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Influence of incorporating defatted soy flour, carrot powder, mango peel powder, and moringa leaves powder on quality characteristics of wheat semolina-pearl millet pasta

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Abstract

Pasta from blend of wheat semolina and pearl millet flour (50:50) having average particle size of 425 μm supplemented with defatted soy flour (DSF) (5, 15, and 25%), carrot powder (CP) (5, 10, and 15%), mango peel powder (MPP) (5, 10, and 15%), and moringa leaves powder (MLP) (3, 5, and 8%) was prepared. With increase in the substitution level of DSF, CP, MPP, and MLP, cooking time (CT) decreased from 8.01 to 5.38 min and cooking loss (CL) increased from 8.06 to 11.90%. Pasta showed better hardness prepared from 5% DSF (14.43 N), 15% DSF (13.99 N), 25% DSF (13.07 N), and 3% MLP (11.73 N) than control pasta (9.90 N). Sensory evaluation revealed that samples were within the acceptable range (except 5% and 8% MLP). Maximum incorporation of 15% DSF, 10% CP, 5% MPP, and 3% MLP was found suitable in terms of color, cooking loss (<8%), hardness, and sensory quality.

Practical application

Pasta consumption ever increasing in domestic as well as international market. Functional ingredients such as cereals, pseudocereals, legume flour, fruit and vegetable powder contains plentiful of antioxidants, vitamins, dietary fiber, minerals, protein, flavonoids, carotenoids and phenolic compounds. Incorporation of such ingredients in pasta increases the nutritional as well as functional properties. In the present study, defatted soy flour (DSF) (5%, 15%, 25%), mango peel powder (MPP) (5%, 10%, 15%), carrot powder (CP) (5%, 10%, 15%) and moringa leaves powder (MLP) (3%, 5%, 8%) was incorporated into wheat semolina and pearl millet flour pasta. Substitution of DSF, MPP, CP and MLP up to 15%, 10%, 5% and 3%, respectively, yielded acceptable pasta with overall improved nutritional characteristics. Thus, DSF, MPP, CP and MLP can be successfully utilized for the preparation of pasta with improved qualities.

1 | INTRODUCTION

Pasta is a one among the ready to cook cereal food that comprises spaghetti, noodles, vermicelli, etc. The popularity of pasta has swelled enormously in the Indian market due to easy convenience and palatability. Currently, there are more than 30 pasta brands available in the country (Anonymous, 2016a) and the market is expected to be around Rs. 250–300 crore (Anonymous, 2016b). It is made from durum wheat semolina and is reported to be rich in starch with low vitamins, minerals, dietary fibers, and phenolic compounds. Pasta, with legumes, herbs, and vegetables, was found as a complete, delicious, and healthy food (Kaur, Sharma, Nagi, & Dar, 2012). In recent years, different functional ingredients have been used to increase the nutritional as well as functional properties of pasta. But substitution or addition of nontraditional ingredients in wheat flour may require compromise between nutritional enhancement and acceptable sensory properties of pasta (Chillo et al., 2010).

Pasta has been enriched with some cereals, pseudocereals, legume flour, fruit, and vegetable powder as a source of fiber, minerals, antioxidants, and polyphenols (Pagani, 1986) viz. sweet potato flour, the defatted soy flour (DSF) and soy protein concentrate (Limroongreungrat & Huang, 2007), mango peel powder (Ajila, Aalami, Leelavathi, & Prasada Rao, 2010), common bean flour (Gallegos-Infante et al., 2010), DSF and carrot powder (Badwaik, Prasad, & Seth, 2012), cereal bran (Kaur et al., 2012), moringa leaves powder (Singh, 2013), white bean, yellow pea and lentil (Wojtowicz & Moscicki, 2014), pasta containing wheat : pearl millet flour (9:1) with vegetable paste (Yadav, Sharma, Chikara, Anand, & Bansal, 2014), carrot juice, groundnut meal, and refined wheat flour (Mridula, Gupta, Khaira, & Bhadwal, 2017). On the similar lines, this study was aimed to prepare pasta supplemented with pearl millet, defatted soy flour, carrot powder, mango peel powder, and moringa leaves powder.

Pearl millet (*Pennisetum glaucum*) is among the most widely grown cereals in the world. It constitutes carbohydrate (67.5 g), protein (11.6 g), fat (5 g), fiber (1.2 g), mineral (2.3 g), calcium (42 mg), iron (8 mg), zinc (3.1 mg), vitamins B, especially niacin, B6, folic acid per 100g (Gopalan, Rama Sastri, & Balasubramanian, 2004). Ready to eat/cook products have been successfully developed from pearl millet (Gull, Prasad, & Kumar, 2015; Jalgaonkar & Jha, 2016; Yadav et al., 2014) but are still to appear in the market. However, it is difficult to prepare 100% pearl millet flour pasta of any particle size due to problems related with retaining post-cooking physical integrity/stability of pasta as it is a gluten free grain (Leder, 2004). Hence, blend composition of wheat semolina and pearl millet flour in the ratio of 50:50 could be used to make pasta with acceptable quality (Jalgaonkar & Jha, 2016).

Soy protein containing all essential amino acids except methionine was suggested as highly digestible (Whitney & Rolfes, 2008). Soybean products also contain high concentrations of iso-flavones (as an antioxidant), genistein, and diadzein. Carrots (*Daucus carota* L) contain highest amount of carotenoids among vegetables (Gray, 1996). In recent years, consumption of carrot and its related products has increased steadily due to the recognition of antioxidant and anticancer activities of β-carotene. Nutritious food products utilizing carrot had been developed and accepted by consumers (Badwaik et al., 2012; Mridula et al., 2017). Mango is one of the important tropical and seasonal fruit which produces 15–20% of peel as by-product during its processing. Mango peel has been reported to be a good source of bioactive compounds such as carotenoids, polyphenols, dietary fibers, vitamins, and enzymes (Ajila, Bhat, & Prasada Rao, 2007). Moringa leaves (dark green leafy vegetables), belong to a food group particularly rich in nutrients as well as natural antioxidants (Singh, 2013).

Therefore, the purpose of this study was to develop functional pasta with the incorporation of functional ingredients (i.e., defatted soy flour, carrot powder, mango peel powder, and moringa leaves powder) in the blend of wheat semolina and pearl millet flour. Cooking qualities, color, texture, nutritional, functional, and sensory properties were investigated systematically.

