The Pharma Innovation Journal 2023; 12(5): 149-155

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 149-155

www.thepharmajournal.com
Received: 15-03-2023
Accepted: 19-04-2023

Chandrakala
M.Tech. Scholar, Department of Processing & Food Engineering, CAE, UAS, Bengaluru, Karnataka, India

Mohithkumar GV
Associate Professor, Department of Processing & Food Engineering, CAE, UAS, Bengaluru, Karnataka, India

Suresha KB
Associate Professor (Dairy Tech.), AICRP-PHET, UAS, Bengaluru, Karnataka, India

Viresh Kumargouda
Project Coordinator, Biogas Development & Training Centre, CAE, UAS, Bengaluru, Karnataka, India

Shrinivas Deshpande
Scientist (Agri. Engg.), ICAR-Krishi Vigyan Kendra, Kandali, Hassan, Karnataka, India

Corresponding Author:
Chandrakala
M.Tech. Scholar, Department of Processing & Food Engineering, CAE, UAS, Bengaluru, Karnataka, India

Development of gluten-free pasta using amaranth flour and methi powder, palak powder, amaranth leaf powder

Chandrakala, Mohithkumar GV, Suresha KB, Viresh Kumargouda and Shrinivas Deshpande

Abstract
Due to the increased prevalence of gluten-related diseases and changes in dietary preferences, there is an increase in demand for gluten-free products. The goal of the present study was to develop gluten-free pasta using formulations containing 100% grain Amaranth flour as base material. By keeping this as base material varying the concentration of Amaranth leaf powder (2%, 4%, 6% and 8%), Methi powder (0.5%, 1.%, 1.5% and 2%), Palak powder (0.5%,1%, 1.5% and 2%) were blended and cold extruded at optimum extrusion conditions to produce pasta products. The cold extruded pasta products were assessed for its sensory and cooking quality characteristics. Pasta incorporated with 98 percent Amaranth flour with 2 percent Amaranth leaf powder had optimum cooking characteristics and found to be more acceptable than other percentages of incorporation. Resulting quality was evaluated by conducting tests analyzing color, cooking time, cooking loss, and water absorption capacity. Moreover, a substantial increase in protein content from 13.56 percent to 14.06 percent was observed with the addition of 2 percent Amaranth leaf powder.

Keywords: Gluten-free pasta, amaranth flour, methi powder, palak powder, amaranth leaf powder

Introduction
Gluten is a complex formed between water and wheat prolamins (glutenins and gliadins) when they are mixed (Ludvigsson *et al.*, 2013) [1]. The prolamins fraction of gluten is known for its large amount of glutamine (35%) and proline (15%) amino acids (Stern *et al.*, 2001) [3]. Prolamins of rye (secalins) and barley (hordeins) (Vader *et al.*, 2003) have a similarly high concentration of these two amino acids and therefore can be referred to as gluten (Hill *et al.*, 2016) [5]. Ingestion of gluten-containing grains triggers gluten-related disorders in individuals who are genetically and /or immunologically susceptible to gluten (Fasano *et al.*, 2015) [6]. The most well- known gluten-related diseases are wheat allergy (WA) and celiac disease (CD). Another gluten related disease that has recently gained attention is non-celiac gluten sensitivity (NCGS).

Wheat allergy is related to the cross-linking of immunoglobulin (Ig)E by repeat sequences in gluten peptides which results in activation of mast cells and the release of inflammatory mediators (Sapone *et al.*, 2012; Tanabe, 2008) [7, 8]. Additionally, celiac disease is a chronic small intestinal immune-mediated enteropathy precipitated by exposure to dietary gluten in genetically predisposed individuals (Ludvigsson *et al.*, 2013) [1]. This disease causes both malabsorption and an abnormal immune reaction to gluten. Conversely, individuals suffering from NCGS do not suffer from small intestine damage; they experience discomfort when they ingest food containing gluten (Sapone *et al.*, 2012) [7]. However, gluten-free (GF) diets improved these observations among patients. Even though all these gluten-related diseases have been studied significantly by researchers to prevent and cure its manifestation, a strict gluten-free diet is currently the only treatment for these diseases (Lohi *et al.*, 2007; Mayer *et al.*, 1991; Niewinski, 2008; Sapone *et al.*, 2012; Wahab, Meijer & Mulder, 2002) [11, 10, 12, 7, 13].

