carbohydrates, proteins, and fibres. Ash, carbohydrate, energy, protein, and crude fibre content of accepted laddu (T3, combination of wheat:quinoa:ragi; 40:30:30) were considerably ($P<0.05$) greater than wheat laddu (T0). The observed increased protein content of quinoa seeds compared to other typical cereals such as wheat supports the findings (Hussain et al., 2020; Arneja et al., 2015; Ibrahium, 2015). Enriquez et al. (2003) also observed that the addition of quinoa into wheat flour improved the protein quality of food items. The results are consistent with the findings of Jancurova et al. (2009), who revealed that quinoa contains more crude fibre than wheat.

4. Proximate composition of cookies

The proximate ingredients of cookies are shown in Table 3. Total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, and calcium were found to be 1.6±0.2%, 4.5±0.2%, 7.3±0.3g/100g, 8.6±0.1%, 78±0.2g/100g, 420.5±1.3Kcal, 1.6±0.2g/100g, 4.1±0.1mg/100g, 110.7±0.3mg/100g in control cookies. Total ash, total moisture, protein content, total fat, total carbohydrate, energy, crude fibre, iron, and calcium in accepted cookies are 1.8±0.1%, 1.6±0.3%, 11.8±0.4g/100g, 7.7±0.2%, 77.1±0.1g/100g, 421.9±0.5Kcal, 2.7±0.1g/100g, 6.0±0.2mg/100g, 131.1±0.1mg/100grespectively. Accepted cookies (T2, combination of wheat:quinoa:ragi; 60:20:20) had considerably ($P<0.05$) less moisture than control cookies (T0, wheat 100%). According to Owusu et al. (2011), the findings are in according with the stated moisture content of several varieties of crackers. Similar research published in 2013 by Khouryeih and Aramounn reveals that CB and QB have a longer shelf life. Accepted cookies (T2, combination of wheat:quinoa:ragi; 60:20:20)

had considerably less fat and carbohydrates (P<0.05) than control cookies (T0, wheat 100%). The fat level of cookies decreased as the proportion of quinoa integration increased. This might be a result of the observed increase in protein and fibre content. The ash, energy, protein, and crude fibre content of accepted cookies (T2, combination of wheat:quinoa:ragi; 60:20:20) were considerably (P<0.05) greater than control cookies (T0, wheat 100%). The observed increased protein content of quinoa seeds compared to other typical cereals such as wheat supports the findings (Arneja et al., 2015; Ibrahium, 2015). Enriquez et al. (2003) also observed that the addition of quinoa into wheat flour improved the protein quality of food items. The results are consistent with the findings of Jancurova et al. (2009), who revealed that quinoa contains more crude fibre than wheat. The results are corroborated by Slinkard's (2014) findings that pasta made with a mix of quinoa and chickpea flour has a higher nutritional value than pasta made with quinoa flour alone.

