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Effect of hydrocolloids on microstructure, texture and quality characteristics of gluten-free pasta

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Abstract Whole amaranth flour was used to prepare gluten free pasta with different hydrocolloids (guar gum, gum acacia and gum tragacanth) at different proportions (0.5 and 1.0%). Different flour blend formed from amaranth flour and hydrocolloids (guar gum, gum acacia and gum tragacanth) were tested for pasting profile. Amaranth flour blend with 1.0% guar gum showed maximum peak viscosity. Developed pasta samples were evaluated for colour analysis, cooking characteristics, texture profile analysis, morphological properties and sensory analysis which shows significant difference from semolina pasta (control). In gluten-free pasta, cooking loss ranged from 8.5 to 17.30%. Pasta with guar gum (1%) showed minimum cooking loss (8.5%). Our results showed that guar gum was best in terms of improving all aspects of gluten free pasta quality.

Keywords Amaranth · Pasta · Hydrocolloids · Pasting properties · Texture properties · Sensory analysis

Introduction

Wheat is a major cereal grain and is the staple food of many countries as well as India. Unfortunately, wheat is known to cause Celiac disease which is characterized by immunoglobulin E (IgE)-mediated allergic reactions in specific individuals [1]. In India, Celiac disease has high incidence (1.04%) in North India [2] and treatment of disease involves gluten free diet [3]. Grain amaranth has several unique features like gluten-free ingredients, high quality protein and the presence of abundant quantities of fibre and minerals such as calcium and iron [4, 5]. The macronutrients content of amaranth flour is similar to wheat, and is 2–3 times higher than other gluten free sources [6]. Thus, it makes amaranth flour a good substitute for wheat and other flours for synthesis of gluten free food products.

Among the gluten free products, the demand of good quality gluten free pasta has always attracted the attention of researchers and celiac disease patient among worldwide. In pasta processing, gluten is mainly responsible for the formation of the structure. Pasta prepared from gluten free flour is usually sticky, inferior in textural quality, and characterized by cooking losses. So, some substances could be used to produce a cohesive structure which can overcome the absence of gluten [7]. In this regard, dairy proteins and hydrocolloids can be used to mimic the viscoelastic properties of gluten and result in improved structure, mouthfeel, acceptability and shelf life of gluten free pasta [8].

Hydrocolloids, commonly named gums, are able to modify overall quality of the food products. Guar gum is obtained from the seeds of the drought tolerant plant *Cyamopsis tetragonoloba*, belongs to leguminosae family [9]. It is a carbohydrate consisting of mannose and galactose in a 2:1 ratio. It can swell in cold water and is widely used as a binder and volume enhancer. It is also used as a novel food additive, food stabilizer, and source of fibre [10]. Gum tragacanth derived from plant of *Astragalus* spp. The gum contains pectinaceous arabinogalactans and fucose-substituted xylogalacturonans. It is known to confer very high viscosities when in aqueous solution, and is described as a complex, highly branched, heterogeneous hydrophilic polysaccharide. Therefore, it used as a stabilizing, viscosity enhancing agent in food emulsions. Gum acacia (GA,

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E-Number 414) is an edible, dried, gummy exudate from the stems and branches of *Acacia senegal* and *Acacia seyal* [11]. It is rich in non-soluble fibre and non-digestible food ingredient that has found many applications in the food and pharmaceutical industries.

This study was designed to study the effect of different hydrocolloids such as guar gum, gum tragacanth and gum acacia on colour, cooking, textural, morphological and sensory properties of gluten free pasta made from whole amaranth flour.

Materials and methods

Procurement of raw material

Amaranth grain variety (VL-44) was purchased from Vivekananda Parvitya Krishi Anusandhan Sansthan (Almora), India. Grains were cleaned and stored in air tight container at 4 °C till further used. Guar gum, gum tragacanth and gum acacia were obtained from Sigma–Aldrich.

Methodology

Preparation of amaranth flour

Dried amaranth grains were milled in cyclotech mill. The flour was passed through 44 mesh sieve and stored at 4 °C till further analysis.

Proximate analysis

The proximate composition of the amaranth flours and gluten free pasta was carried out by AOAC, 1995 [12] for protein (992.23), fat (945.16), moisture (925.08) and ash content (923.03). The crude fibre content was determined using the AACC (32-10.01, 2000) [13].