Most of the foods available in the market such as pasta, bread, and biscuits are made of Gluten containing grains. But, as prevalence of the gluten-related diseases increases, the demand for gluten-free products also rises (Curiel *et al.*, 2014; Sapone *et al.*, 2012) [7]. For example, in the U.S. alone, over 7 percent of the population should avoid gluten for medical reasons, which includes 1 percent of people with celiac disease, 6 percent who have non-celiac gluten sensitivity, and 0.1 percent who are allergic to wheat (Hensel, 2015) [17].

While there are many GF products available, there is still a high demand for pasta by people with celiac disease (Zand Onadi *et al.*, 2012) [14]. Pasta is also one of the simplest food products traditionally prepared by mixing semolina and water (Marti & Pagani, 2013) [18]. Typically, durum wheat proteins, when mixed with water, are known to form a complex matrix responsible for the typical viscoelastic behavior that allows the formation of good quality pasta (Mariotti *et al.*, 2011) [19]. However, absence of gluten creates a challenge to produce quality pasta. Studies show that gluten free foods are not nutritionally rich which leads to unbalanced intake of macro- and micronutrients such as high intake of fat and carbohydrates and low intake of vitamins and proteins (Bardella *et al.*, 2000; Mariani *et al.*, 1998; Thompson *et al.*, 2005) [21, 20, 22]. Thus, it is important to use raw materials of good nutritional quality to provide some health benefits.
According to Aguilar *et al.* (2015) [23], amaranth, which is a dicotyledon, has a protein content of 16 percent, which is higher than regularly consumed cereals such as wheat (12-14%) and rice(7- 10%). Additionally, its protein is considered of very good quality because of its high lysine levels (Bressani, 1994). Moreover, it is rich in minerals (calcium, magnesium, and iron) (Alvarez-Jubete *et al.*, 2009), vitamins (e.g., folic acid), essential amino acids, and essential fatty acids (Becker *et al.*, 1981) [25]. High amounts of unsaturated fatty acids, with a very high level of linoleic acid have also been reported (Alemayehu *et al.*, 2015; Berghofer & Schoenlechner, 2002) [27, 28]. Thus, amaranth can be used as a good raw material to produce GF products due to its high nutritional composition. To further enhance the nutritional quality of gluten free pasta pea protein flour can also be used. Flours from legumes are considered to have a positive effect on glycemic response and sensory qualities (Pellegrini & Agostoni, 2015) [29]. Furthermore, pea has high dietary fibre and good emulsifying properties contributing to lower dough adhesiveness to press elements, facilitate dough flow through a chamber and a die, and lower protein network structure destruction (Tomoskozi *et al.*, 2001) [30]. Thus, the combination of pea protein flour and amaranth flour can be used to develop gluten free pasta.
The objective of this study was to develop gluten-free pasta using amaranth and methi/palak/Amaranth leaf powder and to study resulting quality parameters of the pasta by conducting tests analysing water absorption capacity, cooking loss, cooking time, colour, and moisture content.

Materials and Methods

Raw materials

The main raw materials used for the development of extruded product were Grain Amaranth flour and methi powder/palak powder/Amaranth leaf powder. Amaranth flour was prepared by using domestic grain pulverizer. Leaf powders were prepared by drying clean and blanched leaves (70 – 100 °C, <5 min) in a dehydrator unit at 45 °C for 6-8 hours and fine powders were made using kitchen grinder.

Formulation of flours and leaf powder blends for Pasta production

Different combinations of Amaranth flour and leaf powders were blended to prepare pasta products. Formulation with 100 percent Grain Amaranth flour was taken as control. Formulations made for the preparation of pasta products are presented in Table 1.

Pasta product manufacture

The sieved (BS 44 mesh size) flours of Amaranth flour and leaf powders were blended in the extruder for 5 min and then kneaded for about 45 min after adding required quantity of water. When the dough characteristics was optimum, it was extruded using pasta machine with single screw (make: La Monferrina, Italy; model: P12) fitted with an adjustable die. Finally extruded product was dried in tray drier at 60 °C for 3 h. The dried pasta were then packed in Metalized polyester bags (50 µm), heat sealed and stored at ambient conditions. All the initial product development studies were done at constant extruder operating conditions.

Selection of best formulated pasta product

Among the thirteen formulations tried, one best pasta (formulation) was selected, primarily based on cooking and sensory characteristics. The best adjudged product was the one which had optimum cooking characteristics, good colour and texture, flavour, taste and overall acceptability. The selected pasta product was further studied for storage studies.