Table 3. Compositional analysis of developed food product

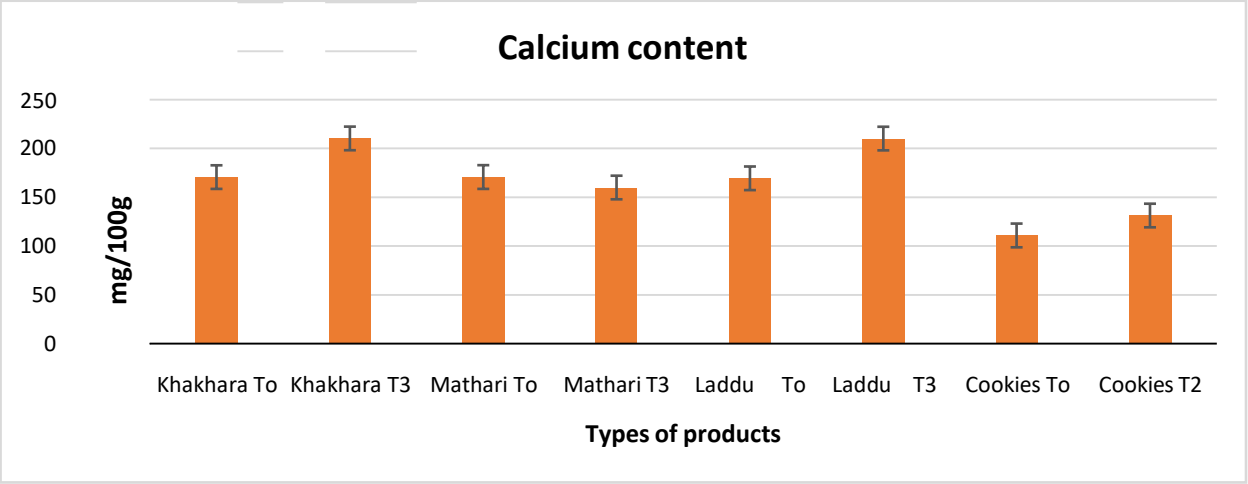
Types of products	Total Ash %	Total Moisture %	Protein content (g/100g)	Total Fat (%)	Total Carbohydrate (g/100g)	Energy (Kcal)	Crude Fibre (g/100g)	Iron (mg/100g)	Calcium (mg/100g)
Khakhara To	3.7±0.1 ^{b}	7.8±0.3 ^{e}	7.9±0.2 ^{f}	9.6±0.2 ^{d}	70.6±0.1 ^{c}	401.9±1.1 ^{cd}	4.1±0.2 ^{a}	2.6±0.1 ^{g}	170.5±0.2 ^{b}
Khakhara T3	2.8±0.3 ^{c}	8.6±0.4 ^{d}	12.4±0.2 ^{a}	8.2±0.2 ^{f}	68.1±0.1 ^{d}	396.2±1.3 ^{d}	4.1±0.3 ^{a}	6.4±02 ^{a}	210.2±0.3 ^{a}
Mathari To	3.6±0.2 ^{b}	23.8±0.1 ^{b}	10.5±0.1 ^{d}	24±0.1 ^{a}	38.4±0.2 ^{h}	411.4±0.9 ^{bc}	1.6±0.3 ^{e}	3.3±0.2 ^{f}	170.6±0.2 ^{b}
Mathari T3	4.8±0.1 ^{a}	2.8±0.1 ^{g}	7±0.2 ^{h}	22.1±0.2 ^{b}	63.4±0.2 ^{f}	480. ±0.6 ^{a}	2.1±0.2 ^{d}	3.8±0.1 ^{e}	159.9±0.3 ^{d}

Laddu To	1.4±0.2 ^{e}	25.5±0.2 ^{a}	8.4±0.3 ^{e}	11.2±0.3 ^{c}	53.7±0.3 ^{g}	369.9±0.7 ^{e}	1.6±0.1 ^{e}	2.5±0.1 ^{h}	169.3±0.2 ^{c}
Laddu T3	1.7±0.1 ^{d}	12.8±0.1 ^{c}	12.1±0.2 ^{b}	7.8±0.1 ^{g}	65.6±0.3 ^{e}	381.4±0.8 ^{e}	2.4±0.1 ^{c}	4.8±0.2 ^{c}	210±0.1 ^{a}
Cookies To	1.6±0.2 ^{de}	4.5±0.2 ^{f}	7.3±0.3 ^{g}	8.6±0.1 ^{e}	78±0.2 ^{a}	420.5±1.3 ^{b}	1.6±0.2 e	4.1±0.1 ^{d}	110.7±0.3 ^{f}
Cookies T2	1.8±0.1 ^{d}	1.6±0.3 ^{h}	11.8±0.4 ^{c}	7.7±0.2 ^{g}	77.1±0.1 ^{b}	421.9±0.5 ^{b}	2.7±0.1 ^{b}	6.0±0.2 ^{b}	131.1±0.1 ^{e}