Total dietary fibre (TDF)

Total dietary fibre of amaranth flour was determined by using method IS – 11062 [14].

Mineral content

The mineral content (Ca, Mg, Zn and Fe) of amaranth flour were determined by using methods of AOAC No. 985.36 [15].

Functional properties

Amaranth flour (5 g) was extracted with 50 ml of methanol for 30 min at room temperature by magnetic stirring followed by centrifugation (3000×*g*/20 min) to get clear supernatant. The solid residue was subjected to a second extraction under the same conditions. Both supernatants were mixed and filtered through Whatman No. 4 filter paper, evaporated to dryness under vacuum and stored at 4 °C until analysis.

Total polyphenol content (TPC) and flavonoids (TFC)

The TPC and TFC were calculated by the methods described by Dewanto et al. [16]. The TPC and TFC were expressed as milligrams of Gallic acid equivalents per gram of dry extract (mg GAE/g DE) and milligrams of Catechin per gram of dry extract (mg CE/g DE) respectively. The calculations were done against the calibration curve of standard Gallic acid and Catechin.

Antioxidant activity (DPPH radical scavenging activity)

Antioxidant activity (AOA) was measured using the method described by Brand-Williams et al. [17]. Antioxidant activity was calculated as percent discoloration.

$$\textit{DPPH redical scavenging activity}\,(\%) = \left\{1 - \left[\frac{\textit{A of sample at } t = 30}{\textit{A of control at } t = 0}\right]\right\} \times 100$$

where, A is absorbance.

Pasting properties of gluten free flour blend

Pasting properties of all the flour blends were studied using a Rapid visco analyzer (RVA Tecmaster, Perten, Australia) using the Standard profile 1. An aqueous dispersion of flour 12.28% w/w; 28.5 g total weight (14% 98 moisture basis) was equilibrated for 1 min at 50 °C, heated at the rate of 12.2 °C/min to 95 °C and held there for 2.5 min. The sample was cooled to 50 °C at the rate of 11.8 °C/min and held there for 2 min. For the first 10 s rapid stirring at 960 rpm was used to disperse the sample and then constant paddle rotational speed (160 rpm) was used throughout the entire analysis.

Gluten free pasta processing

After initial trials, the formulation was set as two different proportions (0.5 and 1.0 g/100 g) of guar gum, gum tragacanth and gum acacia additives in per 100 g of formulation. A fixed amount of water was added to each sample to attain 30% moisture wet basis. Mixed samples were extruded using La Moniferrino (Model Dolly, Asti, Italy) pasta extruder. The pasta samples were dried at 60 °C for 4 h in tray dryer and packed in air tight container for further use.

Gluten free pasta cooking quality

Optimization of cooking time and determination of cooking loss of pasta samples were determined according to AACC approved method [18]. Twenty-five grams of pasta samples were cooked with 250 ml of boiling water for its optimum cooking time. Optimum cooking time was considered when core of the pasta gets completely hydrated. Cooked pasta were drained and weighed when cooled. The drained gruel was measured and 20 ml of gruel in triplicates were transferred to pre-weighed glass petridish to estimate the cooking loss of the pasta.

Water uptake percentage (g/100 g)

The water uptake is the difference in the weight of cooked pasta versus uncooked pasta, expressed as the percentage of weight of uncooked pasta [19].

Texture profile analysis of gluten free pasta

The TA-XT2i Texture Analyzer (Stable Micro Systems Ltd., UK) fitted with a 50 kg load cell was used. Pasta samples were placed adjacent to one another centrally under the compression platen of pasta firmness/stickiness rig. The pre test, test speed and post test speed were 1, 0.5 and 10 mm/s, respectively. The test is a simulation of the action of jaw by compressing the bite size of food two times. The resulting force–time curve is used to extract number of textural parameters. These are primary parameters (hardness and adhesiveness) and secondary parameters (chewiness and gumminess) were done by slight modification by [20].

Colour characteristics of gluten free pasta

Colour of the uncooked pasta was measured using Hunter colour measurement (Mini scan XE plus, USA). Colour readings were expressed by Hunter values for L*, a* and b*. The L* values measure black to white (0–100), a* values measure redness when positive and b* values measure yellowness when positive.