Cooking quality of pasta products

The optimal cooking time for each pasta products was made by using the method proposed by Schoch (1964) [31]. The cooking tests were performed for various cooking times for each pasta sample in order to determine the optimum cooking time (OCT). Briefly 10 g of pasta was cooked in 300 ml of boiling distilled water. Optimum cooking time was when the white core in the pasta was still present but disappeared after squeezing between two glass slides. Once the OCT of each pasta sample was evaluated, the pasta sample was optimally cooked and the weight gain and solid loss during cooking were determined by triplicate. Cooked weight (g) was the weight of cooked pasta after being allowed to drain for 2 min. Solid loss (% total solids weight) was measured by evaporation of the cooking water to dryness under a forced-air at 110 °C overnight.

Sensory evaluation of cooked pasta product

Sensory evaluation of developed pasta products were carried out by a panel of ten members. The products were evaluated for individual characters such as colour, texture, taste, flavour and overall acceptability using a 9-point hedonic scale, 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, 1=Dislike extremely.

Proximate analysis of pasta sample

Moisture, protein, crude fibre fat and ash contents of pasta samples were determined using AOAC method (1980). Carbohydrate was studied by deducting the sum of moisture, fat, crude fibre, protein and ash from 100.

Physical properties of the pasta sample

True density, bulk density, water absorption index and water solubility index was estimated using the stand ard procedures.

Statistical Analysis

Statistical Analysis of experimental data was done using SPSS and OPSTAT software. The data of experiments were analyzed using Completely Rand omized Design (CRD) to determine the significant difference among treatments.

Results and Discussion

Cooking characteristics of developed pasta products

Cooking characteristics in terms of cooking time, swelling power and solid loss for the developed pasta products were evaluated and the data are presented in Table 2. Cooking characteristics revealed that perfect shape of the pasta products was not retained by Amaranth flour as it is gluten free.

Cooking time

The cooking time of the pasta products formulated with different blends was about 4.5 minute. Here, there is no significant difference was observed.

Swelling power

The Swelling power of the pasta products formulated with different blends was found to be varied from 2.45 (g/g) to 2.75 (g/g). It was observed that treatment Control had lowest swelling power which was about 2.45 (g/g) and the treatment P_4 was found have highest swelling power which was about 2.75 (g/g).

Cooking studies revealed that swelling power of each treatment varied with the varying concentration of leaf powder. It could be observed that swelling power of the pasta products were found to be increased with increasing level of leaf powder. This is due to the cooking process which caused the fiber to absorb more water as fiber content is more in Grain Amaranth and Leaf powder and is known to have high affinity of water (Wang *et al.*, 2002) [42]. Similarly, Sarojani *et al.* (2021) [34] reported that swelling power of the pasta made from kodo millet increased as the decrease in incorporation of fine semolina and also Sosulski and Wu (1988) [35] reported that the incorporation of fibre ingredients into wheat flour increased water hydration values in proportional to the level of replacement.

Solid loss

The solid loss of the pasta products prepared from different blends was found to be varied from 10.46 percent to 11.13 percent. It could be observed that treatment A_1 had lowest solid loss which was about 10.46 percent and the treatment P_4 was found have highest percentage solid loss which was about 11.13 percent.

Solid loss of the pasta products varied with the varying concentration of leaf powder. It was observed that with increasing level of leaf powder cooking loss was found to be increased from 10.46 percent to 11.13 percent. This may be the lack of gluten in gluten-free pasta can cause an increase in cooking loss and a decrease in firmness because the starch polymers are less linked to the matrix (Marti *et al.*, 2014). Also, Tudorica *et al.* (2002) [36] showed that increasing of cooking loss could be caused by fibers which use a higher water quantity. Thus, there would be less water available for the starch swelling. Similar effects on increasing cooking losses have been reported for pasta products incorporating non-durum ingredients such as seaweed (Prabhasankar *et al.*, 2009) [37] and Sudha *et al.* (1998) [38] in case of vermicelli prepared from finger millet and its blend with semolina.

Sensory qualities of developed pasta products

The sensory quality characteristics which included colour, texture, flavour, taste and overall acceptability of the pasta products prepared using Grain Amaranth flour fortified with Methi/Palak/Amaranth leaf powder were evaluated.

Colour

The sensory scores for colour ranged from 7.7 to 5.6 and the highest score was recorded for M_1 followed by Control. The least score was recorded for M_4 formulation (Table 3).

