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Quinoa flour as a functional ingredient for improving the nutritional value of maize flatbread

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Abstract
Maize chapatti (Makki di roti) is a traditional food of Punjab, India. Although relished by all, the low nutritional value is the primary concern with maize chapatti, and health-conscious consumers demand healthy options even in traditional foods. In this study, maize flour was supplemented with *Quinoa* flour to improve the nutritional quality of maize chapatti. *Quinoa* flour was added to maize flour at 10, 20, 30, 40 and 50%. Results suggested a significant increase in protein, ash and crude fibre content with the addition of *Quinoa* flour. Maize flatbread made with 30% substitution of *Quinoa* flour had significantly higher (p<0.05) protein content (10.51±0.38%) than control sample (8.12±0.19%). The addition of *Quinoa* also improved the *in vitro* protein digestibility (IVPD %) of *Quinoa* enriched chapatti compared to maize chapatti. Concerning minerals, 30% *Quinoa* flour in the maize flour significantly increased the calcium, magnesium, phosphorus and potassium content of enriched chapatti than control. The sensory evaluation suggested that the addition of *Quinoa* up to 30% had no change in the sensory properties of chapatti. Optimum addition (30%) of *Quinoa* flour in maize flour improved the traditional maize flatbread's physical, nutritional, and sensory aspects. Further, the optimized technology was demonstrated in a farmer training programme. More than 90% of the respondents appreciated the technique for enhancing the nutritional quality of maize chapatti and its ease of adoption.

Keywords: Maize, chapatti, *Quinoa*, gluten free, *in vitro* protein digestibility

1. Introduction
Maize is an essential crop of the world that belongs to the Poaceae family after rice and wheat [1]. Maize has many uses; approximately 35% of the maize is used as a direct food that mostly is consumed in the form of unleavened flatbread (chapatti), primarily in northern India [2]. It is made by adding lukewarm water to maize flour and is mainly prepared for immediate consumption. Moreover, maize chapatti (*Makii di roti*) is the traditional food of Punjab and world-famous for its taste and delicacy. However, the low nutritional quality of maize, mainly in terms of protein and minerals, questions the creditability of the maize diet [3]. Maize lacks essential amino acids lysine and tryptophan [4], which lowers the biological value of maize protein. A few researchers worked on the improvement of the nutritional value of maize flour. For instance, the addition of nettle (*Urtica simensis*) flour significantly increased the ash and mineral content of unleavened maize flatbread [5]. In another study, adding orange-fleshed Sweet Potato improved the β-carotene content of the maize flatbread [6]. Further, it was reported that the adding oyster mushroom powder in maize flour improved the protein and mineral content of the composite flour [7].

Quinoa (*Chenopodium quinoa* Willd) is a wonder crop; therefore, it has been selected as a 21st century crop by FAO [8]; owing to its stress-tolerant ability, it can handle salinity as well as drought stress. Furthermore, researchers are focusing on *Quinoa* due to its quality protein and micronutrient. It is one of the few grains with high biological value proteins with a complete essential amino acid profile [9, 10]. Higher biological value of *Quinoa* proteins are attributed to the balanced amino acids profile of *Quinoa* than most cereals [11], making it a functional ingredient for improving the nutritional value of other cereals flours via supplementation. Various studies suggested the potential of *Quinoa* flour to enhance the nutrition and functionality of food products. For example, *Quinoa* was added to wheat flour in a previous study to develop bread. It was observed that *Quinoa* enriched bread had a low glycemic index and desirable textural characteristics than wheat bread [12]. In addition, *Quinoa* flour is a gluten-free grain that increases its demand in gluten-free diets. *Quinoa*, in combination with grains, improves the product quality; it was reported that the combination of Sorghum and *Quinoa* improved the protein and antioxidant activity of the composite flour [13].

Quinoa flour has better protein digestibility (75 to 80%) than other cereals owing to its amino acid profile [14].