Microstructure of gluten free pasta

Transversely sectioned of uncooked and cooked freeze-dried pasta samples were scanned to understand microstructure of pasta samples using scanning electron microscope (SEM), JEOL, Tokyo, Japan, Model No., JSM-6610-LV, operating at 10–20 kV. Uncooked and cooked pasta samples were mounted on aluminum stub using a double backed cellophane tape, coated in auto fine coater, JEOL-JFC-1600, with gold palladium (60:40, g/g) [21].

Sensory evaluation of gluten free pasta

Freshly cooked pasta made from wheat and amaranth flours were subjected to sensory evaluation using 20 semi-trained panellists drawn within the University community. Coded samples were served and the panellists were asked to evaluate in terms of colour and appearance, firmness (handfeel), texture (mouthfeel) taste and overall quality using a nine-point hedonic rating scale according to Olagunju and Ifesan [22]. A nine-point Hedonic scale was used where, 9-Like extremely, 8-Like very much, 7-Like moderately, 6-Like slightly, 5-Neither like nor dislike, 4-Dislike slightly, 3-Dislike moderately, 2-Dislike very much, and 1-Dislike extremely. Panellists were instructed to cleanse their palate with cold, filtered tap water before testing each sample. Product characterization was carried out under ‘daylight’ illumination and through electric lamps in isolated booths.

Statistical analysis

Data were assessed by Duncan’s multiple range test [23] using statistical 7 (statistical soft, TULSA, USA) statistical software packages at $p < 0.05$ was used to determine the level of significance.

Results and discussion

Chemical composition of amaranth flour

The analyzed chemical parameters were reported in Table 1. The range of chemical parameters (Protein, fat, and ash content) is within the range as reported by [24]. The amaranth grain flour presented the higher amount of total dietary fibre (9.52/100 g) than the earlier study (8.83/100 g) by [25]. The amaranth grain showed lower antioxidant capacity and higher TPC values than the literature [26]. In case of minerals, Ca and Fe were in the higher range of literature while Zn and Mg were in lower than the literature [27]. The gluten free diet are deficient in some minerals like calcium, magnesium, and iron. The high calcium content in amaranth seeds may be of special relevance for celiac subjects due to the well - known prevalence of osteopenia and osteoporosis among celiac patients [27].

Pasting properties of gluten free flour blend

The pasting properties of amaranth flour with addition of different hydrocolloids (guar gum, gum acacia and gum tragacanth) at different level (0.5 and 1.0/100 g) are listed in Table 2. The peak, trough, breakdown, and final viscosities increased significantly ($p < 0.05$) with the addition of

Table 1 Chemical composition of amaranth flour

Parameter	Amaranth flour
Moisture (g/100 g)	8.13±0.05
Ash (g/100 g)	2.91±0.08
Crude fibre (g/100 g)	4.80±0.02
Fat (g/100 g)	6.68±0.08
Protein (g/100 g)	15.05±0.10
Total dietary fibre(g/100g)	9.52±0.22
AOA (DPPH^{R}) (g/100 g)	10.23±0.02
TPC (mg GAE/100 gm extract)	67.07±1.05
TFC (mg CE/100 gm extract)	6.90±0.45
Mineral contents	
Ca (mg/100g)	170.27±0.22
Mg (mg/100g)	117.75±0.06
Fe (mg/100g)	13.1±0.14
Zn (mg/100g)	2.76±0.11

TPC total phenol content, *GAE* gallic acid equivalents, *TFC* total flavonoids content, *CE* Catechin equivalents, *AOA* antioxidant activity, ^{R} radical scavenging activity

guar gum and gum tragacanth, while a reverse trend was observed with addition of gum acacia.

Peak viscosity is the water holding capacity of starch or mixture. At 1% concentration, gum acacia showed lowest peak viscosity, whereas guar gum and gum tragacanth was found to be most effective hydrocolloid in increasing the peak viscosity. Increase in guar gum concentration has been shown to enhance the inter-molecular interaction or entanglement which leads to increase in viscosity [28]. Alam et al. [29] studied the influence of guar, xanthan, arabic, carboxy methyl cellulose and tragacanth gums on wheat flour. Among the hydrocolloids tested, guar gum was found most effective in increasing the peak viscosity whereas gum acacia showed negative impact on peak viscosity.