Texture

The mean sensory scores of pasta products for texture is presented in Table 3. The sensory scores for Texture ranged from 7.6 to 5.3. The highest score was recorded for control pasta followed by M_1 and M_2 formulations (Table 4.2).

Flavour

The mean sensory scores of pasta products with different formulations for organoleptic flavour are presented in the Table 3. It was observed that the highest sensory score for flavour (7.2) was recorded with control and M_1 followed by M_2 (7.0). The mean sensory scores ranged from 7.2 to 6.1.

Taste

The mean sensory scores for Taste ranged from 7.6 to 5.7 (Table 3). The highest score was recorded with M_1 followed by control and M_2 formulations.

Overall acceptability

The overall acceptability of pasta products with different levels are presented in the
Table 3. It was observed that the highest sensory score for M_1 followed by control. The mean sensory scores for overall acceptability ranged from 7.4 to 5.8.

Sensory scores of pasta products formulated with Palak powder

Colour

The sensory scores for colour ranged from 7.5 to 5.4 and the highest score was recorded for control followed by P_1. The least score was recorded for P_4 formulation (Table 4).

Texture

The mean sensory scores of pasta products for texture is presented in Table 4. The sensory scores for Texture ranged from 7.6 to 6.26. The highest score was recorded for control pasta followed by P_1 and P_2 formulations (Table 4).

Flavour

The mean sensory scores of pasta products with different formulations for organoleptic flavour are presented in the Table 4. It was observed that the highest sensory score for flavour (7.2) was recorded with control followed by P_1 (7.0). The mean sensory scores ranged from 7.2 to 5.5.

Taste

The mean sensory scores for Taste ranged from 7.2 to 5.2 (Table 4). The highest score was recorded with control and P_1formulations.

Overall acceptability

The overall acceptability of pasta products with different levels are presented in the Table 4. It was observed that the highest sensory score for control followed by P_1. The mean sensory scores for overall acceptability ranged from 7.2 to 5.5.

Sensory scores of pasta products formulated with Amaranth leaf powder

Colour

The sensory scores for colour ranged from 7.9 to 6.6 and the highest score was recorded for A_1 followed by Control. The least score was recorded for A_4 formulation (Table 5).

Texture

The mean sensory scores of pasta products for texture is presented in Table 4.2b. The sensory scores for Texture ranged from 7.6 to 6.1. The highest score was recorded for A_1 followed by control and A_2 formulations (Table 5).

Flavour

The mean sensory scores of pasta products with different formulations for organoleptic flavour are presented in the Table 5. It was observed that the highest sensory score for flavour (7.8) was recorded with A_1 followed by control (7.2). The mean sensory scores ranged from 7.8 to 6.0.

Taste

The mean sensory scores for Taste ranged from 7.6 to 5.6 (Table 5). The highest score was recorded with A_1 and control followed by A_2 formulations.

Overall acceptability

The overall acceptability of pasta products with different levels are presented in the Table 5. It was observed that the highest sensory score for A_1 followed by control. The mean sensory scores for overall acceptability ranged from 7.7 to 6.0.

Selection of best pasta product fortified with leaf powder

One best pasta product was selected based on cooking and sensory characteristics of pasta products. Cooking characteristics revealed that pasta formulated with 98 percent Amaranth flour and 2 percent Amaranth leaf powder was found to have optimum cooking characteristics when compared with other formulated pasta products. Sensory analysis of pasta products during selection showed that pasta formulated with 98 percent Amaranth flour and 2 percent Amaranth leaf powder had significantly higher scores as it exhibited optimum cooking characteristics. From the overall acceptability rating, it can be concluded that the pasta enriched with 98 percent Amaranth Flour and 2 percent concentration of ALP had better acceptance than other formulated pasta products. The study revealed that addition of Amaranth leaf powder (ALP) at higher levels exhibit bitter taste to pasta products. Many of the studies showed that products formulated with higher concentrations of ALP may generally be unacceptable to most consumers in terms of Taste and Texture.

Nutritional analysis of optimized pasta product

The pasta product made from Amaranth flour and Amaranth leaf powder (ALP) was analysed for proximate composition. The incorporation of ALP was found to improve the nutrient value of pasta product.

The nutritional composition of developed pasta product fortified with Amaranth leaf powder in terms of moisture content, protein, fat, fibre, ash and carbohydrates are presented in Table 6. The moisture content of the product was found to be 6.73 percent. The protein, fat, crude fibre, ash and carbohydrate of pasta product were 14.06 percent, 7.06 percent, 8.02 percent, 3.45 percent and 60.68 percent respectively.