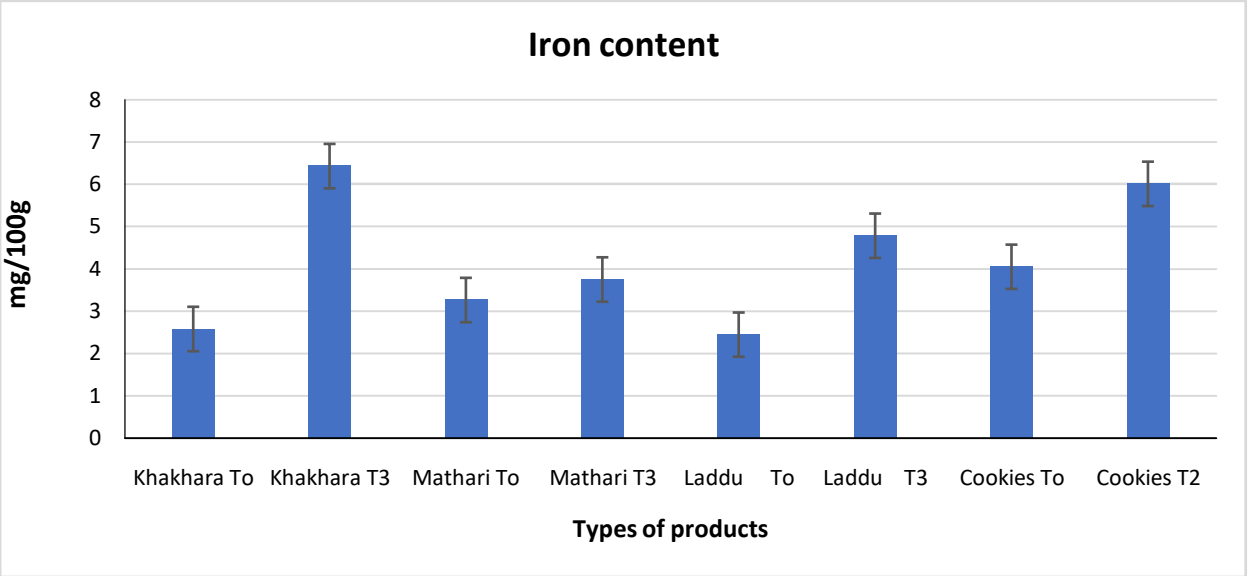
All values shown are means±SD and superscript with different alphabets in a row were significantly different from each other

C. Micronutrient study of prepared products

The findings of khakhara's mineral composition are shown in Fig 1a,b. Iron and calcium content of wheat khakhara, laddu, and cookies (T0, control) were significantly lower ($P<0.05$) than the accepted khakhara (T3), laddu (T3), and cookies (T2) (T3, combination of wheat:quinoa:ragi; 40:30:30; T2, combination of wheat:quinoa:ragi; 60:20:20) whereas, the iron content of accepted mathari (T3, combination of wheat:quinoa:ragi; 40:30:30) were significantly higher ($P<0.05$) than control mathari (T0, wheat 100%) but in case of calcium content, accepted mathari (T3, combination of wheat:quinoa:ragi; 40:30:30) was found to be significantly lower ($P<0.05$) than control mathari (T0, wheat 100%). Enriquez et al. (2003) similarly found an increase in the ash level of wheat-quinoa blends when the amount of quinoa and ragi was increased. Similar research by Sujatha and Kowsalya (2016) on iron-rich ladoo supplemented with green leafy vegetables revealed that it included a respectable quantity of carbohydrates, protein, fat, and iron. Among the evaluated cooking techniques such as baking (cookies) and frying (mathari), roasting (laddu, khakhara) had the highest nutritional content.



a)



b) Figure 1. Micronutrients analysis of prepared food products a) calcium b) iron

CONCLUSION

The research indicated that quinoa and ragi may be utilised to manufacture wheat-based mathari, khakhara, laddu, and cookies with a high sensory and nutritional value, including sufficient amount of carbohydrates, protein, fat, dietary fibre, and minerals. Mathari, khakhara, and laddu produced using mixture T3 (40 % wheat flour, 30 % quinoa flour, and 30 % ragi flour) were found to be extremely accepted, whereas combination T2 (60 % wheat flour, 20 % quinoa flour, and 20 % ragi flour) was determined to be optimal for cookies. In terms of protein, fibre, calcium, zinc, and iron, the nutritional profile of the items was favourable. Among the studied cooking techniques, such as baking (cookies) and frying (mathari), roasting (laddu, khakhara) produced the best nutritional composition with the

highest level of micronutrients, and the greatest number of customers enjoyed the items.

REFERENCES

Albayrak M, Gunes Erdogan. Traditional foods: interaction between local and global foods in turkey. African Journal of business management. 2010; 4(4):555- 561.