2 | MATERIALS AND METHODS

Pearl millet (cv. Pusa composite) was procured from the farm of Indian Agricultural Research Institute, New Delhi (India). The grain was thoroughly cleaned and freed from foreign materials. Wheat semolina (WS), Soybean, commercial fresh local red carrots, mangoes cv. Dasheri and Moringa leaves powder was purchased from local market in New Delhi, India.

The clean and dry pearl millet grain was ground into flour using a hammer mill (Sanco, India). Blend composition of WS and pearl millet flour (PMF) in the ratio of 50:50 having average particle size 425 μm was used for making pasta (Jalgaonkar & Jha, 2016).

Soy flour was prepared by grinding soybean using hammer mill (Sanco, India) and processed for defatting by soxhlet apparatus using petroleum ether (boiling point 40–60 °C) as solvent for 16 hr. Flour was dried in tray dryer (MSW-216, Macro Scientific Works, New Delhi) at 60 °C to a moisture content of 10% w.b. (Badwaik et al., 2012).

Carrot and mangoes were washed in running tap water to remove extraneous material, peeled and shredded subsequently. Peeling of carrot was done by hand peeler. Peeled carrots were shredded manually. After washing, mangoes were peeled using sharp knife and the underlying pulp was removed by gently scraping with its blunt edge. The shreds of carrots and mango peel spread in thin layer (< 1 cm) for uniform drying in tray dryer at 60 °C for 6–8 hr until moisture content reached to 9–10% (w.b). Dried carrot shreds and mango peel was ground in a mixer grinder. The defatted soy flour (DSF), carrot powder (CP), mango peel powder (MPP), and moringa leaves powder (MLP) was passed through 250-μm sieve and packed in zip-lip low density polyethylene pouches of 10-μm thickness for further use.

2.1 | Preparation of functional pasta

To prepare functional pasta, DSF (5%, 15%, and 25%), CP (5%, 10%, and 15%), MPP (5%, 10%, and 15%), and MLP (3%, 5%, and 8%) was incorporated into WS : PMF (50:50) blend. Moisture content of the blend was adjusted to 30% (w.b.) by moisture addition. The difference between targeted and actual conditioned moisture content was approximately 0.5%. Conditioned feed mixture was metered into the twin screw extruder (BTPL make, Kolkata, India) by a twin-screw feeder equipped with it. The extruder operating condition was set as 70 °C barrel temperature, 12 rpm feeder speed, and 10 screw speed: feeder speed ratio (the parameters were optimized in a separate study by the authors). A concentric double cylinder type die was used to get a cylindrical hollow product with wall thickness of 0.91 mm. After the extruder system parameters (product temperature and motor torque) reached a steady state, the samples were collected in open pans and allowed to come to room temperature and then cut into small pieces (15*mm length) by knife. Drying of pasta was carried out in tray dryer (MSW-216, Macro Scientific Works, New Delhi) maintained at 50 °C till it attained 8–9% (w.b.) moisture content. The resultant dried product was cooled and packed in biaxially oriented polypropylene (BOPP) packaging material (100 μm) having water vapor transmission rate (WVTR) 7.71 g/m^{2}day until the further analysis was carried out.

2.2 | Quality evaluation of functional pasta

Association of Official Analytical Chemists (1990) methods were used for analysis of moisture content (Method 925.10), protein content (Method 960.52), ash content (Method 923.03), and fat content (ether extract, Method 920.85). A factor of 6.25 was applied to convert N into protein (Rathi, Kawatra, & Sehgal, 2004). Iron, zinc, and calcium contents of the samples were estimated using the respective standard curve prepared for each element (American Association of Cereal Chemists, 2003, Method 40–70). The standard curve was prepared by running samples of known strength and absorbance was read in atomic absorption spectrophotometer (ZEEnit-700, Jena, Germany). Ascorbic acid was determined by 2, 6-dichlorophenol indophenols visual titration method (Ranganna, 1986). Total flavanoids content was estimated by method Chen (1998). Antioxidant activity was determined by CUPRAC (Cupric Reducing Antioxidant Capacity) method (Apak, Guclu, Ozyurek, & Celik, 2008). Total carotenoids (Ranganna, 1986) and phenol content (Swain & Hillis, 1959) were also determined. The parameters were evaluated in triplicate.

The cooking time is the minimum time necessary to gelatinize the starch. It was assessed by pressing cooked pasta between two glass plates and measuring the time for the white core of the pasta to disappear (Abecassis, Abbou, Chaurand, Morel, & Vernoux, 1994). Cooking loss (CL) was measured according to the BIS method (BIS: 1485, 2010) using following Equation 1:

$$\mathrm{CL}=\frac{(M1-M)\times V\times 100}{\text{Volume of gruel taken for estimation}\times\text{Weight of uncooked pasta}} \tag{1}$$

where,

$M1=$ mass in grams of petri dish with total dry solids; $M=$ mass in grams of empty petri dish; $V=$ total volume of gruel in mL.

Color of pasta was measured using Hunter color lab (Model No. LX16244, Hunter associates Laboratory, Virginia) in terms of CIE "*L*," "*a**," and "*b**." Color measurements were taken in five replications. Change in color was calculated using Equation 2.

$$\Delta E=\sqrt{(L_0-L_1)^2+(a_0-a_1)^2+(b_0-b_1)^2} \tag{2}$$

Where, L_0, a_0, and b_0 are the L, a, and b values for blend of WS : PMF (50:50) and L_1, a_1, and b_1 are the corresponding values for functional ingredients incorporated pasta samples.

Textural properties of cooked pasta were measured using the Texture Analyzer (Model: *TA + HDi®*, Stable Micro Systems, UK) equipped with a cylindrical probe (p/75 mm). Texture analyzer settings used were: Mode: Texture Profile Analysis 2 (return to start); Pre-Test Speed: 3 mm/s; Test Speed: 1 mm/s; Post-Test Speed: 10 mm/s; distance: 50% in compression mode; Time: 1 s; Data acquisition rate: 200 pps. From the TPA curve, hardness, cohesiveness, springiness, gumminess, and chewiness were calculated as suggested by Limroongreungrat and Huang (2007). From each cooking test, five samples were taken and their mean values were reported.

For determination of bulk density, 10 g of uncooked pasta was taken in 100 ml measuring cylinder. The cylinder was tapped until no visible decrease in volume was noticed. Bulk density (kg/m^3) was calculated using Equation 3 as also followed by Badwaik et al. (2012).

$$\text{Bulk density}=\frac{\text{Weight of sample}}{\text{Volume occupied by pasta}} \tag{3}$$

Sensory evaluation of developed pasta along with commercial pasta was carried out as per BIS method (BIS: 6273, 1971) using 9-point-hedonic scale.