Breakdown viscosity is the viscosity difference between the peak viscosity and the trough viscosity and occurs as a result of holding slurries at high temperature and mechanical shear stress which leads to further disruption of the swollen starch granules resulting in leaching of amylose into the solution Tsakama et al. [30]. Among the hydrocolloids tested; guar gum was the most effective in increasing the breakdown which is 21.86 RVU whereas 1.0% gum acacia shows least breakdown 17.53 RVU. Setback is the re-association between starch molecules during cooling. The addition of different hydrocolloids shows a significant difference in setback. As the concentration of different gums was increased, a reduction in the setback was noticed. Similar trend also reported by Alam et al. [29] for setback value of wheat flour added with different hydrocolloids. Reduction in setback is attributed to the interaction between the hydrocolloids and leached amylose which controls the re-association of amylase chains.

Colour of gluten free pasta

The colour characteristics of the pasta (uncooked) are presented in Table 3. The L* values of gluten free pasta lower than the control pasta prepared from semolina. This could be due to low L* values of amaranth flour used in pasta preparation as compared to semolina used in control pasta. Hence pasta looked darker than control pasta. The L* values of gluten free pasta ranged from 49.33

Table 3 Colour properties of gluten free pasta

Sample	%	L - value	a - value	b - value
Control		65.33^{a}±1.41	1.69^{b}±0.21	28.40^{a}±0.81
Amaranth + guar gum	0.5	51.96^{b}±1.71	5.22^{a}±0.40	19.21^{b}±1.48
	1.0	50.43^{b}±0.81	5.75^{a}±0.14	22.61^{b}±1.27
Amaranth + gum acacia	0.5	49.33^{b}±0.12	5.22^{a}±0.10	21.13^{b}±0.73
	1.0	51.69^{b}±1.56	5.43^{a}±0.26	21.85^{b}±0.68
Amaranth + gum tragacanth	0.5	50.93^{b}±2.33	5.25^{a}±0.18	21.11^{b}±0.75
	1.0	51.07^{b}±1.48	5.46^{a}±0.24	22.15^{b}±1.44

Mean values in the same column with different letters differ significantly ($p < 0.05$)

Table 2 Pasting properties of gluten free flour blend

Sample	%	PV (RVU)	Trough (RVU)	B.D. (RVU)	F.V. (RVU)	S.B. (RVU)	P.T. (°C)
Amaranth + guar gum	0.5	88.95^{a}±0.65	68.16^{c}±0.62	19.20^{d}±0.39	79.20^{c}±0.50	11.71^{b}±0.26	77.45^{b}±0.03
	1.0	95.00^{b}±0.76	74.31^{b}±0.61	21.86^{b}±0.35	83.06^{b}±0.37	10.32^{c}±0.35	77.55^{b}±0.02
Amaranth + gum acacia	0.5	86.16^{c}±0.95	68.03^{c}±0.79	18.73^{d}±0.37	77.09^{d}±0.85	10.24^{c}±0.21	77.55^{b}±0.03
	1.0	84.44^{d}±1.36	66.70^{d}±0.65	17.53^{e}±0.43	76.30^{d}±0.59	9.45^{d}±0.29	77.55^{b}±0.03
Amaranth + gum tragacanth	0.5	87.96^{a}±0.56	67.76^{cd}±0.54	20.50^{c}±0.31	77.64^{cd}±0.35	10.84^{a}±0.22	77.55^{b}±0.02
	1.0	94.05^{b}±0.35	72.65^{a}±0.64	20.98^{a}±0.34	81.19^{a}±0.45	9.93^{c}±0.22	77.45^{b}±0.02

Mean values in the same column with different letters differ significantly ($p < 0.05$)

PV peak viscosity, *BD* breakdown, *FV* final viscosity, *SB* setback, *PT* pasting temperature to 51.96 whereas control showed 65.33. Similarly, Rosa et al. [31] documented that the amaranth flour showed a negative effect on L* (darker) value of pasta prepared from buckwheat flour and different addition levels of amaranth flour and rice flour.There was no significant difference was observed in a* value (redness) of the different gluten free pasta samples, ranging from 5.22 to 5.75 while control pasta showed significant lower a* value (1.69). Similarly, there was no significant difference was noticed in b* value (yellowness) among gluten free pasta samples, which ranged from 19.21 to 22.61 but these values were significantly lower than control pasta (28.40). In general, the colour values of gluten free pasta samples were significantly different than the control pasta. This may be due to the different colour of amaranth flour in comparison with wheat flour.