Apart from the few studies mentioned above, maize flatbread has rarely been studied for nutritional up-gradation. However, traditional foods are part of our heritage and are not just food items but a customary part of our culture. So, it is not just a scientific matter but a moral responsibility to study and upgrade the nutritional quality of traditional foods while keeping their original integrity. This would help keep the pace of traditional foods with modern health-conscious consumers. With this aim, maize flour was supplemented with *Quinoa* flour, and the quality characteristics of flatbread were studied to optimize the level of *Quinoa* in maize to achieve our goal, i.e. giving an improved nutritional profile to our traditional maize flatbread.

2. Material and Methods

2.1 Raw materials and flour formulations preparation: Good quality maize grains, *Quinoa* grains and xanthan gum were purchased from the local market of District Bathinda (Punjab-India). Maize grains were cleaned and then ground in a stone mill. *Quinoa* grains were soaked in water for 5-6 hours to remove saponins. Furthermore, *Quinoa* grains were dried and passed through a pearling machine to remove the bitterness and antinutritional factors. Pearled *Quinoa* grains were ground in a stone mill. Both the flours were sieved through a mesh no (70), the size of 200 microns. The combination of flours formulations were prepared by substituting maize flour with *Quinoa* flour as mentioned in Table 1. Flours were mixed and sieved three times for homogenous mixing. Again, maize flour was served as the control. The flours formulations were packed in food grade plastic container and placed in refrigeration storage (4-7 °C) for further analysis and product preparation.

Table 1: Maize flour and *Quinoa* flour percentage in composite flour

Formulations	Maize flour (%)	*Quinoa* flour (%)	Xanthan gum (%)
Control	100	-	0.5
F1	90	10	0.5
F2	80	20	0.5
F3	70	30	0.5
F4	60	40	0.5
F5	50	50	0.5

2.2 Proximate composition: Moisture, protein fat, ash, and fibre of raw material and prepared chapatti were estimated using a standard procedure [15]. A carbohydrate (CHO) of raw material was calculated using 100-proximate composition.

2.3 Flatbread (Chapatti) preparation: Flatbreads (Chapattis) were made as per the traditional method. For each sample, a 500 g flour formulation was taken for dough making. To ensure uniformity in dough making, a dough maker (Kitchen aid) was used, and lukewarm water (30±2 °C) was added. As both the flours were gluten-free, only a mixing time of 3-4 minutes was enough for dough making. Approximately 35 g of dough was manually taken and rolled into flatbread with hands. The Chapattis were baked on a hot iron flat pan (tawa) at 150 °C for 2-2.5 minutes on each side. After baking, Chapattis were cooled, packed in a muslin cloth and placed in a casserole to study physical and sensory parameters. For proximate analysis, Chapattis were cooled, dried and then packed in plastic zip pouches.

2.4 Colour analysis: The Color of chapatti was measured in terms of ‘L*’, ‘a*’, ‘b*’ colour scales [16]. The instrument used for the analysis was “A Minolta CR-300 Chroma Meter” manufacture by Konica Minolta (Japan). The ‘L*’ values indicates the lightness of the food product. The scale for ‘L*’ varies form 0-100; where 0 means darkness and 100 means whiteness. The positive and negative ‘b*’ values indicate yellow and blue hues of food product. The remaining ‘a*’ indicates red (+ ve) and blue hues (-ve). A pure white and black slab was used to calibrate the color instrument.

2.5 Texture studies: For measuring the texture of chapatti, hardness in terms of shear force was calculated as per the method [17] with modifications. Texture analyzer (model no LR-5K by Lloyd Instruments Ltd, United Kingdom) was used and setting were kept at 1KN (Kilo Newton), blade speed was kept at 100mm/minutes along with 26.0 mm deflection Each chapatti was divided into 4 pieces and shear force was calculated as Newton.

2.6 *In vitro* protein digestibility: *In vitro* protein digestibility (IVPD) of Chapattis was carried out using multienzyme hydrolysis method [18]. The sample (as prepared in total starch determination) of 100 mg of each chapatti was taken and mixed with 10 ml of distilled water; the pH was set at 8.0 with sodium hydroxide. A 5-mL aliquot of multienzyme solution containing trypsin, peptidas and a-chymotrypsin was then added to the protein suspension. Further samples were incubated for 10 minutes, after digestion, pH of the solution was measured and results for IVPD% was expressed as digestible protein (%) =210.464 -18.103x pH.