2.3 | Statistical analysis

The experiment was carried out using completely randomized design. Results are expressed as mean ± standard error of triplicate analysis for all measurements except color, textural properties, and sensory evaluation. Analysis of variance (ANOVA) and least significant differences were calculated using Statistical Analysis Software (SAS) version 9.3. Significance was accepted at $p \le .05$.

3 | RESULTS AND DISCUSSION

3.1 | Proximate composition of DSF, CP, MPP, and MLP

The functional ingredients used for pasta preparation DSF, CP, MPP, and MLP were analyzed for proximate composition and shown in Table 1. DSF had highest protein content (39.73%) followed by MLP (17.15%), CP (7.13%), and MPP (6.48%), respectively. Fat (5.23%), ash (10.16%), iron (141.98 mg/100g), and calcium (1,623.18 mg/100g) content was found maximum in MLP. Zinc content was found highest in DSF (4.48 mg/100g) followed by MLP (2.33 mg/100g), CP (2.05 mg/100g), and MPP (1.39 mg/100g).

MPP had highest ascorbic acid content of 67.34 mg/100g followed by MLP, CP, and DSF. Total flavanoids content (mg/100g) and antioxidant activity (μmolTrolox/g) was found highest in MLP followed by MPP, CP and DSF, respectively. Total carotenoids content in MLP (55.17 mg/100g) was observed highest and was followed by CP (28.51 mg/100g) and MPP (19.55 mg/100g). MLP had highest phenol content of 6,936.11 mg/100g followed by MPP (4,592 mg/100g), CP (170.54 mg/100g) and DSF (138.05 mg/100g).

3.2 | Cooking time (CT)

Significant variation ($p \le .05$) was reflected in developed pasta with respect to CT (Table 2). CT of control pasta was found as 8.01 min which decreased from 7.91 to 5.38 min with the increase in level of DSF, CP, MPP, MLP varied (Table 2). The difference in CT of enriched pasta samples could be attributed to the difference in gelatinization temperature of respective starch or blend of starches (Benhur et al., 2015). DSF, CP, MPP, and MLP incorporated pasta required less time to cook as compared to control pasta. The physical disruption of the gluten matrix by powder particles provided a path of water absorption into the pasta containing nontraditional ingredients resulted in shorter CT (Manthey, Yalla, Dick, & Badaruddin, 2004). Among all the developed pasta, MLP incorporated pasta required least time during cooking followed by CP, DSF, and MPP. This might be due to the faster reconstitution of fine vegetable powder distributed in the pasta matrix (Rekha, Chauhan, A. S., Prabhasankar, Ramteke, & Venkateswara Rao, 2012). Gallegos-Infante et al. (2010) reported that CT of spaghetti decreased from 10 to 8.45 min with the addition of 30% common bean flour in wheat semolina. With the addition of 35% of split pea or faba pea significantly ($p < .05$) decreased the CT of pasta from 9.3 min (100% wheat semolina) to 8.7 min (35% split pea) and 8.5 min (35% faba bean), respectively (Petitot, Boyer, Minier, & Micard, 2010).

TABLE 1 Proximate composition of DSF, CP, MPP, and MLP

Composition	DSF	CP	MPP	MLP
Moisture content (% w.b.)	10.33 ± 0.07^a	10.92 ± 0.02^b	9.04 ± 0.11^c	9.38 ± 0.13^c
Ash (%)	4.89 ± 0.01^b	4.97 ± 0.01^b	3.04 ± 0.03^c	10.16 ± 0.03^a
Protein (%)	39.73 ± 0.06^a	7.13 ± 0.10^c	6.48 ± 0.62^d	17.15 ± 0.12^b
Fat (%)	1.30 ± 0.36^c	0.80 ± 0.02^d	1.81 ± 0.02^b	5.23 ± 0.03^a
Iron (mg/100g)	14.45 ± 0.03^b	11.12 ± 0.02^c	8.06 ± 0.02^d	141.98 ± 0.05^a
Zinc (mg/100g)	4.48 ± 0.01^a	2.05 ± 0.03^b	1.39 ± 0.01^c	2.33 ± 0.00^b
Calcium (mg/100g)	166.29 ± 0.01^c	197.94 ± 0.09^b	134.29 ± 0.01^d	1623.18 ± 1.04^a
Ascorbic acid (mg/100g)	12.74 ± 0.20^d	26.78 ± 1.70^c	67.34 ± 0.20^a	61.62 ± 0.20^b
Total flavanoids (mg/100g)	21.20 ± 0.02^d	37.77 ± 0.16^c	340.00 ± 0.05^b	353.34 ± 0.07^a
Total carotenoids content (mg/100g)	–	28.51 ± 0.00^b	19.55 ± 0.20^c	55.17 ± 0.00^a
Antioxidants activity (μmolTrolox/g)	13.54 ± 0.00^d	29.52 ± 0.70^c	3649.25 ± 1.40^b	4868.77 ± 0.30^a
Total phenol content (mg/100g)	138.05 ± 2.44^d	170.50 ± 0.64^c	4592.00 ± 4.53^b	6936.11 ± 1.96^a

(Values are mean ± SE of three replications; mean in the same rows followed by same superscript letter are not differed significantly at $p \leq .05$).

3.3 | Cooking loss (CL)

CL being an important indicator of pasta quality quantifies the amount of solids lost into cooking water. Addition of functional ingredients had significant effect ($p \leq .05$) on CL of developed pasta (Table 2). Total solids loss of control pasta was 8.06% which increased with the incorporation of DSF, CP, MPP, and MLP. It may be due to absence of gluten protein in these flours. As, gluten protein network is responsible for retaining the physical integrity of pasta during cooking, a weaker

TABLE 2 Cooking time, cooking loss, *L*, *a**, *b** value, color change, hardness, and bulk density of pasta enriched with DSF, CP, MPP, and MLP