Cooking characteristics of gluten free pasta

The data about the effect of gums on cooking qualities of gluten free pasta are presented in Table 4.The cooking quality comprises data such as cooking loss, water uptake and cooking time. Among the cooking parameters, cooking loss is one of the main parameter taken into consideration during the evaluation of pasta quality.

Cooking loss in gluten free pasta ranged from 8.5–17.3/100 g, which was higher than control pasta (7.4/100 g). Among gluten free pasta, pasta with 1.0% guar gum showed minimum cooking loss (8.5/100 g) whereas pasta incorporated with 0.5% gum acacia showed maximum cooking loss (17.3/100 g). Similarly, the incorporation of guar gum reduced the cooking loss in gluten free vermicelli Hymavathi et al. [32] this might be due to the formation of strong network between starch and gums thereby arresting any leaching of the dry matter from the vermicelli.

Optimum cooking time was defined as the cooking time needed for the ‘‘white pasta center core’’ to disappear when pasta was squeezed between 2 glass petri plates. The cooking time for all gluten free pasta was significantly lower (198–246 sec) than control (366 sec). Similarly, decrease in cooking time was observed in spaghetti based on maize and oat flours with different hydrocolloids Padalino et al. [7].

Water uptake indicates the degree of pasta hydration. It may affect the eating quality of pasta. The water uptake of all gluten free pasta was higher ranged from 161.29 to 180.60/100 g than control pasta 144.78/100 g. Among gluten free pasta, the highest water uptake (180.60/100 g) was observed in case of pasta with 1.0% guar gum whereas lowest water uptake (161.29/100 g) was observed in 0.5% gum acacia added pasta.

Textural profile analysis of gluten free pasta

The textural properties of pasta is the important parameter to determining the final acceptance by consumers Tudorica et al. [33] The textural properties of gluten free pasta containing different hydrocolloids are shown in Table 5. The addition of various hydrocolloids shows positive effects on the textural properties of gluten free pasta. The control pasta prepared from semolina showed more hardness (3.85 N) than gluten free pasta which ranged from 0.85 to 2.59 N. Among the all gluten free pasta samples, pasta prepared with 1.0% guar gum showed highest hardness (2.59 N). Han et al. [34] also documented similar results; they showed hardness of the rice starch noodles was significantly increased by the addition of gellan gum. Adhesiveness is a primary function of surface characteristic that depends on the viscoelasticity of noodles Adhikari et al. [35]. Adhesiveness is the most undesirable characteristic which is a measure of the extent of attachment of the product to teeth. The control pasta showed lowest adhesiveness (−58.37) as compared with gluten free pasta. There was a significant difference was observed in adhesiveness when hydrocolloid percentage increased from 0.5 to 1.0%. The adhesiveness value is decreased when hydrocolloid concentration was higher (1.0%) in the gluten free pasta samples. Among gluten free pasta, 1.0% guar gum incorporated pasta showed least adhesiveness (−36.31) whereas, pasta having 0.5% gum acacia indicated highest adhesiveness

Table 4 Cooking characteristics of gluten free pasta

Sample	%	Optimal cooking time (s)	Water uptake (g/100 g)	Cooking loss (g/100g)
Control		366	$144.78^{a}\pm0.08$	$7.4^{g}\pm0.11$
Amaranth + guar gum	0.5	198	$172.65^{d}\pm0.14$	$11.4^{e}\pm0.10$
	1.0	240	$180.60^{b}\pm0.16$	$8.5^{f}\pm0.20$
Amaranth + gum acacia	0.5	240	$154.62^{g}\pm0.17$	$17.3^{a}\pm0.15$
	1.0	246	$161.29^{f}\pm0.15$	$14.5^{c}\pm0.20$
Amaranth + gum tragacanth	0.5	192	$168.89^{e}\pm0.11$	$16.4^{b}\pm0.15$
	1.0	246	$174.36^{c}\pm0.22$	$12.6^{d}\pm0.20$

Mean values in the same column with different letters differ significantly ($p < 0.05$)