2.7 Sensory attributes of Chapattis: Chapattis were evaluated for appearance, pliability, aroma, tearing strength, eating quality and overall quality. Ten panellists were asked to give the scores using 9.0 point hedonic scale, where 9.0 means like extremely liked and 1.0 means extremely disliked.

2.8 Dissemination of technology: Technology was demonstrated to promote the developed technology as well as to get the response from the end-users. For this, 30 trainees, including small scale cereal millers and farmers, were given one-week skill development training on “value addition of cereals and pulses. Under this programme, demonstrations were given for milling and supplementing with wheat *Quinoa* flour. Prepared Chapattis were evaluated for sensory attributes and compared with control. In addition, trainees were given lectures regarding the nutritional profile of maize and *Quinoa* and the importance of protein, ash and fibre in the diet. More than 85% of the participants were local food processors and farmers who are associated with active Self-Help Groups that were progressively involved in processing and value addition of cereals and pulses. After the training, the participant’s responses in the form of a questionnaire covering different maize and *Quinoa* enriched flour and Chapattis were recorded.

2.9 Statistical analysis of data: The obtained data was analyzed using statistical Analysis of Variance (ANOVA) for determining the significance (95% probability, $p<0.05$) of the given treatments. The data was analyzed was analyzed using SPSS software (version 19.0).

3. Results and Discussion

3.1 Proximate composition of flours

Quinoa flour had almost double the amount of protein content (15.31%) compared to maize flour (8.12%). On the other hand, maize flour had significantly lower fibre (1.13±.0.12%) and ash (1.17±0.13%) content than *Quinoa* flour (Table 2). Our study observed that *Quinoa* had 2.41±.0.21% fibre, 2.91±.0.22% ash and 65.14±.1.25% carbohydrates. Maize flour not only had low protein content compared to *Quinoa* flour; it was reported to lack essential amino acids lysine and tryptophan [4], whereas *Quinoa* protein has a complete amino acid profile [9]. Results for maize protein (%) are inconsistent with those reviewed by [19]. In an earlier study [20] it was reported that *Quinoa* flour contained 14% protein, 2.54% ash, 6.44% fat and 65.95% carbohydrates. We also observed the similar results regarding the proximate composition of *Quinoa*. In a previous review regarding the nutritional value of corn, it was reported that it contains 8.84 g protein, 4.57% fat, 2.15 g fibre, and 2.33% ash [1]. Concerning mineral content, maize flour had an appreciable amount of potassium (69.89±1.78 mg/100 g) and phosphorus 14.78±0.21 mg/100 g), whereas minerals like magnesium, calcium, zinc and iron were less. The mineral profile of *Quinoa* suggested an excellent amount of calcium (158.89±2.89 mg/100 g), magnesium (231.78±2.34 mg/100g), phosphorus (289±3.89 mg/100 g) and potassium (937.56±9.56 mg/100 g). Our findings regarding the mineral profile of maize and *Quinoa* are inconsistent with finding of [21, 22]. However, some differences were observed in the mineral profile of maize and *Quinoa* flour; this might be due to varietal differences. Proximate composition of *Quinoa* showed that it has the potential to improve the nutritional values of other cereals via supplementation. In this study maize flour was fortified with *Quinoa* flour to improve nutritional value to maize chapatti.

Table 2. Proximate composition of maize flour and *Quinoa* flour

Parameter	**Maize flour**	***Quinoa* flour**
Moisture (%)	8.12±0.13^{a}	8.59±0.63^{a}
Protein (%)	9.47±1.15^{a}	15.31±1.37^{b}
Fat (%)	2.84±0.19^{a}	5.29±0.57^{b}
Fibre (%)	1.13±.0.12^{a}	2.41±0.21^{b}
Ash (%)	1.17±0.13^{a}	2.91±0.22^{b}
Carbohydrates (%)	78±2.57^{b}	65.14±1.25^{a}
Minerals (mg/100g)		
Calcium	7.21±0.11^{a}	158.89±2.89^{b}
Magnesium	8.34±0.48^{a}	231.78±2.34^{b}
Phosphorus	14.78±0.21^{a}	289±3.89^{b}
Iron	1.45±0.05^{a}	3.78±0.21^{b}
Potassium	69.89±1.78^{a}	937.56±9.56^{b}
Zinc	7.39±0.58^{a}	11.89±0.78^{b}