Functional pasta	Cooking time (min)	Cooking loss (%)	*L* value	*a** value	*b** value	Color change (▲*E*)	Hardness (N)	Bulk density (kg/m^3)
Control	8.01 ± 0.43^{ab}	8.06 ± 0.02^c	38.37 ± 0.01^d	1.71 ± 0.01^c	16.12 ± 0.03^a	0.00 ± 0.00^d	9.90 ± 0.28^b	274.33 ± 2.18^a
5% DSF	7.91 ± 0.03^a	8.11 ± 0.03^c	45.53 ± 0.00^c	2.15 ± 0.01^a	13.18 ± 0.00^b	7.99 ± 0.00^c	14.43 ± 0.68^a	267.10 ± 2.74^a
15% DSF	7.50 ± 0.11^b	8.34 ± 0.02^b	54.55 ± 0.00^b	1.91 ± 0.00^b	12.63 ± 0.01^c	16.57 ± 0.00^b	13.99 ± 0.83^a	250.86 ± 2.73^b
25% DSF	6.58 ± 0.02^c	9.21 ± 0.04^a	60.45 ± 0.01^a	1.76 ± 0.00^d	11.59 ± 0.01^c	22.28 ± 0.01^a	13.07 ± 0.39^a	231.70 ± 0.15^c
F_{DSF}	14.71^S	715.87^S	7.074E^5 ^{S}	1.035E^3 ^{S}	6.531E^3 ^{S}	3435982^S	9.04^S	36.37^S
LSD_{DSF}	0.86	0.12	0.12	0.09	0.05	0.02	2.10	12.33
Control	8.01 ± 0.30^a	8.06 ± 0.01^c	38.37 ± 0.01^d	1.71 ± 0.01^d	16.12 ± 0.03^d	0.00 ± 0.00^d	9.90 ± 0.28^a	274.33 ± 2.18^a
5% CP	7.51 ± 0.01^{ab}	8.25 ± 0.04^c	47.57 ± 0.00^c	5.95 ± 0.01^c	16.28 ± 0.00^c	10.53 ± 0.00^c	9.78 ± 0.79^a	264.46 ± 0.99^b
10% CP	7.05 ± 0.00^{bc}	8.86 ± 0.06^b	48.47 ± 0.00^b	8.59 ± 0.00^b	16.84 ± 0.00^b	12.25 ± 0.00^b	9.52 ± 0.50^{ab}	254.57 ± 2.33^c
15% CP	6.42 ± 0.00^c	11.90 ± 0.00^a	48.72 ± 0.00^a	10.03 ± 0.01^a	18.72 ± 0.01^a	13.54 ± 0.00^a	8.17 ± 0.66^b	246.96 ± 0.66^c
F_{CP}	10.15^S	1303.02^S	1.720E^5 ^{S}	2.092E^5 ^{S}	4.049E^3 ^{S}	2747265^S	41.19^S	25.48^S
LSD_{CP}	0.83	0.19	0.37	0.18	0.10	0.01	1.18	9.27
Control	8.01 ± 0.30^{ab}	8.06 ± 0.01^c	38.37 ± 0.01^d	1.71 ± 0.01^c	16.12 ± 0.03^a	0.00 ± 0.00^d	9.90 ± 0.28^a	274.33 ± 2.18^a
5% MPP	7.58 ± 0.01^b	8.11 ± 0.02^c	43.75 ± 0.00^a	4.17 ± 0.01^a	12.35 ± 0.01^b	7.04 ± 0.01^a	5.78 ± 0.47^b	271.36 ± 0.98^{ab}
10% MPP	7.29 ± 0.01^c	8.45 ± 0.03^b	41.05 ± 0.01^b	4.00 ± 0.00^b	11.92 ± 0.01^c	5.52 ± 0.01^b	5.12 ± 0.29^{bc}	265.82 ± 0.02^b
15% MPP	7.20 ± 0.01^c	9.91 ± 0.10^a	40.60 ± 0.00^c	4.04 ± 0.00^b	12.08 ± 0.01^c	5.20 ± 0.01^c	4.41 ± 0.25^c	254.87 ± 0.53^c
F_{MPP}	5.44^S	136.26^S	2.581E^4 ^{S}	1.994E^4 ^{S}	7.642E^3 ^{S}	125325^S	2.03^{NS}	24.59^S
LSD_{MPP}	0.84	0.29	0.16	0.04	0.09	0.03	2.06	6.80
Control	8.01 ± 0.00^a	8.06 ± 0.01^c	38.37 ± 0.01^d	1.71 ± 0.01^a	16.12 ± 0.03^a	0.00 ± 0.00^d	9.90 ± 0.28^{ab}	274.33 ± 2.18^a
3% MLP	7.04 ± 0.00^b	8.13 ± 0.18^c	46.13 ± 0.00^a	0.28 ± 0.01^b	14.50 ± 0.01^b	8.06 ± 0.01^a	11.73 ± 1.04^a	271.52 ± 0.09^{ab}
5% MLP	6.16 ± 0.00^c	9.06 ± 0.17^b	43.08 ± 0.00^b	0.14 ± 0.01^c	14.14 ± 0.00^c	5.40 ± 0.00^b	8.69 ± 1.08^b	261.78 ± 2.15^b
8% MLP	5.38 ± 0.00^c	10.05 ± 0.00^a	39.54 ± 0.00^c	0.09 ± 0.01^d	12.40 ± 0.00^d	4.28 ± 0.01^c	7.19 ± 0.67^b	242.50 ± 2.18^c
F_{MLP}	28.31^S	827.38^S	8.892E^4 ^{S}	5.016E^3 ^{S}	4.783E^3 ^{S}	578941^S	3.98^S	29.17^S
LSD_{MLP}	0.84	0.13	0.09	0.04	0.05	0.01	2.97	10.46

(Values are mean ± SE; mean in the same columns followed by same superscript letter are not differed significantly at $p \leq .05$; *F* refers to *F* value; LSD refers to least significant difference.)

^{S}Significant.

^{NS}Nonsignificant.

structure leaches more solids into cooking water, increasing cooking residues (Gull et al., 2015). Similarly, Ansari, Kalbasi-Ashtari, and Gerami (2013) reported that addition of 0%, 10%, and 20% DSF in wheat flour increased the CL of spaghetti from 6.29 to 7.68%. As the gluten-soy protein matrix has a porous network, soy protein (with a globular shape) aggregated and immersed into the gluten fibrils (Roccia, Ribotta, Perez, & Edel Leon, 2009). Limroongreungrat and Huang (2007) reported that addition of DSF or soy protein concentrate (SPC) at levels of 0–45% in sweet potato flour increased the CL from 9.9 to 16.6%.

