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Development and Effectual Evaluation of Gluten Free Multi Millet Pasta based on Nutritional, Sensory and Colour Characteristics

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ABSTRACT

Background: Sorghum (Variety: *Parbhani shakti*) is India's first bio-fortified sorghum with significantly higher iron and zinc content than regular sorghum. Today's customers are expected to accomplish more than just feed their hunger and give them the nutrients they need to stay healthy.

Methods: Present investigation was undertaken to develop gluten free multi millet pasta by using sorghum, pearl millet and finger millet with 1% carboxyl methyl cellulose and compared with wheat pasta for its nutritional and sensory properties. Pasta products were prepared with different formulations wheat (100% wheat flour) and sorghum, pearl millet and finger millet in the proportion of 90:5:5 (SPF_1), 80:10:10 (SPF_2), 70:15:15 (SPF_3) and 60:20:20 (SPF_4) and examined for pasta making potential.

Result: Proximate composition of raw materials showed that wheat contains highest protein compared to sorghum, pearl millet and foxtail millet. Sensory evaluation results revealed that pasta made form sorghum, pearl millet and finger millet in the proportion of 90:5:5 (SPF_1) was highly acceptable (Overall acceptability score 8.3) next to wheat pasta (Overall acceptability score 8.5).This study showed that highly nutritious gluten free pasta could be prepared with sorghum, pearl millet and finger millet in the proportion of 90:5:5 (SPF_1) with 1% carboxyl methyl cellulose.

Key words: Celiac disease, Gluten free, Millets, Pasta, Sensory evaluation.

INTRODUCTION

In modern world of globalization, consumer demands healthy nutritious products at affordable price, easy to cook with less time and effort, good sensory quality, versatility and long shelf life (Ranganna *et al*., 2014). Pasta is generally produced from wheat, which is abundant in starch and scarce in dietary fibers, minerals and vitamins. Preparation of pasta from sorghum, pearl millet and finger millet is not practiced which may strengthen the nutritional value of gluten free foods. Wheat gluten containing food consumption is concerned with clinical conditions like celiac diseases, non celiac gluten sensitivity and gluten allergy. Under such conditions to overcome this gluten free foods should be incorporated in diet. Cereal based gluten free product consumption is not only related to celiac disease but also other metabolic disease which required diet with of high fiber, low glycemic index, low fat (Cervini *et al*., 2021). Sorghum, pearl millet and finger millet are rich in iron, calcium, zinc and nutritionally superior to major cereals because of its energy, protein content and phytochemical content (Gull *et al*., 2016).

Millets are first pseudo cereals to be used for dietary purpose at household level and are substitute to wheat considering its nutritive value (Nagaraju *et al*., 2021) and are gluten free (Bhuvaneswari and Nazni, 2021) rich in minerals, dietary fiber and low in starch, fat and proteins which are staple foods of India and underutilized for pasta (Gull *et al*., 2017). Even though the nutritional importance of millets and its utilization for ready to cook products is limited to the consumers in rural population which leads to certain deficiency diseases of minerals. Pasta production is a simple processing technology at household level by utilizing whole grains flour (Rao and Deosthale, 1988).

Sorghum (Variety: *Parbhani shakti*) is India's first bio-fortified sorghum with significantly higher iron and zinc content than regular sorghum. It offers cost effective and sustainable solution to address micronutrient deficiency. Millets used as a alternative for exploring the utilization for making pasta. Composite flour of millets is considered as advantageous as it reduces the importation of wheat and encourages use of locally grain millet which is inexpensive and improves nutritional value (Akajiaku *et al*., 2017). Lack

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of gluten affects the structure, this improvement of gluten free pasta depends on selection of raw materials and use of functional additives such as carboxyl methyl cellulose and natural gums which improves the texture of gluten free products (Gao *et al*., 2017). Adding CMC (soluble fibers) to cereal based foods has beneficial effects on cholesterol and blood glucose level (Esparza *et al*., 2021).

MATERIALS AND METHODS

The present research work took place during year 2020-2022 at the "MIT school of Food Technology, MIT Art, Design and Technology, University, Pune and Department of Food Process Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV) Parbhani.