Data are expressed as means ± SD (n=3).
Values with the same letter in the same row are not significantly different at $p<0.05$

3.2 Moisture content and physical characteristics of chapatti

The physical characteristics of composite chapatti are presented in Table 3. Based on the results, it was noticed that the moisture content of composite chapatti was significantly ($p<0.05$) higher compared to the control sample. It was 28.21±1.12% for control, increasing to 32.89±1.78%, 33.91±2.14% and 33.90±1.54% for F3, F4 and F5 formulation, respectively. The higher moisture content (%) of *Quinoa* enriched Chapattis could be attributed to the high protein of the *Quinoa* flour. An earlier study reported that *Quinoa* flour has a higher water absorption rate owing to its higher protein content [23]. In addition, our study observed a decrease in the hardness of *Quinoa* enriched chapatti up to 40%. However, a further increase in *Quinoa* flour (50%) resulted in increased hardness of the chapatti compared to the control (maize flour chapatti). Concerning textural properties, both maize and *Quinoa* flour are gluten-free; the absence of gluten affects the textural properties of gluten-free bread, cakes and flatbread. The *Quinoa* flour Chapattis were softer compared to the control sample. In an earlier finding [24] observed that addition of *Quinoa* flour in blends of rice flour and potato starch decreased the hardness of the prepared cakes.

Colour plays a significant role in accepting newly developed or fortified food products. Traditional maize chapatti has vibrant yellow colour; in this study, we focused on optimizing the level of fortification of *Quinoa* flour to an extent where the integrity of the natural colour of maize chapatti could be maintained along with the enhanced nutritional composition. The addition of *Quinoa* flour increased the L* value of the composite Chapattis; similar results are depicted from the visual appearance (Fig. 1); as the amount of *Quinoa* increased, a decrease in lightness (L*) was visible. As we further increased the level of *Quinoa* flour, both visual and instrumental colour analysis indicated a significant increase in the lightness of the Chapattis compared to the control chapatti. Further, a decreasing trend was observed for the b* values for *Quinoa* enriched chapatti. The addition of *Quinoa* in optimum levels (up to 30%) had a non-significant change in b* values or yellowness of the chapatti. As b* values indicate yellowness, results suggested the addition of *Quinoa* up to 30% had a non-significant effect on the natural colour of maize chapatti. As we increased the level of *Quinoa* flour to 40% and 50%, a significant decrease was observed in b* values compared to the control sample. *Quinoa* flour had a lighter hue than maize, therefore a decrease in lightness (L*) and yellowness (b*) was observed in the chapatti, corresponding to the amount of *Quinoa* in the blend. This might be due to the light colour of *Quinoa* flour than maize flour; at a higher level (50%), the addition of *Quinoa* imparted the light color to the chapatti, which was depicted from higher L* and lower b* values. Adding *Quinoa* beyond the 10% level significantly increased the redness of the chapatti. A previous study [25], reported that addition of *Quinoa* flour in wheat increased the a* (redness) values of the Chapattis. However, at the highest level of supplementation of *Quinoa* flour (50%), a decrease in a* value was observed.