With increase in the level of DSF (5 to 25%), CP (5 to 15%), MPP (5 to 15%), and MLP (3 to 8%), CL gradually increased from 8.11 to 9.21%, 8.25 to 11.90%, 8.11 to 9.91%, and 8.13 to 10.05%, respectively (Table 2). CP incorporated pasta showed highest increase in the CL which might be due to the presence of sugars and fiber which have high affinity for water resulting in the partial development of gluten network (Wang, Rosell, & Benedito, 2002) leading to a weak structure. Incorporation of carrot pomace powder (2 to 10%), MPP (0 to 7.5%), and MLP (2.5 to 5%) in durum wheat semolina increased the CL of pasta from 10 to 16.40% (Gull et al., 2015), from 5.84 to 8.71% (Ajila et al., 2010), and from 4.66% to 5.80% (Singh, 2013), respectively.

Drastic increase in CL was observed beyond addition of 15% DSF, 10% CP, 10% MPP, and 3% MLP. As per the Indian standard (BIS: 1485, 2010), cooking loss in pasta and alike products has been suggested to be $<$8%. Therefore, addition of DSF, CP, MPP, and MLP up to 15%, 5%, 5%, and 3%, respectively was considered appropriate for making pasta. Similar effect of increasing CL have been reported for wheat semolina pasta containing non-gluten ingredients such as sorghum flour (Benhur et al., 2015), cereal brans (Kaur et al., 2012), common bean flour (Gallegos-Infante et al., 2010), finger millet (Gull et al., 2015), split pea, faba bean, white bean, yellow pea, lentil (Petitot et al., 2010; Wojtowicz & Moscicki, 2014), defatted peanut flour, and carrot powder (Badwaik et al., 2012).

3.4 | Color

Addition of various levels of DSF, CP, MPP, and MLP resulted in significant variation in the color values of prepared pasta samples (Table 2). Gray color was found prominent in control sample while pasta enriched with DSF, CP, MPP, and MLP had yellow, orange, maroon, and green color, respectively (Figure 1). Difference in the color characteristics of pasta could be attributed due to presence of different colored pigments in respective flour/powder. Also, nonenzymatic browning and pigment destruction induced the color change during extrusion cooking.

L value of pasta, which indicates lightness-darkness, varied from 39.54 to 60.45 (Table 2). DSF had significant ($p < .05$) positive effect on lightness of pasta samples. As the level of incorporation of DSF increased, *L* value too increased indicating lighter pasta. The increase in lightness of DSF incorporated pasta occurred due to lighter color of DSF as compared to PMF. Limroongreungrat and Huang (2007) reported that addition of DSF and soy protein concentrate (SPC) (0%, 15%, 30%, and 45%) in sweet potato flour significantly increased *L* value (40.6 to 48.7) and decreased a^* value (21.6 to 15.2) of cooked pasta; however, DSF and SPC did not affect b^* value of pasta.

But, incorporation of CP, MPP, and MLP beyond 5%, 5%, and 3%, respectively, led to decrease in *L* value of pasta (Table 2).

Table 2 shows higher redness in case of CP incorporated pasta followed by MPP, DSF, and MLP, respectively. The a^* value of enriched pasta samples varied from 2.15 to 5.95 which was higher than the control pasta (1.71). As expected, it increased positively from 5.95 to 10.03 and from 4.04 to 4.17 with increase in CP and MPP levels. a^* value of MLP incorporated pasta was lower than the control pasta. The decrease could be attributed to the incorporation of chlorophyll pigment from MLP (Singh, 2013). However, a^* and b^* value of pasta incorporated with CP was higher than control pasta (Table 2), may be due to presence of carotenoids pigment in CP. Gull et al. (2015) found that the incorporation of 2–10% of carrot pomace powder in durum wheat semolina decreased *L* value (79.12 to 67.31) and increased a^* value (1.16 to 8.60) and b^* value (16.16 to 26.35) of uncooked pasta samples. Addition of carrot juice (14–30 ml) containing groundnut meal (10–20 g) and refined wheat flour (80–90 g) increased the lightness (approximately 30–37) and redness (approximately 7–9) of pasta (Mridula et al., 2017). Singh (2013) reported that incorporation of 2.5%, 5%, and 10% of MLP in durum semolina resulted in decrease the *L* (from 44.98 to 19.14), a^* (3.52 to 0.30), and b^* (15.25 to 5.51) value of pasta. The b^* value of incorporated pasta samples varied from 11.92 to 18.72. The yellowness of pasta was observed higher in CP (16.28) and MLP (14.50) incorporated pasta samples (Table 2).

Total color change (▲*E*) on addition of functional ingredients is reported in Table 2. A consistent increase in color change may be observed on addition of DSF and CP. However, color change increased with addition of up to 5% MPP and 3% MLP but beyond these levels, color change reduced.

Visual appearance suggested that the color of cooked pasta was more acceptable up to incorporation of 25% DSF, 10% CP, 5% MPP, and 3% MLP, respectively (Figure 1).

3.5 | Hardness

Incorporation of DSF, CP, and MLP significantly ($p \leq .05$) affected hardness of pasta (Table 2). Variation in the hardness of pasta with different ingredients (Table 2) could be due to variation in gluten strength due to substitution by non-gluten ingredients (Krishnan & Prabhasankar, 2010). However, nonsignificant difference ($p \geq .05$) in hardness of pasta was observed with incorporation of MPP (Table 2).

Addition of DSF increased the hardness of pasta from 9.90 N (control) to 14.43 N (5% DSF) (Table 2). Addition of MLP up to 3% improved the hardness (11.73 N) of pasta. Texture of pasta is greatly dependent on the protein network and presence of strong protein network makes pasta more firm (Foo, Yew, Liong, & Azhar, 2011). Furthermore, increase in the proportion of DSF from 5 to 25% resulted in minor decrease in hardness from 14.43 to 13.07 N. Similarly, in case of MLP, firmness decreased drastically from 11.73 to 7.19 N with increase in the incorporation from 3 to 8% (Table 2). The reduction in firmness suggested weakened protein network despite increase in protein content. However, nonsignificant