AOAC, (2005). Official Aethods of Analysis of the AOAC International, 18th ed. Association of Official analytical chemists, Gaithersburg, MD.

Arneja, I., Tanwar, B., & Chauhan, A (2015). Nutritional composition and health benefits of golden grain of 21 st century quinoa (Chenopodium quinoa Willd.): A Review. Pakistan Journal of Nutrition, 14(12): 1034–1040.

Bawachkar R.R., More D.R., Alane S.T., Praveen B.R. and Swami A.M. (2021). Studies on Development, Sensory Evaluation and Nutritional Composition of Quinoa Bar. Biological Forum – An International Journal, 13(2): 314-319.

Bhathal, S., Grover, K. and Gill, N. (2015). Quinoa- A treasure trove of nutrients. Journal of Nutrition Research, 3(1): 45-49.

Dini, I., Tenore, G.C. and Dini, A. (2004). Phenolic constituents of Kancolla seeds. Food Chemistry, 84: 163-8.

Enriquez, N., Peltzer, M., Raimundi, A., Tosi, V., & Pollio, M. L. (2003). Characterization of wheat and quinoa flour blends in relation to their breadmaking quality. Anales Des La AsociacionQuimica Argentina, 91(4-6): 47–54.

Elsohaimy, S. A., Refaay, T. M., &Zaytoun, M. A. M. (2015). Physicochemical and functional properties of quinoa protein isolate. Annals of Agricultural Sciences, 60(2): 297–305.

Garcia A, Reis C, Serpa J, Viegas J, Ferreira M, Almeida S et al. Physical-sensory evaluation of a cereal with quinoa: a preliminary study. Biomedical and biopharma ceutical research. 2018; 15(1):27-38.

Handa C., Goomer S., Siddhu A. Physiochemical properties and sensory evaluation of fructoligosaccharide enriched cookies. Journal of Food Science and Technology. 2014;49(2):192-199.

Hussain, A., Gul, H., Rauf, M. and Wang, L. (2020). Development of fiber enriched date bars from natural resources. Fresenius Environmental Bulletin, 29(07): 6126-6133.

Ibrahium MI. Minerals bioavailability of wheat biscuit supplemented by quinoa flour. Middle East journal of agriculture research. 2015; 4(4):769-778.

Inglett, G. E., Chen, D., & Liu, S. X. (2015). Antioxidant Activities of Selective Gluten Free Ancient Grains. Food and Nutrition Sciences, 6: 612–621.

Izzo, M. and Niness, K. (2001). Formulating nutrition bars with inulin and oligofructose. Cereal Foods World, 46: 102-106.

Jacobsen, S.E. (2003). The worldwide potential for quinoa (Chenopodium quinoa Willd.). Food Review International, 19: 167-177.

James, L.E.A. (2009). Quinoa (Chenopodium quinoa Willd.): composition, chemistry, nutritional, and functional properties. Advances in Food and Nutrition Research, 58(1): 1-31.

Jancurová, M., Minarovičová, L. and Dandar, A. (2009). Quinoa – a review. Czech Journal of Food Sciences, 27(2): 71-79.

Kotagi, S.K. (2011). Little millet (Panicum miliare) flakes: development, value addition, quality evaluation, consumer acceptability and commercialization. Ph.D. Thesis, Department of Food Science and Nutrition, University of Agriculture Sciences, Dharwad.

Liu, S., Willett, W.C., Stampfer, M.J., Hu, F.B., Franz, M., Sampson, L., Hennekens, C.H. and Manson, J.A.A. (2000). Prospective study of dietary glycemic load, carbohydrate intake and risk of coronary heart diseases in U.S women. American Journal Clinical Nutrition, 71: 1455–1461.

Lobato, L.P., Pereira, A.I.C., Lazaretti, M.M., Barbosa, D.S., Carreira, C.M., Mandarino, J.M.G. and Grossmann, M.E. (2011). Snack bars with high soy protein and isoflavone content for use in diets to control dyslipidemia. International Journal of Food Sciences and Nutrition, 1–10.