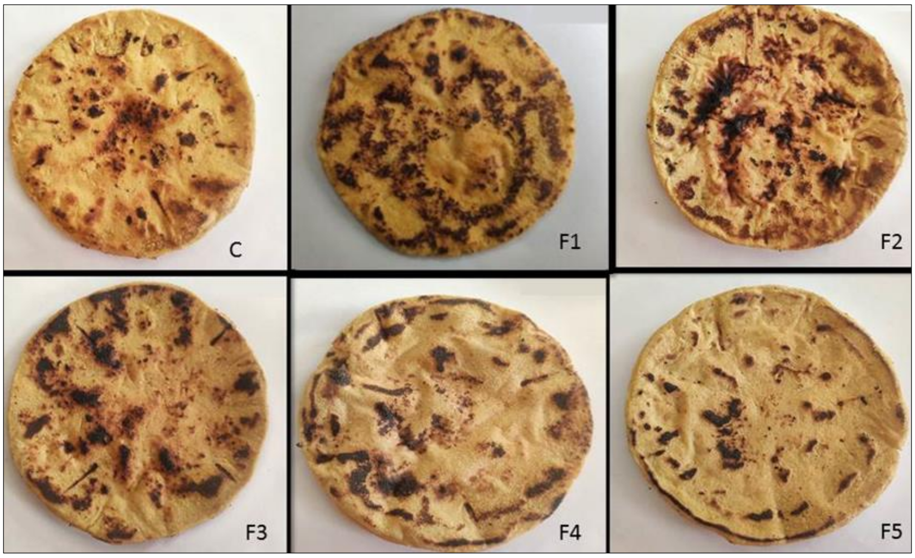

Fig 1: Visual appearance of chapatti samples, C: Maize chapatti used as a control, F1: Maize flour: quinoa flour (90:10), F2: Maize flour: quinoa flour (80:20), F3: Maize flour: quinoa flour (70:30) F4: Maize flour: quinoa flour (60:40), F5: Maize flour: quinoa flour (50:50)

Table 3: Moisture and physical quality measurements of composite *chapatti*

Samples	Moisture (%)	Texture (Shear Force (N)	L*	a*	b*
Control	28.21±1.12[a]	7.58±0.17[b]	59.19±2.14[a]	1.19±0.11[a]	27.36±1.20[bc]
F1	29.45±2.12[a]	6.89±0.11[ab]	62.43±1.89[a]	1.91±0.12[a]	26.18±1.13[b]
F2	31.34±2.35[ab]	6.34±0.29[a]	65.18±2.56[ab]	2.89±0.23[b]	25.45±1.40[b]
F3	32.89±1.78[b]	5.65±0.22[a]	66.23±2.45[b]	3.07±0.21[bc]	24.21±1.18[b]
F4	33.91±2.14[b]	6.94±0.35[ab]	67.19±1.32[b]	4.56±0.31[c]	20.34±1.15[a]
F5	33.90±1.54[b]	8.45±0.56[bc]	69.45±1.26[bc]	2.34±0.12[b]	18.45±1.21[a]

Data are expressed as means ± SD (n = 3). Values with the same letter in the same column are not significantly different at $p<0.05$

3.3 Proximate composition of chapattis

The nutritional composition of the composite Chapattis prepared by substituting *Quinoa* flour with maize flour is presented in Table 4. The addition of *Quinoa* flour significantly improved enriched chapatti's protein, fibre and ash content. The protein content of control Chapattis was (8.12%); the addition of *Quinoa* contributed significantly to the protein content of enriched Chapattis. Chapatti made by substituting 20% and 40% of *Quinoa* flour had 20.44% and 36.69% higher protein content than the control chapatti. *Quinoa* flour had higher fat content than maize flour (Table 2). Adding a higher amount of *Quinoa* flour (above 30%) significantly increased the fat content of Chapattis. At the same substitution levels above 30%, an increase in crude fibre content of Chapattis was also observed. Ash content is the indicator of the mineral content; the ash content of control chapatti was 0.93±0.11% which increased to 1.59±0.14% and 1.71±0.11% with the addition of 30% and 40% *Quinoa* flour, respectively. A previous study (25) reported that addition of *Quinoa* in wheat flour significantly increased the protein content of chapatti from 12.12% in control to 15.85% in *Quinoa* (30%) enriched chapatti; fortification of also increased the amino acids profile and mineral content of fortified chapatti compared to control sample. In another study [26], fortification of *Quinoa* flour (25%) in wheat flour improved the nutritional quality of bread in terms of fibre, mineral and proteins with better amino acid profile and high biological value. This could be attributed to the better amino acid profile of *Quinoa* proteins compared to maize proteins. Another study reported that *Quinoa* flour significantly increased the protein content of pasta [27]. However, a no significant change was observed in fat and ash content of enriched pasta. *Quinoa*'s composition varies according to the variety and environmental factors.