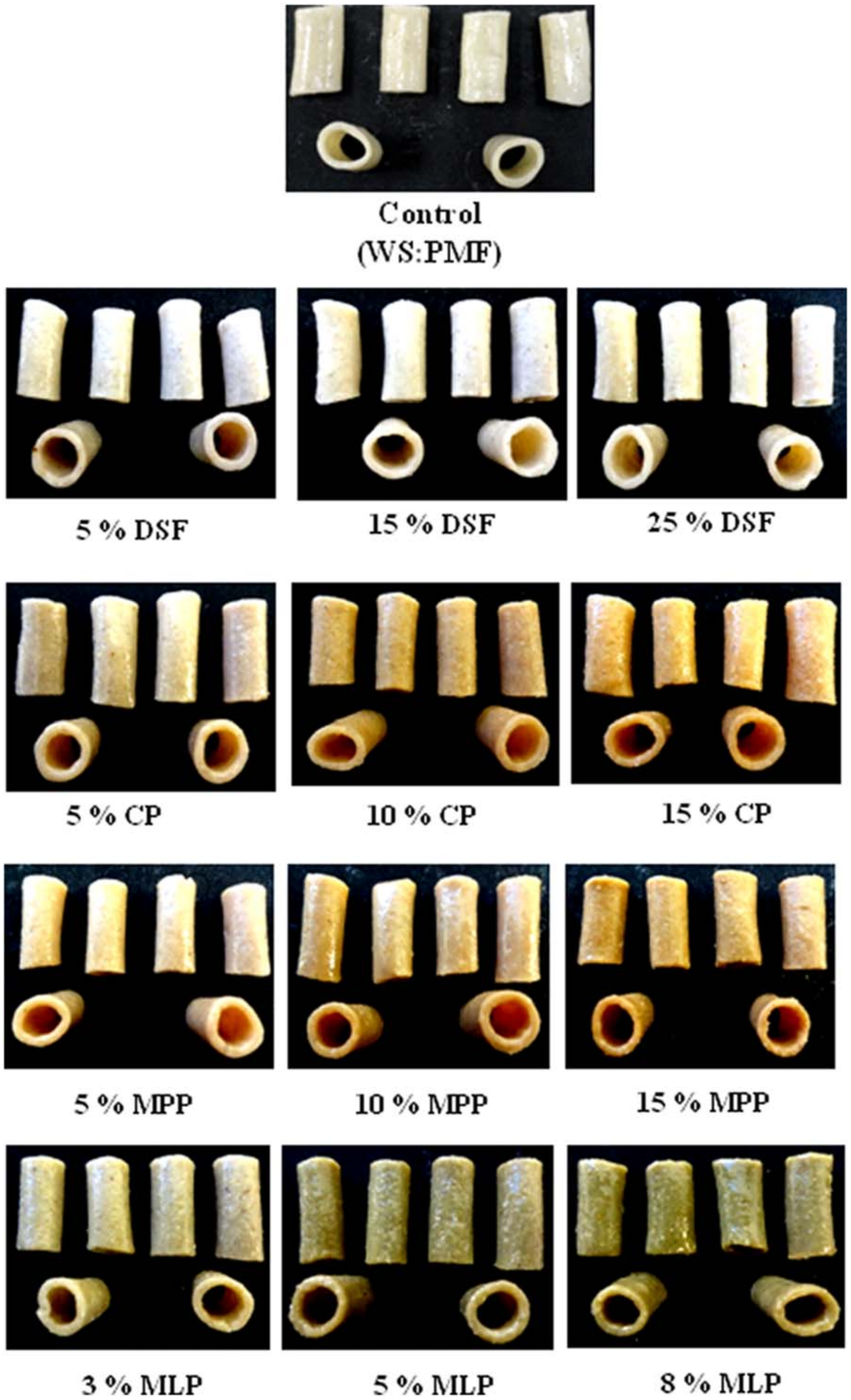

FIGURE 1 Cooked pasta incorporated with different levels of DSF, CP, MPP, and MLP

difference between the mean values of hardness was detected between 5%, 15%, and 25% incorporated DSF pasta.

About twofold decrease in the firmness of pasta with the addition of 5% of CP was observed. However, beyond this level of incorporation, firmness of pasta decreased from 5.78 to 4.41 N (reduction by 24%) (Table 2). In case of MPP incorporated pasta, around 2%, 4%, and 17% reduction in firmness was observed with the addition of 5%, 10%, and 15% of MPP, respectively (Table 2). The firmness of CP and MPP incorporated pasta at different levels decreased, probably due to presence of fiber and sugars as they have high affinity for water (Wang et al., 2002) that was possibly only partially available for gluten network development. Also with increased fiber content, starch solubilization, and molecular association of the leached out amylose and amylopectin fractions resulted in disturbing the protein matrix, led to develop a weak network (Singh, 2013). Gull et al. (2015) reported that incorporation of carrot pomace powder (0–10%) in durum wheat semolina decreased the firmness of pasta from 5.94 to 2.88 N.

TABLE 3 Sensory evaluation of functional pasta

Pasta	Color	Appearance	Texture	Taste	Overall acceptability
Control	6.83 ± 0.14^{b}	7.00 ± 0.47^{a}	7.00 ± 0.47^{a}	8.00 ± 0.00^{a}	7.67 ± 0.27^{a}
5% DSF	7.00 ± 0.00^{ba}	7.33 ± 0.27^{a}	7.33 ± 0.27^{a}	6.67 ± 0.27^{b}	7.08 ± 0.07^{a}
15%DSF	7.33 ± 0.27^{ba}	8.00 ± 0.00^{a}	8.00 ± 0.00^{a}	7.67 ± 0.27^{a}	7.75 ± 0.21^{a}
25% DSF	7.67 ± 0.27^{a}	7.33 ± 0.27^{a}	7.67 ± 0.27^{a}	7.33 ± 0.27^{ba}	7.50 ± 0.24^{a}
F value	2.19^{NS}	1.27^{NS}	1.33^{NS}	3.89^{NS}	1.32 ^{NS}
LSD	0.82	1.22	1.22	0.94	0.84
5% CP	7.00 ± 0.00^{ba}	6.00 ± 0.47^{a}	6.83 ± 0.14^{a}	7.00 ± 0.00^{a}	6.70 ± 0.24^{a}
10% CP	7.67 ± 0.27^{a}	7.33 ± 0.27^{a}	7.33 ± 0.27^{a}	8.00 ± 0.47^{a}	7.58 ± 0.34^{a}
15% CP	7.33 ± 0.27^{ba}	6.67 ± 0.27^{a}	6.67 ± 0.27^{a}	7.33 ± 0.27^{a}	7.00 ± 0.00^{a}
F value	2.19^{NS}	1.46^{NS}	0.56^{NS}	2.25^{NS}	2.28^{NS}
LSD	0.82	1.54	1.25	1.09	1.00
5% MPP	7.67 ± 0.27^{a}	7.33 ± 0.27^{a}	7.00 ± 0.00^{a}	7.67 ± 0.27^{a}	7.42 ± 0.24^{a}
10% MPP	6.67 ± 0.27^{b}	6.33 ± 0.27^{ba}	5.67 ± 0.27^{b}	6.67 ± 0.27^{b}	6.33 ± 0.27^{b}
15% MPP	6.33 ± 0.27^{b}	6.00 ± 0.00^{b}	5.33 ± 0.27^{b}	6.33 ± 0.27^{b}	6.00 ± 0.00^{b}
F value	3.56^{NS}	2.67^{NS}	5.53^{S}	7.56^{S}	8.47^{S}
LSD	0.98	1.21	1.22	0.94	0.91
3% MLP	7.33 ± 0.27^{a}	7.33 ± 0.47^{a}	7.00 ± 0.00^{a}	7.93 ± 0.19^{a}	7.40 ± 0.49^{ba}
5% MLP	6.33 ± 0.27^{cb}	6.00 ± 0.00^{cb}	6.00 ± 0.00^{ba}	6.67 ± 0.27^{b}	6.25 ± 0.31^{cb}
8% MLP	5.67 ± 0.27^{c}	5.67 ± 0.47^{c}	5.33 ± 0.27^{b}	5.67 ± 0.27^{c}	5.58 ± 0.24^{c}
F value	5.62^{S}	4.53^{S}	6.00^{S}	18.03^{S}	5.47^{S}
LSD	0.98	1.22	1.09	0.86	1.37