Table 5 Textural characteristics of gluten free pasta

Sample	%	Hardness (N)	Adhesiveness	Gumminess	Chewiness
Control		$3.85^{a}\pm0.38$	$-58.37^{a}\pm0.81$	$255.18^{a}\pm4.30$	$223.73^{a}\pm5.81$
Amaranth + guar gum	0.5	$1.79^{b}\pm0.47$	$-16.52^{e}\pm0.51$	$118.73^{b}\pm3.24$	$108.19^{b}\pm4.40$
	1.0	$2.59^{c}\pm0.42$	$-36.31^{c}\pm0.45$	$171.78^{c}\pm6.33$	$158.19^{c}\pm8.90$
Amaranth+ gum acacia	0.5	$0.95^{d}\pm0.27$	$-12.34^{f}\pm0.56$	$67.87^{d}\pm10.23$	$59.33^{d}\pm7.32$
	1.0	$1.77^{b}\pm0.06$	$-29.48^{d}\pm0.85$	$120.79^{b}\pm6.67$	$103.12^{b}\pm10.50$
Amaranth + gum tragacanth	0.5	$0.85^{d}\pm0.24$	$-14.19^{e}\pm0.60$	$54.67^{d}\pm10.88$	$46.34^{d}\pm7.69$
	1.0	$1.65^{b}\pm0.77$	$-30.17^{b}\pm0.92$	$116.77^{b}\pm8.26$	$101.38^{b}\pm6.70$

Mean values in the same column with different letters differ significantly ($p < 0.05$)

(−12.34). Similarly, Padalino et al. [7] also reported that the addition of hydrocolloids decreased the adhesiveness in gluten free spaghetti.

The control pasta prepared from semolina showed highest value of chewiness (223.73). Significant difference in chewiness was observed in all gluten free pasta with different proportion (0.5 and 1.0%) of hydrocolloids. Pasta prepared with 1.0% guar gum addition showed maximum chewiness (158.19) as compared with other gluten free pasta. Han et al. [34] reported that the chewiness, which is related to the hardness, was also significantly increased in rice starch noodles that contained gellan gum and locust bean gum.

Morphological properties of gluten free pasta

The microstructures of best pasta (1.0% guar gum) was done before and after cooking and presented in the Fig. 1. Scanning electron microscopy (SEM) techniques were used to investigate the structural integrity of raw and cooked pasta. The microscopic examination of raw pasta revealed a structure with visible starch granules deeply embedded in the protein matrix. Many small holes were apparent in the microstructure of the uncooked pasta (Fig. 1R) which could permit the penetration of water into the interior of pasta during cooking. After cooking the structural changes was observed in cooked pasta (Fig. 1C), starch granules were not visible as they were probably enveloped by protein network and formed a complex composite structure. Sudha and Leelavathi [36] also reported similar microstructure of pasta prepared from dried pea flour and amaranth flour.

Sensory analysis of gluten free pasta

The scores for sensory attributes of pasta with different levels of hydrocolloids are given in Table 6. The score of sensory evaluation includes attributes such as colour and appearance, firmness (handfeel), texture (mouthfeel) and taste. The score of sensorial attributes of gluten free pasta, such as colour and appearance, firmness (handfeel), texture (mouthfeel) and taste decreased as compared with control sample. Data showed that control sample recorded highest value (8.10) for overall quality. However, gluten free pasta showed lower score (7.23) for overall quality. Moreover, no significant difference was observed in colour and appearance attributes among all gluten free pasta samples. The

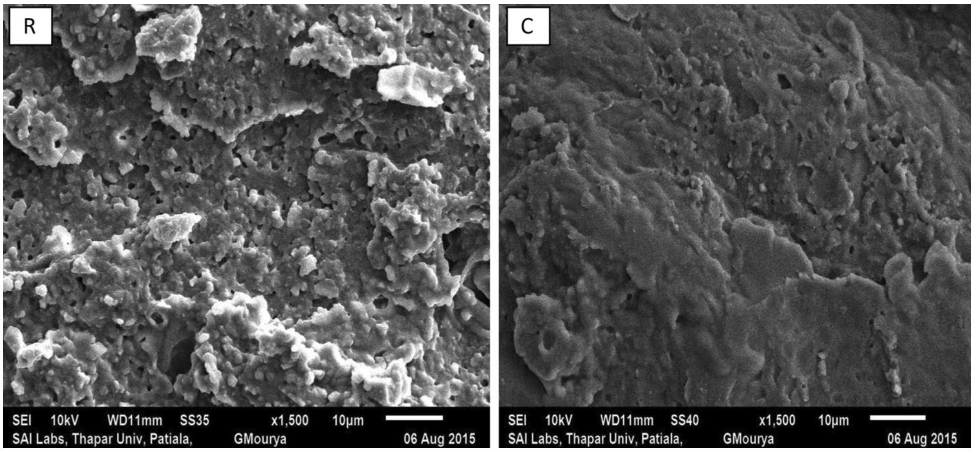

Fig. 1 Scanning electron micrographs of raw amaranth flour pasta (R) and cooked amaranth flour pasta (C) at magnification 1500