The calcium content of control sample was 6.5±0.56 mg/100g which increased to 52.86±1.59 to 82.91±2.15 mg/100g in F3 and F4 formulations, respectively. Furthermore, the addition of *Quinoa* flour significantly ($p<0.05$) increased magnesium, phosphorus and potassium content of the *Quinoa* enriched Chapattis. In a previous study, it was reported that the mineral contents of wheat flat bread fortified with 30% *Quinoa* flour had a significantly higher amount of minerals such as magnesium, calcium, iron, potassium and manganese than control flatbread [25]. *Quinoa* enriched Chapattis had significantly higher IVPD% compared to the control sample. This might be due to the complete amino acid profile of *Quinoa* flour. The amino acid profile of *Quinoa* is complete than most of the cereals [11]. Earlier study [14] on *Quinoa* proteins showed that IVPD% of *Quinoa* varieties varied 76.30% to 84.0%. The IVPD% of proteins is an important quality characteristic of nutritional quality. *Quinoa* flour had better protein digestibility than maize flour (Fig. 2). *Quinoa* enriched chapatti, which had a 20% or higher amount of *Quinoa* in the formulation, had a significant ($p<0.05$) higher IVPD% than the control. Moreover, it was reported earlier that *Quinoa* protein has better digestibility than other cereals [8].

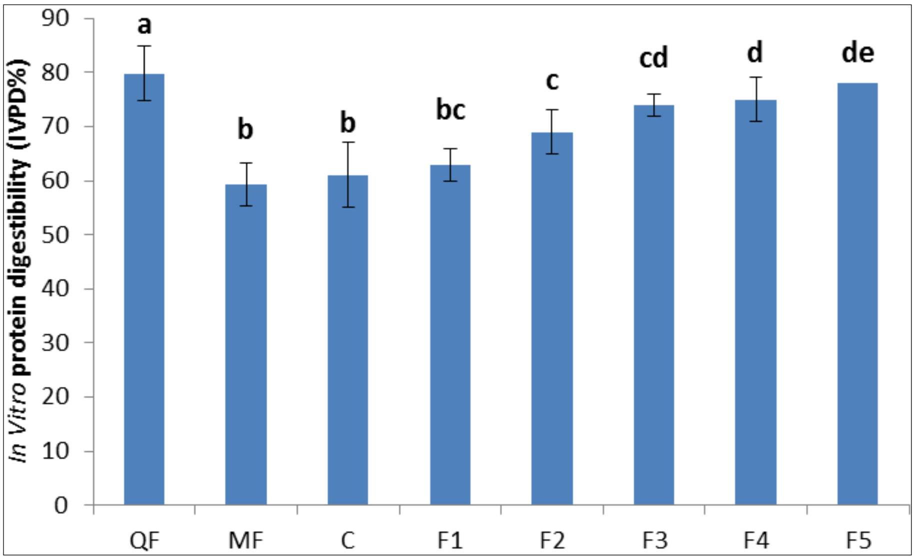

Fig 2: *In vitro* protein digestibility (IVPD %), QF: *Quinoa* flour, MF: Maize flour, C: Maize *chapatti* used as a control, F1: Maize flour: *Quinoa* flour (90:10), F2: Maize flour: *Quinoa* flour (80:20), F3: Maize flour: *Quinoa* flour (70:30) F4: Maize flour: *Quinoa* flour (60:40), F5: Maize flour: *Quinoa* flour (50:50)