(Values are mean ± SE; mean in the same columns followed by same superscript letter are not differed significantly at $p \leq .05$; LSD refers to least significant difference.)
[S]Significant.
[NS]Nonsignificant.

3.6 | Bulk density

Bulk density (BD) is an important parameter in the production of expanded and formed food products (Benhur et al., 2015). It determines the packaging requirements, material handling and volume of samples during storage and packaging. It signifies the heaviness of flour (Upadhyaya, Gowda, Pundir, Reddy, & Singh, 2006). Significant variation with respect to bulk density was observed in pasta prepared with the incorporation of different functional ingredients (Table 2). BD of control pasta (274.33 kg/m^3) was observed to be higher than pasta enriched with DSF, CP, MPP, and MLP, respectively (Table 2). Bulk density of pasta decreased with increase in the level of different ingredients which could be due to the change in the wheat gluten content in the blend which reduces its binding properties (Badwaik et al., 2012).

It was also observed that with increasing proportion of DSF (5 to 25%), CP (5 to 15%), MPP (5 to 15%), and MLP (3 to 8%), BD of pasta decreased gradually from 267.10 to 231.70 kg/m^3, 264.46 to 246.96 kg/m^3, 271.36 to 254.87 kg/m^3, and 271.52 to 242.50 kg/m^3, respectively. The drastic reduction in BD was found in DSF incorporated pasta followed by CP, MLP, and MPP pasta. Benhur et al. (2015) reported that bulk density of pasta prepared from 50:50 blend of wheat semolina and sorghum semolina (450 kg/m^3) was maximum compared to pasta prepared from 100% sorghum semolina (360 kg/m^3). While incorporation of defatted peanut flour (DPF) and carrot powder (10 g) in wheat semolina, the bulk density of pasta increased from 241.6 to 321.3 kg/m^3 with an increase in level of DPF from 8 to 22 g (Badwaik et al., 2012). Therefore, increase and decrease in bulk density is dependent on the proportion of wheat protein and starch contents in the flour.

3.7 | Sensory evaluation

Sensory evaluation showed that all the pasta samples prepared from different blends were within the acceptable range (except 5 and 8% MLP incorporated pasta) might be due to high leafy flavor and bitter in taste (Table 3). Similarly, Singh (2013) highlighted that 5 and 10% moringa leaves incorporated pasta appeared slightly unacceptable. Dachana, Jyotsna, Indrani, and Prakash (2010) reported that with increase in the level of dried MLP (0 to 15%), the crust and crumb color of cookies became green and had bitter taste and gritty mouthfeel at 15% incorporation in wheat flour.

In comparison to control pasta, nonsignificant ($p \leq .05$) effect of DSF was observed on sensory attributes of functional pasta (Table 3). Color, appearance, texture, and taste of pasta prepared from incorporation of DSF were appreciated substantially by the panel than the control pasta. Overall acceptability scores suggested that pasta with 15% DSF had better acceptability. Ansari et al. (2013) reported that spaghetti enriched with 20% DSF improved its overall acceptability scores by 10%. Also, spaghetti prepared with 20% DSF and tendered with xanthan gum at 0.4% improved organoleptic values for color, flavor, chewiness, stickiness, and hardness by 80%.

Similarly, sensory evaluation of the pasta revealed nonsignificant ($p \leq .05$) effect of CP incorporation (Table 3). Color of CP incorporated pasta (7.67) was found superior to control sample (6.83). Pasta with 10% CP was adjudged superior in terms of overall acceptability. In case of MPP incorporated pasta, nonsignificant ($p \leq .05$) effect was observed on color and appearance. However, texture, taste and overall acceptability of pasta were significantly affected by incorporation of MPP. The color of control pasta was gray which was significantly improved after addition of 5% MPP as seen in Figure 1 and Table 3. However, further increasing of MPP percentage, the effect was nonsignificant on appearance, texture, taste and overall acceptability. Above this level (>5% MPP), the color of pasta was relatively dark (Figure 1) which reduced the acceptability. Also, at 10 and 15% level of MPP the pasta had slightly bitter taste which might be due to high content of polyphenol (Ajila, Leelavathi, & Prasada Rao, 2008).

Also, overall acceptability score of pasta with 5% MPP was found to be higher, suggesting it as appropriate limit for incorporation. Similarly, Ajila et al. (2010) highlighted that MPP beyond 5% was not acceptable in terms of taste and overall acceptability.

Significant ($p \leq .05$) effect of addition of MLP on sensory attributes was observed. Pasta with 3% MLP had good score for color (7.33), appearance (7.33), texture (7.00), and taste (7.93), almost equal to the control. However, pasta containing 5% and 8% MLP was unacceptable. Therefore, to achieve good sensory properties, only 3% addition of MLP was considered appropriate. Wheat and pearl millet flour (9:1) with incorporation of vegetable paste (2% dry solids of carrot, tomato and turnip) decreased the color, aroma, taste, texture, and mouthfeel of pasta, while addition of spinach improved sensory characteristics (Yadav et al., 2014).