Table 6 Sensory analysis of gluten free pasta

Sample	%	Colour and appearance	Firmness (handfeel)	Texture (mouthfeel)	Taste	Overall quality
Control		8.00^{a}±0.20	7.86^{a}±0.16	8.20^{a}±0.18	7.86^{a}±0.21	8.10^{a}±0.08
Amaranth + guar gum	0.5	7.10^{b}±0.33	6.11^{c}±0.22	6.66^{c}±0.08	6.50^{e}±0.14	6.70^{c}±0.11
	1.0	7.23^{b}±0.21	7.16^{b}±0.13	7.10^{b}±0.31	7.22^{b}±0.13	7.23^{b}±0.22
Amaranth + gum acacia	0.5	7.16^{b}±0.30	5.00^{d}±0.18	6.30^{e}±0.10	6.31^{de}±0.16	6.33^{e}±0.08
	1.0	7.26^{b}±0.10	5.60^{e}±0.20	6.66^{c}±0.18	6.84^{c}±0.08	6.80^{c}±0.11
Amaranth + gum tragacanth	0.5	7.11^{b}±0.40	5.20^{d}±0.26	6.55^{ce}±0.16	6.21^{d}±0.14	6.44^{ce}±0.14
	1.0	7.25^{b}±0.29	6.21^{c}±0.16	6.70^{c}±0.15	6.91^{c}±0.20	6.88^{c}±0.26

Mean values in the same column with different letters differ significantly ($p < 0.05$)

Table 7 Chemical composition of gluten free pasta

Parameters	Control pasta	Gluten free pasta
Protein	12.1±0.08^{a}	15.00±0.16^{b}
Fat	0.42±0.04^{a}	6.60±0.05^{b}
Ash	0.74±0.02^{a}	1.58±0.02^{b}
Total dietary fibre	4.43±0.10^{a}	8.86±0.08^{b}

Mean values in the same row which is not followed by the same letter are significantly different ($p < 0.05$)

addition of higher concentration (1.0%) hydrocolloids significantly improved also the sensory properties of cooked pasta samples. Additionally, it was observed that pasta prepared with 1.0% guar gum to amaranth flours shows higher sensory scores for firmness, texture, taste and overall quality of pasta.

Chemical composition of gluten free pasta

Taking into consideration all the aforementioned attributes, pasta prepared with 1.0% guar gum was best among all six type gluten free pasta. So, the chemical composition of best pasta sample (1.0% guar gum) was compared to control pasta. It can be seen from Table 7 that the gluten free pasta is superior than the control pasta in all chemical composition. It may be due to higher chemical composition of amaranth grain than the wheat. The result is in agreement with [31, 37] who found that the nutritional value of pasta enhanced by the addition of amaranth flour.

Conclusion

This work is based on production of gluten free pasta by using amaranth flour with different hydrocolloids. This study showed that the quality of gluten free pasta could be improved by using different levels (0.5 and 1.0/100 g) of hydrocolloids (guar gum, gum acacia and gum tragacanth). Likewise, with addition of higher levels of hydrocolloids showed positive effect on pasta textural properties like hardness, gumminess and chewiness. The incorporation of hydrocolloids also improved the cooking quality of pasta. The study indicated that among all three hydrocolloids, pasta with higher concentration of guar gum (1.0/100 g) reduced the maximum cooking loss. Our result shows that the addition of hydrocolloids greatly enhances cooking, textural and sensory properties of gluten free pasta. Best overall quality gluten free pasta was obtained with the addition of 1.0% guar gum. However, compared to semolina pasta, the gluten-free pasta produced from amaranth with addition of different hydrocolloids differs in terms of colour, textural and cooking characteristics. The use of amaranth flour with hydrocolloids in the fabrication of gluten-free pasta is a novel approach to provide with a healthy alternative, to traditional gluten containing pasta products, to the large population of consumers suffering of the celiac disease and gluten sensitivity.

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