Sorghum variety *Parbhani shakti* was procured form All India Coordinated Research Project on Sorghum, VNMKV, Parbhani (Maharashtra, India). Wheat, pearl millet and finger millet were procured form local market of Pune (Maharashtra India). All grains of this study were cleaned manually from dirt, dust, damaged seed and strange materials and milled by using flour mill. Flours were passed through 100 mesh sieve to obtain fine flour. Four composite flour blends were chosen based on preliminary trials without jamming of pasta extruder screw inside barrel for desirable physical textural and nutritional properties (Nagaraju *et al*., 2021).

Preparation of pasta

Preliminary trials for pasta products from non wheat composite flour (sorghum, pearl millet, finger millet) were conducted which showed that breakable pasta, shape not form hence these can be overcome by incorporating CMC at 0, 0.5 and 1% which reported that good quality of pasta was produced with 1% CMC. As per formulation for pasta products presented in Table 1. Weighed amount of composite flour and other supplemented components were put into pasta extruder. With a knife sliding over the outside die surface, the extruded product tube type pasta was cut into consistent length (2.54 cm) pieces. The extruded pasta was dried at 50°C for 3-4 hours to achieve a moisture content of about 9% (db).

Proximate analysis

The representative samples of wheat flour, sorghum, pearl millet, finger millet flour and pasta products were analyzed for proximate principles such as moisture, protein, fat, ash, crude fibre content were analyzed as per standard method by Association of Analytical chemists (AOAC) 1984. Carbohydrate and mineral contents such as calcium, iron, zinc, manganese, copper were determined as per method described by Abdulrahman and Omoniyi (2016).

Sensory analysis

Five types of pasta were cut into 5 cm length and cook till white core in cross section disappeared in water at 100°C. 300 ml of water was poured in a vessel and boiled. Then a pinch of salt, oil and ready to cook pasta was added to the boiling water. The pasta was cooked on a medium flame for 3 minutes. Once done the pasta was drained to a colander. For seasoning oil was heated in a pan, added ginger garlic paste, onion and fried until they turn golden brown. Then added chilli powder, chilli sauce, soya sauce, vinegar, tomato sauce and properly mixed. Then sauce mixture was added to cooked pasta and tossed gently till sauce gets coated well. A semi-trained panel of ten judges evaluated cooked pasta samples for sensory parameters such as colour, flavour, taste, texture and overall acceptability using a 9-point hedonic scale, where 1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8- like very much and 9- like extremely (Bastos *et al*., 2016).

Measurement of colour

Colour of gluten free mineral enriched millet pasta incorporated with CMC deliberate through by means of "Hunter Lab Colorimeter (Model No. Colour flex, EZ)". Hunter Lab Calorimeter was calibrated with white tile. Average L*, a*, b* values of raw and cooked pasta were reported and pasta product was analyzed in triplicate. (Rhee *et al*., 2004).

Statistical analysis

Statistical analysis done by IBM, SPSS statistic software, all the data and figures were evaluated by ANOVA.

RESULTS AND DISCUSSION

Proximate composition and mineral contents of wheat, sorghum, pearl millet and finger millet

Results of proximate composition and mineral contents of wheat, sorghum, pearl millet and finger millet were summarized in Table 2. Moisture content of wheat,

Table 1: Formulation of wheat and composite millet flour (Gluten free) pasta.

Products	Wheat flour (g)	Sorghum flour (g)	Pearl millet flour (g)	Finger millet flour (g)	Water (ml)	Carboxyl methyl cellulose (g)
Control (Wheat)	100	-	-	-	50	-
SPF_1 (90:5:5)	-	90	5.0	5.0	50	1.0
SPF_2 (80:10:10)	-	80	10	10	50	1.0
SPF_3 (70:15:15)	-	70	15	15	50	1.0
SPF_4 (60:20:20)	-	60	20	20	50	1.0

(SPF: Sorghum flour + Pearl millet flour + Finger millet flour).