Pasta product was found to contain higher moisture content of about 6.73 percent. This could be due to higher crude fibre content of Grain Amaranth and Amaranth leaf powder. Higher crude fibre content is usually associated with higher water content due to the tendency of fiber to absorb and retain water (Wang *et al.*, 2002) [42].

Higher percentage of protein and fibre content were found in pasta product. This was contributed by the protein and fibre content of Grain Amaranth and Amaranth leaf powder. The obtained results were in accordance to those of the study conducted by Singh *et al.* (2009) [40] in which biscuit, mathi, matar and sev containing Amaranth leaf powder had higher protein and total dietary fibre. Similarly, Qumbisa *et al.* (2020) [41] observed increase in nutritional value of noodles prepared from wheat flour fortified with Amaranth leaf powder.

Physical characteristics of optimized pasta product

Physical properties such as density, colour, WAI and WSI of the selected pasta product are presented in Table 7. True density and bulk density of the pasta product were found to be 2.0g/ml and 0.62 g/ml respectively. Tri-stimulus colour values (*L**, *a**, *b**) of the pasta product were about 62.77, 1.97 and 19.33 respectively. It was observed that Water Absorption Index and Water Solubility Index of the pasta product was about 20.32 percent and 14.4 percent respectively. The difference in WAI and WSI may be due to the hydrophilic polysaccharides present in their respective flour (Oninawo and Asugo, 2004) [43]. Similar observations have been made by Benhur *et al.* (2015) [44] in case of sorghum pasta blended with wheat semolina reported that WAI of extrudates increased with an increase in sorghum semolina in the blend and WSI of the extrudates increased with an increase in wheat semolina in the blend.

Table 1: Formulations used for preparation of pasta products

Formulation	Amaranth flour (%)	Leaf powder (%)	Water (ml/200 g)
Control	100	-	115
M_1	99.5	0.5	115
M_2	99	1	115
M_3	98.5	1.5	115
M_4	98	2	115
P_1	99.5	0.5	115
P_2	99	1	115
P_3	98.5	1.5	115
P_4	98	2	115
A_1	98	2	115
A_2	96	4	115
A_3	94	6	115
A_4	92	8	115

Note: M: Methi powder, P: Palak powder, A: Amaranth leaf powder

Table 2: Cooking characteristics of pasta products

Formulations	Cooking time (min)	Swelling power (g/g)	Solid loss (%)
C	4.5	2.45	10.50
M_1	4.5	2.52	10.84
M_2	4.5	2.58	10.92
M_3	4.5	2.61	10.97
M_4	4.5	2.69	11.08
P_1	4.5	2.54	10.85
P_2	4.5	2.61	10.97
P_3	4.5	2.68	11.05
P_4	4.5	2.75	11.13
A_1	4.5	2.46	10.46
A_2	4.5	2.52	10.84
A_3	4.5	2.57	10.92
A_4	4.5	2.62	10.96

Note: C: Control (100% Amaranth flour); M_1: Grain Amaranth flour (99.5%): Methi powder (0.5%); M_2: Grain Amaranth flour (99%): Methi powder (1%); M_3: Grain Amaranth flour (98.5%): Methi powder (1.5%); M_4: Grain Amaranth flour (98%): Methi powder (2%); P_1: Grain Amaranth flour (99.5%): Palak powder (0.5%); P_2: Grain Amaranth flour (99%): Palak powder (1%); P_3: Grain Amaranth flour (98.5%): Palak powder (1.5%); P_4: Grain Amaranth flour (98%): Palak powder (2%); A_1: Grain Amaranth flour (98%): Amaranth leaf powder (2%); A_2: Grain Amaranth flour (96%): Amaranth leaf powder (4%); A_3: Grain Amaranth flour (94%): Amaranth leaf powder (6%) and A_4: Grain Amaranth flour (92%): Amaranth leaf powder (8%)

Table 3: Mean sensory scores of Amaranth flour fortified with Methi powder

S.No.	Formulation	Colour and Appearance	Texture/Mouth feel	Flavour/Aroma	Taste	Overall acceptability
1	Control	7.5	7.6	7.2	7.2	7.2
2	M_1	7.7	7.5	7.2	7.6	7.4
3	M_2	7.2	7.0	7.0	7.0	6.7
4	M_3	6.8	6.4	6.7	6.2	6.2
5	M_4	5.6	5.3	6.1	5.7	5.8
	SEm (±)	0.085	0.096	0.096	0.106	0.106
	CD @ 5%	0.269	0.304	0.304	0.335	0.335

Note: M_1: Grain Amaranth flour (99.5%): Methi powder (0.5%); M_2: Grain Amaranth flour (99%): Methi powder (1%); M_3: Grain Amaranth flour (98.5%): Methi powder (1.5%); M_4: Grain Amaranth flour (98%): Methi powder (2%); SEm: Stand ard error of mean, CD: Critical difference.