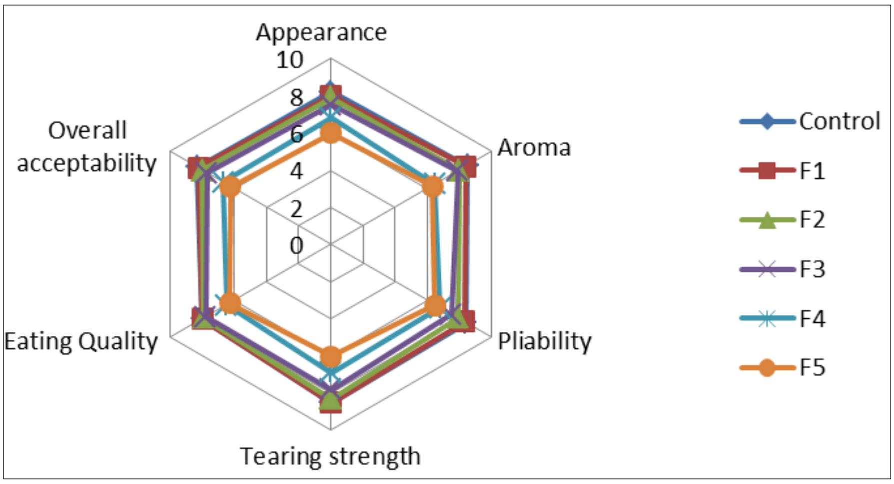

Fig 3: Radar graph showing the sensory profile of maize and maize-quinoa flour enriched *Chapattis*
Control: Maize *chapatti* used as a control, F1: Maize flour: quinoa flour (90:10), F2: Maize flour: quinoa flour (80:20), F3: Maize flour: quinoa flour (70:30) F4: Maize flour: quinoa flour (60:40), F5: Maize flour: quinoa flour (50:50)

Table 4: Proximate composition of *chapattis*

Parameter	Control	F1	F2	F3	F4	F5
Protein (%)	8.12±0.19^{a}	9.10±0.35^{b}	9.78±0.26^{b}	10.51±0.38^{bc}	11.10±0.41^{cd}	11.78±0.39^{d}
Fat (%)	2.26±0.12^{a}	2.49±0.14^{a}	2.68±0.11^{a}	3.07±0.13^{ab}	3.31±0.11^{b}	3.56±0.15^{b}
Crude fibre (%)	1.01±0.11^{a}	1.09±0.15^{a}	1.19±0.15^{a}	1.32±0.16^{ab}	1.47±0.13^{b}	1.61±0.14^{b}
Ash (%)	0.93±0.11^{a}	1.18±0.13^{a}	1.28±0.12^{ab}	1.59±0.14^{c}	1.71±0.11^{cd}	1.92±0.12^{d}
Mineral (mg/100g)						
Calcium	6.5±0.56^{a}	21.6±1.42^{b}	35.62±1.29^{c}	52.86±1.59^{d}	67.88±1.22^{e}	82.91±2.15^{f}
Magnesium	7.21±0.49^{a}	26.8±1.21^{b}	47.92±1.29^{c}	65.16±1.25^{d}	78.28±1.78^{e}	103.43±1.38^{f}
Phosphorus	12.34±0.78^{a}	38.93±1.56^{b}	65.46±1.26^{c}	87.51±1.21^{d}	104.12±1.35^{f}	121.51±1.27^{e}
Iron	1.21±0.45^{a}	1.57±0.11^{a}	1.62±0.21^{a}	1.79±0.22^{ab}	2.08±0.38^{b}	2.13±0.32^{bc}
Potassium	62.89±2.67^{a}	152.8±2.89^{b}	221.7±2.48^{c}	308.7±2.59^{d}	389.6±4.29^{e}	439.50±3.89^{f}
Zinc	6.32±0.78^{a}	7.81±0.51^{b}	8.06±0.32^{b}	8.18±1.01^{bc}	8.64±0.67^{c}	9.01±0.63^{d}

Data are expressed as means ± SD (n = 3) Values with the same letter in the same row are not significantly different at $p<0.05$