sorghum, pearl millet and finger millet were 10.31%, 9.28%, 9.67% and 10.45% respectively. Protein content of wheat was recorded 11.74% and among all millets lowest was recorded in sorghum (7.85%) and highest in pearl millet (8.75)%. Carbohydrate content of all grains ranged from 66.89 to 71.65%. Crude fat of all grains recorded were 1.87 to 5.23%. The highest ash value was recorded in finger millet (2.46%) and lowest in wheat (1.04%) crude fibre content of pearl millet was recorded highest (9.04%) lowest in wheat (5.61%). Susanna and Prabhasankar (2013) and Khan *et al*. (2013) reported variable values of moisture (9.32%), protein (10.8 to 11.45%) fat (0.67%), ash (1.19%) for various wheat samples. Kamble *et al*. (2021) and Tadesse (2019) reported moisture (9.2% and 7.1%) protein (11.30% and 12.14 %), fat (2.87 and 3.25%), ash (1.59 and 1.60%), crude fibre (1.30% and 0.85%) and carbohydrates 74.66% for sorghum. Sheethal *et al*. (2022) reported the values for moisture, ash, fat, protein, fibre, carbohydrates 7.87%, 1.24%, 4.30%, 93.45%, 9.02% and 74.88% for pearl millet. Singh and Raghuvanshi (2012) and Gull *et al*. (2015) recorded values for carbohydrate 72 to 79.5% and 68%, protein 5.62 to 12.70% and 7.3%, ash1.7 to 4.13% and 2.2%, moisture 12.06%, fat 2.67%, fibre 3.03% for finger millet. Calcium iron, zinc, manganese and copper content of wheat, sorghum, pearl millet and finger millet indicates that highest calcium was obtained from finger millet (181.2 mg/100 g) whereas iron content ranged from 3.82 to 5.22 mg/100 g, zinc 1.53 to 4.86 mg/100 g, manganese 1.15 to 3.22 mg/100g and copper 0.38 to 0.62 mg /100 g. Shukla and Shrivastava (2014) reported iron content 4.2 mg/100g and calcium 18.2 mg/100 g for wheat. Gull *et al*. (2015) reported calcium 109.2 mg/100 g, zinc 4.2 mg/100 g, iron 8.7 mg/100 g for pearl millet and calcium 139.2 mg/100 g, zinc 0.73 mg/100 g for finger millet.

Proximate composition and mineral contents of wheat and composite millet flour (Gluten free) pasta

Proximate composition and mineral contents of wheat and composite millet flour (Gluten free) pasta presented in Table 3. Showed that moisture content of wheat was (8.94%) while pasta samples SPF_4 had highest moisture content (9.39%) this shows that control pasta will have more shelf life than other pasta products. Proteins of pasta ranged from 7.92 to 11.5% highest in wheat pasta and lowest in SPF_1 this is because of protein content of wheat flour is higher but the leucine and tryptophan content is more in sorghum flour (Akajiaku, 2017).

Carbohydrate content of pasta products were 69.52 to 71.55% highest in wheat pasta (71.55) and lowest in SPF_4 (69.52%). With decreasing level of sorghum and increasing level of Pearl and finger millet carbohydrate content decreased from 71.19, to 69.52%, carbohydrates are considered as a low cost source of energy for the body. Crude fat content of pasta samples ranged from 1.80 to 3.45%. Control sample had the lowest (1.80) and SPF_4 had the highest fat (3.45%). As the level of pearl millet and finger millet increased in pasta products from 5 to 20% fat

Table 2: Proximate composition and mineral contents of wheat, sorghum, pearl millet and finger millet.

Raw materials	Proximate composition g/100 g						Mineral composition µg/100 g				
	Moisture	Proteins	Carbohydrate	Crude fat	Ash	Crude fiber	Calcium	Iron	Zinc	Manganese	Copper
Wheat	10.31 ± 0.01^d	11.74 ± 0.01^a	69.44 ± 0.01^b	1.87 ± 0.01^d	1.04 ± 0.02^d	5.61 ± 0.01^d	18.4 ± 0.2^d	4.6 ± 0.1^c	2.85 ± 0.02^c	3.15 ± 0.01^b	0.42 ± 0.01^c
Sorghum	9.28 ± 0.00^c	7.85 ± 0.01^d	71.65 ± 0.01^a	3.04 ± 0.01^b	1.58 ± 0.02^c	6.45 ± 0.01^c	55.19 ± 0.01^c	4.89 ± 0.01^b	4.86 ± 0.01^a	1.22 ± 0.01^c	0.46 ± 0.00^b
Pearl millet	9.67 ± 0.01^b	8.75 ± 0.02^b	68.88 ± 0.01^c	5.23 ± 0.01^a	1.94 ± 0.01^b	9.04 ± 0.01^a	108.5 ± 0.2^b	3.82 ± 0.02^d	3.82 ± 0.01^b	1.15 ± 0.01^d	0.38 ± 0.02^d
Finger millet	10.45 ± 0.02^a	8.42 ± 0.02^c	66.89 ± 0.02^d	2.94 ± 0.03^c	2.46 ± 0.01^a	8.84 ± 0.02^b	181.2 ± 0.1^a	5.22 ± 0.01^a	1.53 ± 0.01^d	3.22 ± 0.01^a	0.62 ± 0.01^a