Table 4: Mean sensory scores of Amaranth flour fortified with Palak powder

S. No	Formulation	Colour and Appearance	Texture/Mouth feel	Flavour/Aroma	Taste	Overall acceptability
1	Control	7.5	7.6	7.2	7.2	7.2
2	P_1	6.8	6.6	7.0	7.2	6.8
3	P_2	6.4	6.2	6.8	6.4	6.2
4	P_3	6.0	5.6	5.9	5.6	5.8
5	P_4	5.4	5.3	5.5	5.2	5.5
	SEm (±)	0.106	0.106	0.096	0.115	0.121
	CD @ 5%	0.335	0.335	0.304	0.363	0.381

Note: P_1: Grain Amaranth flour (99.5%): Palak powder (0.5%); P_2: Grain Amaranth flour (99%): Palak powder (1%); P_3: Grain Amaranth flour (98.5%): Palak powder (1.5%); P_4: Grain Amaranth flour (98%): Palak powder (2%); SEm: Stand ard error of mean, CD: Critical difference.

Table 5: Mean sensory scores of Amaranth flour fortified with Amaranth leaf powder

S. No	Formulation	Colour and Appearance	Texture/Mouth feel	Flavour/Aroma	Texture/Mouth feel	Taste	Overall acceptability
1	Control	7.7	7.2	7.2	7.2	7.6	7.2
2	A_1	7.9	7.6	7.8	7.6	7.6	7.7
3	A_2	7.2	7	7.1	7	7.2	7
4	A_3	6.9	6.9	6.8	6.9	6.7	6.9
5	A_4	6.6	6.1	6	6.1	5.6	6
	SEm (±)	0.085	0.096	0.106	0.096	0.139	0.085
	CD @ 5%	0.269	0.304	0.335	0.304	0.438	0.269

Note: A_1: Grain Amaranth flour (98%): Amaranth leaf powder (2%); A_2: Grain Amaranth flour (96%): Amaranth leaf powder (4%); A_3: Grain Amaranth flour (94%): Amaranth leaf powder (6%); A_4: Grain Amaranth flour (92%): Amaranth leaf powder (8%); SEm: Stand ard error of mean, CD: Critical difference.

Table 6: Proximate composition of optimized pasta product

Parameters (%)	Optimized pasta
Moisture	6.73
Protein	14.06
Fat	7.06
Fibre	8.02
Ash	3.45
Carbohydrate	60.68

Table 7: Physical parameters of developed pasta product

Parameters	Quantity
True density (g/ ml)	2.0
Bulk density (g/ ml)	0.62
Colour	*L**=62.77, *a**=1.97, *b**=19.33
Water Absorption Index (WAI)	20.32 (%)
Water Solubility Index (WSI)	14.4 (%)

Conclusion

Pasta having 98% Amaranth flour incorporated with 2% Amaranth leaf powder was found to be finest acceptable than other percentages of incorporation. The addition of increasing levels of nutrient-rich, in a long way, improves the health status of the vast majority of the health-conscious population. It was observed that protein content increased substantially as the leaf powder was added to the AF. The study showed that incorporation of leaf powder into extruded products creates a huge opportunity for food processors to provide healthy dietary fiber-enriched products.