3.4 Sensory evaluation of chapattis

The addition of *Quinoa* flour alters the sensory attributes of maize chapatti (Fig. 3). However, the addition of *Quinoa* at lowers levels (10%) had a non-significant change in *Quinoa* enriched chapatti compared to the control sample. Fortified chapatti at 20% and 30% levels of *Quinoa* were liked and appreciated by panellists, depicted by higher scores for all F2 and F3 formulation parameters. The sensory analysis showed that up to 30% addition of *Quinoa* flour at optimum levels improved the flavour and aroma of the chapatti depicted by the higher scores for these parameters. The addition of *Quinoa* flour significantly ($p<0.05$) increased the nutritional value of enriched Chapattis. The addition of *Quinoa* flour at optimum levels (20% and 30%) improved the sensory attributes of the Chapattis. In an earlier study, adding *Quinoa* flour was reported to significantly enhance wheat bread's sensory properties [28]. With a further increase in *Quinoa* substitution level, decrease in sensory scores was noted. At higher levels of *Quinoa* supplementation, slight bitterness was observed in the chapatti, which decreased the sensory scores of the Chapattis.

3.5 Response of farmers and small entrepreneurs toward the technology

Based on the response to questionnaires from the farmers and small food processors, it was observed that 97% of the respondents were unaware of the poor nutritional quality of maize, mainly in terms of protein (Table 5). Further, it was noted that 95% of the respondents were unaware of *Quinoa*'s nutritional value, which is one of the best protein sources from a plant source. Fortification of maize flour with *Quinoa* flour was appreciated and liked by more than 90% of the respondents. However, above 30% level of *Quinoa*, most respondents observed an intense aroma and after taste of *Quinoa* in the chapatti. Moreover, local entrepreneurs involved in milling appreciated and strongly rated the technology in terms of ease of adoption to improve the nutritional value of our traditional food (Makki di roti). Further, this technology was demonstrated in a farmer skill development programme and was well-received by the participants. Adopting this technology at the commercial level would also encourage the local farmers to cultivate *Quinoa*. Most of the entrepreneurs trained are members of well-organized self-help groups (SHG), thus base on response received, this easy to adopt and cost-effective technique will be highly adopted and helpful for small scale grain miller processor.

Table 5: Response of farmers and small food processors towards *Quinoa* enriched maize flour chapatti

Attributes regarding maize-*Quinoa* chapatti and technique	#Responses		
Knowledge of low nutritional quality of maize flour compared to our stable food wheat flour	Not aware (97%)	Aware (03%)	-
Knowledge of nutritional value of *Quinoa* mainly for its protein quality	Not Aware (95%)	Aware (05%)	-
Potential of *Quinoa* flour as a functional ingredient for enhancing the nutritional value of other cereals	Not aware (95%)	Aware (05%)	
Ease of adoption	Strongly agree (91%)	Neither agree nor disagree (5%)	Disagree (4.0%)
Cost effective	Strongly agree (85.50%)	Neither agree nor disagree (7.6%)	Disagree (6.9%)
Organoleptic qualities*	Strongly agree (96%)	Neither agree nor disagree (04%)	-
Overall quality of the product	Strongly agree (93%)	Neither liked nor disliked (07%)	-
Willing to pay more for fortified maize flour with enhanced nutrition	Yes (96%)	May be or May be not (2.5)	No (1.5%)

*Organoleptic qualities include colour, taste and aroma#Based on information collected from 30 respondent who imparted training on "value addition of cereals and pulses

4. Conclusions

Novelty of the work is improvement in nutritional status of traditional maize chapatti using *Quinoa* flour. Resulted *Chapattis* prepared with combination of 70% maize flour and 30% *Quinoa* flour had significantly higher protein, fibre, ash and mineral content compared to control sample. Further, *in vitro* digestion studies suggested an increase in protein quality by increasing IVPD% of *Chapattis*. This work is expected to increase the use of local crops for supplementing the existing food product to achieve balanced nutrition at an affordable price. The reported work is expected to encourage the production of *Quinoa* crop in the region. Meat protein are expensive, use of local crops in combination is an economical and adaptable method for protein enrichment. This will eventually benefit consumers as well as able to extend commercial opportunity for this product.

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5.1 Adherence to ethical standards

This study does use any experimentation using human or animal subjects.

5.2 Conflict of interest

The authors have no known potential conflict of interest.

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