The mean values in same column with different superscript letters are significantly different at $p < 0.05$ as per the Duncan's multiple comparison test. The values are expressed as mean ± SD (n =3).

content increased from 3.15 to 3.45% pasta products with high fat content may develop rancidity during storage and also restricts to cardiac, obese patients. Control sample had lowest ash content 0.8% and ash content of gluten free pasta ranged from 1.72 to 1.82% which showed that high ash content is related to high mineral content of multi millet gluten free pasta.

Crude fibre content of wheat pasta was lowest 5.41% and of gluten free pasta ranged from 6.71 to 7.41% with increasing level of pearl and finger millet. Dayakar rao *et al*. (2021) reported moisture 8.25% to 10.02%, protein 9.3 to 9.7%, fat 0.44 to 0.84%, fibre 0.76 to 0.90% and carbohydrates 71.3 to 74.7% for wheat sorghum pasta products. Cervini *et al*.(2021) reported moisture 11.3%, protein 8.0%, fat 1.1% ash 0.5% fibre 1.2% carbohydrate 87.6% for rice pasta products Akajiaku *et al*. (2017) reported the values of moisture 7.5 to 8.5%, protein 9.5 to 14.2%, fat 1.3 to 2.3%, ash 1.8 to 2.4%, fibre 1.4 to 1.9 and carbohydrate 70.56 to 75.96% for sorghum wheat noodles Benhur (2015) reported moisture 8.25 to 10.02%, proteins 9 to 9.7%, fat 0.44 to 0.84%, fibre 0.76 to 0.90% carbohydrates 71.3 to 74.7% for sorghum wheat pasta. The mineral contents of wheat pasta and gluten free pasta showed that calcium content of wheat pasta was lowest 22.74 mg/100 g and 61.18 mg/100 g to 91.19mg/100g for pasta products SPF_1 to SPF_4. Iron content of all pasta products was in the range of 4.4 mg/100 g to 4.85 mg/100 g. Lowest zinc was recorded in wheat pasta (2.92 mg/100 g) whereas highest was recorded in SPF_2 (4.41 mg/100 g), manganese content of all pasta products varied from 1.19 to 3.12 mg/100 g. Whereas copper content was in the range of 0.38 mg/100 to 0.46 mg/100 g.

Sensory analysis of wheat and composite millet flour (Gluten free) pasta

Sensory evaluation of wheat and composite millet flour (Gluten free) pasta was conducted on 9 point hedonic scale by 10 members for colour, flavor, taste, texture and over all acceptability of the developed pasta was presented in Fig 1. Overall acceptability of pasta ranged from 6.0 to 8.5% highest for control (8.5) and lowest for SPF_4 (6.0). Sensory evaluation of pasta reveled that SPF_1 Pasta prepared form 90:5:5 ratio of sorghum, pearl millet, finger millet was liked by panelist member very much after controlled pasta, obtained score of 8.3 on the 9 point hedonic scale. The mean overall score of developed pasta from gluten free flour was in the range of 6 to 9 shows highly acceptable pasta product. Results showed that wheat flour could be replaced to an extent of 100% with sorghum flour, pearl millet flour and finger millet flour (90:5:5) to obtain gluten free pasta without affecting much sensory quality of pasta. In terms of sensory properties the pasta samples with increased proportion of pearl millet (5 to 20%) and finger millet (5 to 20%) and decreased proportion of sorghum (90 to 60%) scored low. Similar types of results were reported for sensory evaluation of foxtail millet based vermicelli with black gram flour (Pandey *et al*. 2017). The

Table 3: Proximate composition and mineral contents of wheat and composite millet flour (Gluten free) pasta.