References

1. Ludvigsson JF, Leffler DA, Bai JC, Biagi F, Fasano A, Green PH, Lundin KEA. The Oslo Definitions for Coeliac Disease and Related Terms. Gut. 2013;62(1):43-52.
2. Balakireva AV, Zamyatnin AA. Properties of Gluten Intolerance: Gluten Structure, Evolution, Pathogenicity and Detoxification Capabilities. Nutrients. 8(10), 644.
3. Stern M, Ciclitira PJ, Van Eckert R, Feighery C, Janssen FW, Méndez E, Wieser H. Analysis and Clinical Effects Of Gluten In Coeliac Disease. European Journal of Gastroenterology & Hepatology. 2001;13(6):741-747.
4. Vader LW, Stepniak DT, Bunnik EM, Kooy YM, De Haan W, *et al.* characterization of cereal toxicity for celiac disease patients based on protein homology in Grains. Gastroenterology. 2003;125(4):1105-1113.
5. Hill ID, Fasano A, Guand Alini S, Hoffenberg E, Levy J, Reilly N, *et al*. Naspghan clinical report on the diagnosis and treatment of gluten-related disorders. Journal of Pediatric Gastroenterology and Nutrition, 2016;63(1):156-165.
6. Fasano A, Sapone A, Zevallos V, Schuppan D. Nonceliac Gluten Sensitivity. Gastroenterology. 2015;148(6):1195-1204.
7. Sapone A, Bai JC, Ciacc C, Dolinsek J, Green PH, Hadjivassiliou M, Ullrich R. Spectrum of gluten-related disorders: consensus on new nomenclature and classification. BMC Medicine. 2012;10(1):13.
8. Tanabe S. Analysis of food allergen structures and development of foods for allergic; c2008.
9. Patients. Bioscience, Biotechnology and Bio-chemistry. 0802050767-0802050767
10. Mayer M, Greco L, Troncone R, Auricchio S, Marsh MN. Compliance of adolescents with coeliac disease with a gluten free diet. Gut. 1991;32(8):881-885.
11. Lohi S, Mustalahti K, Kaukinen K, Laurila K, Collin P, Rissanen H, *et al*. Increasing Prevalence of coeliac disease over time. Alimentary pharmacology & Therapeutics. 2007;26(9):1217-1225.
12. Niewinski M.M. Advances in celiac disease and gluten-free diet. Journal of the American Dietetic Association. 2008;108(4):661-672.
13. Wahab PJ, Meijer JW, Mulder CJ. Histologic Follow-Up of people with celiac disease on a gluten-free diet: slow and incomplete Recovery. American Journal of Clinical Pathology. 2002;118(3):459-463
14. Zand Onadi RP, Botelho RBA, Gandolfi L, Ginani JS, Montenegro FM, Pratesi R. Green Banana pasta: an alternative for gluten-free diets. Journal of the Academy of Nutrition and Dietetics. 2012;112:1068-1072.
15. Curiel JA, Coda R, Limitone A, Katina K, Raulio M, Giuliani G, *et al*. Manufacture and characterization of pasta made with wheat flour Rendered Gluten-free using fungal proteases and selected sourdough lactic acid bacteria. Journal of Cereal Science. 2014;59(1):79-87.
16. Hensel K. Gluten Free Without The Sacrifice. Food Technology. 2015;11(69):20-31.
17. Hensel K. Gluten Free Without The Sacrifice. Food Technology. 2015;69:11.
18. Marti A, Pagani. What can play the role of gluten in gluten free pasta. Trends in Food Science & Technology. 2013;3(31):63-71.
19. Mariotti M, Iametti S, Cappa C, Rasmussen P, Lucisano M. Characterisation of gluten-free pasta through conventional and innovative Methods: Evaluation of the Uncooked Products. Journal of Cereal Science. 2011;53(3):319-327.
20. Mariani P, Viti MG, Montouri M, La Vecchia A, Cipolletta E, Calvani L, *et al.* The Gluten-Free Diet: A Nutritional risk factor for adolescents with celiac Disease. Journal of Pediatric Gastroenterology and Nutrition. 1998;27(5):519-523.
21. Bardella MT, Fredella C, Prampolini L, Molteni N, Giunta AM, Bianchi PA. Body Composition and dietary intakes in adult celiac disease patients Consuming A Strict Gluten Free Diet. The American Journal of Clinical Nutrition. 2000;72(4):937-939.
22. Thompson T, Dennis, M, Higgins LA, Lee AR, Sharrett MK. Gluten-Free Diet Survey: Are Americans with coeliac disease consuming recommended amounts of fibre, iron, calcium and Grain Foods? Journal of Human Nutrition and Dietetics. 2005;18(3):163-169
23. Aguilar EG, De Jesús Albarracín, G., Uñates MA, Piola HD, Camiña JM, Escudero NL. Evaluation of the nutritional quality of the grain protein of New Amaranths Varieties. Plant Foods for Human Nutrition. 2015;70(1):21-26.
24. Alvarez-Jubete L, Arendt EK, Gallagher E. Nutritive Value and Chemical Composition of Pseudocereals As Gluten-Free Ingredients. International Journal of Food Sciences and Nutrition. 2009;60(Sup4):240-257.
25. Bressani R. Composition and Nutritional Properties of amaranth. Amaranth, biology, chemistry and Technology. Paredes-López O, Editor. Crc Press, Boca Ratón, Florida; c1994. p. 185-206. Isbn: 0849353742
26. Becker R, Wheeler EL, Lorenz K, Stafford AE, Grosjean OK, Betschart AA, *et al.* A Compositional Study of