Miranda, M., Vega-Gálvez, A., Quispe-Fuentes, I., Rodríguez, M.J., Maureira, H. and Martínez, E.A. (2012). Nutritional aspects of six quinoa (Chenopodium quinoa Willd.) ecotypes from three geographical areas of Chile. Chilean Journal of Agricultural Research, 72(2): 175-181.

Mostafa MY. Evaluation of quinoa (Chenopodium quinoa wild) fortification on the quality of pasta production. Bulletin of the national nutrition institution of the Arab republic of Egypt. 2017; 50(1):144-169.

Nisar M, More DR, Zubair S, Sawate AR, Hashmi SI. Studies on development of technology for preparation of cookies incorporated with quinoa seed flour and its nutritional and sensory quality evaluation. International journal of chemical studies. 2018; 6(2):3380-3384.

Owusu, D., & Oduro, I. (2011). Development of crackers from cassava and sweetpotato flours using Moringa oleifera and Ipomoea batatas leaves as fortificant. American Journal of Food and Nutrition, 1(3): 114–122.

Padmashree, A., Sharma, G.K, Srihari, K.A. and Bawa, A.S. (2012). Development of shelf stable protein rich composite cereal bar. Journal of Food Science and Technology, 49(3): 335-341.

Priyanka M, Suneetha J, Maheshwari K, Suneetha KB, Anila kumara B. Development and evaluation of quinoa based snack items. Journal of pharmacognosy and

Rehman, W.U, Shah, U., Rabi, K., Munir, M., Saleeem, A., Iqbal, A., Shah, F., Shah, S., Khan, Z.U., Hamayun, Stikic, R., Glamoclija, D., Demin, M., Vucelic-Radovic, B., Jovanovic, Z and Milojkovic-Opsenica, D. (2012). Agronomical and nutritional evaluation of quinoa seeds (Chenopodium quinoa Willd.) as an ingredient in bread formulations. Journal of Cereal Science, 55: 132-138.

Saiyed S, Sengupta R. Multigrain Baked Chakli for Obesity. International journal of Food Nutritional Sciences. 2014; 3(3):2320-7879.

Salazar DM, Naranjo M, Perez LV, Valencia AF, Acurio LP, Gallegos LM et al. Development of newly enriched bread with quinoa flour and whey. 3rd International Conference on Agricultural and Biological Science, 2017, 1-8.

Shaivya M, Sunita M. Nutritional analysis of value-added product by using pearl millet, quinoa and prepare readyto-use upma mixes. International journal of food science and nutrition. 2016; 1(5):41-43.

Srilakshmi. Food science and nutrition. New Age International Publishers, 2007.

Sujatha K, Kowsalya S. Formulation and Evaluation of Iron Rich Food Supliment from Green Leafy Vegetables for Aneamic Adolescent. International journal of current research. 2016; 8(11):42102-42106.

Sujatha K, Kowsalya S. Formulation and Evaluation of Iron Rich Food Supliment from Green Leafy Vegetables for Aneamic Adolescent. International journal of current research. 2016; 8(11):42102-42106.

Swami A.M. (2021). Studies on Development, Sensory Evaluation and Nutritional Composition of Quinoa Bar. Biological Forum – An International Journal, 13(2): 314-319.

Vayalil, P.K. (2012). Date fruits (Phoenix dactylifera Linn): An emerging medicinal food. Critical Reviews in Food Science and Nutrition, 52(3): 249–271.

Vega-Gálvez, A.V., Miranda, M., Vergara, J., Uribe, E. and Puente, L. (2010). Nutrition facts and functional potential of quinoa (Chenopodium quinoa Willd.), an ancient Andean grain: A review. Journal of Science Food Agriculture, 90: 2541-2547.

Yadav DN, Sharma G, Bawa AS. Optimisation of soy fortified instant sooji halwa mix using response surface methodology. Journal of Food Science and technology. 2007; 44:297-300.

Yadav, L. and Bhatnagar, V. (2015). Formulation and Sensory Evaluation of Ready-to-Eat Cereal Bars Made with the Raw and Processed Soya Flour. Trends in Biosciences, 8(9): 2455-2459.

Yadav, L. and Bhatnagar, V. (2016). Formulation Quality Evaluation and Shelf-life of value Added Cereal Bar by incorporation of Defatted Soy Flour. International Journal of Food Fermentation Technology, 6(2): 251- 259.