Product	Proximate composition g/100 g						Mineral's composition µg/100 g				
	Moisture	Proteins	Carbohydrate	Crude fat	Ash	Crude fiber	Calcium	Iron	Zinc	Manganese	Copper
Wheat Control	8.94±0.01^e	11.50±0.01^a	71.55±0.01^a	1.80±0.01^e	0.8±0.03^d	5.41±0.01^e	22.74±0.01^e	5.4±0.05$_a$	2.92±0.01^e	3.12±0.01^a	0.38±0.01^b
SPF_1	9.31±0.01^d	7.92±0.01^e	71.19±0.01^b	3.15±0.02^d	1.72±0.01^c	6.71±0.01^d	61.18±0.01^d	4.85±0.01^b	4.53±0.01^a	1.19±0.01^e	0.45±0.01^a
SPF_2	9.34±0.01^c	7.99±0.01^d	70.74±0.01^c	3.24±0.01^c	1.75±0.01^b	6.94±0.01^c	73.19±0.01^c	4.81±0.01^{bc}	4.41±0.01^b	1.40±0.01^d	0.45±0.01^a
SPF_3	9.36±0.01^b	8.06±0.01^c	70.27±0.01^d	3.35±0.02^b	1.76±0.01^b	7.20±0.01^b	82.18±0.01^b	4.77±0.01^{cd}	4.19±0.01^c	1.51±0.01^c	0.46±0.01^a
SPF_4	9.39±0.01^a	8.41±0.01^b	69.52±0.01^e	3.45±0.01^a	1.82±0.01^a	7.41±0.01^a	91.19±0.01^a	4.73±0.01^d	3.98±0.01^d	1.60±0.01^b	0.46±0.01^a

The mean values in same column with different superscript letters are significantly different at $p<0.05$ as per the Duncan's multiple comparison test. The values are expressed as mean ± SD (n =3).

firmness was decreased and stickiness increased form sample SPF_1 to SPF_4. Pasta prepared from high amylose starch is known as too firm therefore optimum amylose to amylopectin ratio is considered for its good quality (Benhur *et al*., 2015).

Score for colours also decreased from sample control to SPF_4 may be due to inherit colour of millets. Texture was granular and crumbly which not liked by panel members which decreases score for texture from control to SPF_4. Based on sensory evaluation gluten free pasta (SPF_1) could be considered a product of good acceptability by consumer.

Effect of cooking on colour values of wheat and composite millet flour (Gluten free) pasta

When evaluating pasta's aesthetically appealing features and market value, color is an important consideration. Color was measured using cooked and uncooked pasta samples that were able to maintain their whole, original shape after cooking was expressed in Table 4.

Effect of cooking on colour values of wheat and composite millet flour (Gluten free) pasta indicates that brightness (L* value) of raw wheat pasta was recorded 63.10 and for SPF_1 to SPF_4 were recorded 63.65 to 59.15 as the proportion of sorghum flour decreased from 90 to 60% and finger millet and pearl millet flour increased from 5 to 20% in gluten free products brightness (L* value) decreased from 63.10 to 59.15.

Brightness of cooked wheat pasta was 64.50 and for SPF_1 to SPF_4 the values were 59.35 to 52.72. cooking of wheat pasta increases L* value from 63.10 to 64.50 where as cooking of gluten free products decreases L value for SPF_1 from 63.65 to 59.35, for SPF_2 decreased from 63.09 to 58.16, for SPF_3 decreased from 59.45 to 53.01 and for SPF_4 decreased from 59.15 to 52.72 respectively. Cooking increased brightness for wheat pasta where as is decreased for gluten free pasta.

Redness (a*) value) of raw wheat pasta was recorded 5.69 and for SPF_1 to SPF_4, values were 3.83 to 4.79 as the proportion of sorghum flour decreased from 90 to 60% and finger millet and pearl millet flour increased from 5 to 20%. (a* value) increased from 3.83 to 4.79. Redness of cooked wheat pasta was 5.33 and for SPF_1 to SPF_4 the values were 4.25 to 5.87. cooking of wheat pasta decreases a* value from 5.69 to 5.33 whereas cooking of gluten free products increases a value for SPF_1 was 3.83 to 4.25, for SPF_2 value was 3.89 to 4.26, for SPF_3 it was 4.57 to 5.72 and for SPF_4 it was 4.79 to 5.87 respectively.

Yellowness (b* value) of raw wheat pasta was recorded 21.13 and for SPF_1 to SPF_4 was decreased from 17.58 to 15.84 as the proportion of sorghum flour decreased from

Table 4: Effect of cooking on colour values of wheat and composite millet flour (Gluten free) pasta.