Amaranth Grain. Journal of Food Science. 1981;46(4):1175-1180.
27. Alemayehu FR, Bendevis MA, Jacobsen SE. The Potential for utilizing the seed crop amaranth (*Amaranthus* Spp.) In East Africa as an alternative Crop to support food security and climate change Mitigation. Journal of Agronomy and Crop Science. 2015;201(5):321-329.
28. Berghofer E, Schoenlechner R. Grain Amaranth. In P. S. Belton & JRN Taylor (Eds.), Pseudo Cereals and Less Common Cereals. Grain Properties and Utilization Potential. Berlin, Heidelberg, Germany: Springer-Verlag. Ch. 7; c2002.
29. Pellegrini N, Agostoni C. Nutritional Aspects of Gluten-Free Products. Journal of the Science of Food and Agriculture. 2015;95(12):2380-2385.
30. Tömösközi S, Lasztity R, Haraszi R, Baticz O. Isolation and Study of the Functional Properties of Pea Proteins. Food/Nahrung. 2001;45(6):399-401.
31. Schoch TJ. Swelling Power and Solubility of Granular Starches. Foodchem. 1964;39:99-107.
32. Aoac. Official Methods of Analysis. 13th Edition, Association of Official Analytic Chemists, Washington, DC; c1980.
33. Wang JS, Rosell CM, De Barber CB. Effect of the Addition of different Fibres on the wheat dough Performance and Bread Quality. Food Chem. 2002;79(2):221-226.
34. Sarojani JK, Suvarna CH, Js H, Sneha S. Development of ready to cook Kodo Millet Pasta. J Pharm. Innov. 2021;10(6):910-915.
35. Sosulski FW, Wu KK. High Fiber Breads Containing Field Pea Hulls, Wheat, Corn and Oat Brans. Cereal Chem. 1998;65:186-191.
36. Tudorica CM, Kuri V, Brennan CS. Nutritional and Physicochemical Characteristics of Dietary Fiber Enriched Pasta. J Agric. Food Chem. 2002;50:347-356.
37. Prabhasankar P, Ganesan P, Bhaskar N, Hirose A, Stephen N, Gowda LR. Edible Japanese Seaweed, Wakame (*Undaria pinnatifida*) As an Ingredient in Pasta: Chemical, Functional and Structural Evaluation. Food Chem. 2009;115(2): 501-508.
38. Sudha M. Nutritional Evaluation of Food Products Incorporating Grain Amaranthus. M.Sc. Thesis, University of Agricultural Sciences, Dharwad; c1989. p. 62.
39. Marti A, Barbiroli A, Marengo M, Fongaro L, Iametti S, Pagani MA. Structuring and texturing Gluten-Free Pasta: Egg Albumen or whey proteins. Eur. Food Res. 2014;38:217-224.
40. Singh S, Darshan Punia D, Khetarpaul N. Nutrient Composition of Products Prepared By Incorporating Amaranth (*Amaranthus tricolour*) Leaf Powder. Nutr. Food Sci. 2009;39(3):218-226.
41. Qumbisa ND, Ngobese NZ, Kolanisi U, Siwela M, Cynthia GF. Effect of Amaranthus leaf powder addition on the nutritional composition, Physical Quality and Consumer Acceptability of Instant Noodles. S. Afr. J. Bot. 2020;11:59-65.
42. Wang JS, Rosell CM, De Barber CB. Effect of the addition of different fibres on the wheat dough performance and bread quality. Food Chem. 2002;79(2):221-226.
43. Oninawo IA, Asugo S. Effects of germination on the nutrient content and functional properties of pigeon pea flour. J. Food Sci. Technol. 2004;41(2):170-174.
44. Benhur DR, Bhargvi, Kalpana, Vishala, Ganapathy KN, Patil JV. Development and stand ardization of Sorghum Pasta Using Extrusion Technology. J Food Sci. Technol. 2015;52(10):6828-6833.