Sample	L*		a*		b*	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
Control (wheat)	63.10±0.02[b]	64.50±0.04[a]	5.69±0.04[a]	5.33±0.03[c]	21.13±0.03[a]	23.61±0.01[a]
SPF_1	63.65±0.01[a]	59.35±0.01[b]	3.83±0.01[e]	4.25±0.03[d]	17.58±0.02[b]	17.66±0.01[b]
SPF_2	63.09±0.03[b]	58.16±0.01[c]	3.89±0.01[d]	4.26±0.04[d]	17.27±0.01[c]	17.18±0.01[c]
SPF_3	59.45±0.07[c]	53.01±0.01[d]	4.57±0.01[c]	5.72±0.02[b]	16.49±0.01[d]	16.58±0.02[d]
SPF_4	59.15±0.08[d]	52.72±0.02[e]	4.79±0.01[b]	5.87±0.01[a]	15.84±0.02[e]	15.21±0.01[e]

The mean values in same column with different superscript letters are significantly different at p<0.05.as per the Duncan's multiple comparison test. The values are expressed as mean ± SD (n =3).

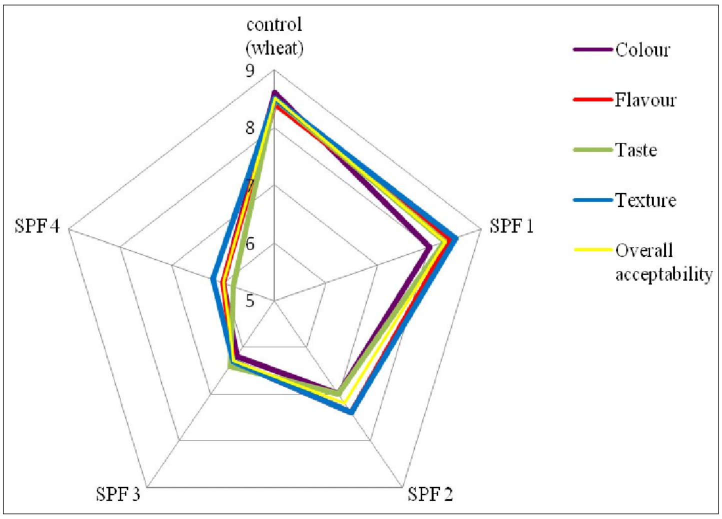

Fig 1: Sensory evaluation of wheat and composite millet flour (Gluten free) pasta.

90 to 60% and finger millet and pearl millet flour increased from 5 to 20%. Yellowness (b* value) decreased from 17.58 to 15.84. Yellowness of cooked wheat pasta was 23.61 and for SPF_1 to SPF_4 was decreased from 17.66 to 15.21. cooking of wheat pasta increased b* value from 21.13 to 23.61 whereas cooking of gluten free products increased b* value for SPF_1 was 17.58 to 17.66, SPF_2 was 17.27 to 17.18, for SPF_3 it was 16.49 to 16.58 and for SPF_4 it was 15.84 to 15.21 respectively.

Pasta brightness was reduced by addition of composite flour perhaps as a result of increased ash content of millet flours in gluten free pasta products. This is consistent with earlier research on dehydrated pasta enriched by means of green pea, chickpea and lentil flour (Wood, 2009; Zhao *et al*. 2005). Gluten free composite millet flour dried pasta's brightness was further reduced as millet flour was raised. Addition of millet flour resulted in decline in brightness and raise in darkness which possibly will be due to lower protein content in millet flour. The L* value of cooked wheat pasta samples increased this rise in lightness may be the result of colour loss during cooking. Pasta made from uncooked wheat had the greatest a* value when compared to Gluten free pasta made from sorghum, finger millet and pearl millet.

CONCLUSION

This study reported that replacement of wheat with multi millet such as sorghum, pearl millet and finger millet for development of gluten free pasta improved the nutritional value and their potential as functional foods. The results of this study can be beneficial to improve nutritional quality of multi millet gluten free pasta. The lack of gluten affects sensory properties of pasta products. For development of gluten free pasta products, combination of millets, use of hydrocolloids, processing technologies serve this purpose and requires further research. High nutritional quality gluten free pasta helps to incorporate in the diet of celiac disease consumers. Nutritional value of sorghum, pearl millet and finger millet indicates its potential application in gluten free pasta product development.

Conflict of interest

All authors declare that they have no conflict of interest.

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