It was inferred from the study that incorporation of 15% DSF, 10% CP, 5% MPP, and 3% MLP for preparation of functional pasta was appropriate in terms of cooking, sensory, and other quality parameters. Among the four functional ingredients, soy flour was adjudged best with highest overall acceptability.

3.8 | Nutritional and functional composition

Protein content of DSF incorporated pasta was found to be the highest (15.49%). Ash content of pasta enriched with DSF increased from 0.82 to 1.43% (Table 4). Highest increase in mineral contents (iron, zinc, and calcium) was found in DSF added pasta (about twofold) followed by MLP (1.56 fold), CP (1.39 fold), and MPP (1.25 fold) incorporated pasta. Increase in functional properties of pasta viz. ascorbic acid, total flavonoids, antioxidants activity, and total carotenoids on addition of DSF, CP, MPP, and MLP was observed.

Limroongreungrat and Huang (2007) reported that DSF contains 34% of protein and 46.89% of carbohydrates. Ansari et al. (2013) found that addition of 0, 10, and 20% DSF in wheat flour along with 4% xanthan gum increased the protein as well as ash content of dried spaghetti from 11.6 to 16.7% and 0.52 to 1.20%, respectively.

Mridula et al. (2017) highlighted that addition of carrot juice in wheat flour significantly increased the antioxidant activity of pasta. Antioxidant activity (17.46%) was found maximum with higher amount of carrot juice (30 ml) in combination with groundnut meal (20 g) and wheat flour (85 g), while minimum antioxidant activity (2.41%) was observed with 14 ml of carrot juice along with groundnut meal (10 g) and wheat flour (85 g), respectively. Similarly, addition of vegetable paste (2%) in wheat and pearl millet flour (9:1) significantly improved the protein, ash, fat, iron, and calcium content of pasta (Yadav et al., 2014).

Ajila et al. (2007) reported that peels of different Indian mango varieties are rich in polyphenols content (45 to 109 mgg^{-1} of peel). Also, addition of 0 to 7.5% of MPP in durum wheat semolina increased the carotenoid content of the macaroni from 0.47 to 8.40 mg/100g.

Singh (2013) reported that MLP contains 9.58% of ash and 21.30% of protein. Increase in MLP incorporation (2.5, 5, and 10%) in

TABLE 4 Nutritional and functional properties of pasta enriched with DSF, CP, MPP, and MLP

Functional pasta	Ash (%)	Protein (%)	Iron (mg/100g)	Zinc (mg/100g)	Calcium (mg/100g)	Ascorbic acid (mg/100g)	Total flavanoids (mg/100g)	Total carotenoids content (mg/100g)	Antioxidant activity (μmol Trolox/g)
Control	0.82 ± 0.01^{d}	12.34 ± 0.09^{bc}	8.91 ± 0.01^{dc}	2.93 ± 0.01^{dc}	21.66 ± 0.05^{e}	4.94 ± 0.26^{d}	6.30 ± 0.17^{e}	–	4.78 ± 0.01^{ed}
15% DSF	1.43 ± 0.05^{a}	15.49 ± 0.61^{a}	12.24 ± 0.28^{b}	4.88 ± 0.10^{a}	46.75 ± 0.96^{a}	8.32 ± 0.52^{b}	8.03 ± 0.07^{c}	–	5.72 ± 0.32^{c}
10% CP	1.23 ± 0.01^{b}	12.16 ± 0.31^{d}	9.21 ± 0.02^{c}	3.08 ± 0.16^{c}	40.55 ± 0.02^{b}	6.89 ± 0.09^{c}	7.63 ± 0.27^{dc}	5.86 ± 0.04^{a}	7.62 ± 0.13^{ba}
5% MPP	0.94 ± 0.03^{c}	12.35 ± 0.02^{bc}	8.92 ± 0.01^{dc}	3.13 ± 0.02^{c}	25.92 ± 0.08^{d}	9.10 ± 0.18^{a}	16.53 ± 0.12^{ba}	2.93 ± 0.03^{cb}	7.77 ± 0.13^{a}
3% MLP	0.94 ± 0.01^{c}	12.44 ± 0.01^{b}	12.58 ± 0.02^{a}	3.87 ± 0.01^{b}	38.46 ± 0.90^{cb}	9.10 ± 0.15^{a}	$17.98 \pm 0.22\ ^{a}$	3.43 ± 0.18^{b}	$4.87^{d} \pm 0.02$

(Values are mean ± SE of three replications; mean in the same columns followed by same superscript letter are not differed significantly at $p \leq .05$).

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TABLE 5 Nutritional quality of control and functional pasta before and after cooking

	Control			Pasta with 15% DSF			Pasta with 10% CP			Pasta with 5% MPP			Pasta with 3% MLP		
	FP	AC	% decrease	FP	AC	% decrease	FP	AC	% decrease	FP	AC	% decrease	FP	AC	% decrease
MC (%w.b.)	10.17 ± 0.08^{f}	63.59 ± 0.03^{b}		10.16 ± 0.08^{f}	62.39 ± 0.07^{c}		10.27 ± 0.04^{ef}	61.70 ± 0.06^{d}		10.39 ± 0.11^{e}	64.17 ± 0.06^{a}		10.28 ± 0.07^{ef}	62.49 ± 0.04^{c}	
Color change (▲E)	0.00 ± 0.00	0.00 ± 0.00		16.57 ± 0.00^{b}	17.88 ± 0.03^{a}		12.25 ± 0.00^{d}	13.38 ± 0.01^{c}		7.04 ± 0.01^{h}	7.75 ± 0.01^{g}		8.06 ± 0.01^{f}	10.62 ± 0.00^{e}	
Ash (%)	0.82 ± 0.01^{de}	0.77 ± 0.01^{e}	6.10	1.43 ± 0.05^{a}	1.35 ± 0.01^{a}	5.59	1.23 ± 0.01^{b}	$1.10\ 6 \pm 0.01^{c}$	5.69	0.94 ± 0.03^{d}	0.87 ± 0.01^{de}	7.45	0.94 ± 0.01^{d}	0.88 ± 0.02^{de}	6.38
Protein (%)	12.34 ± 0.06^{cd}	11.82 ± 0.06^{e}	4.21	15.49 ± 0.61^{a}	14.55 ± 1.49^{b}	6.07	12.16 ± 0.31^{d}	11.34 ± 1.05^{f}	6.74	12.35 ± 0.02^{cd}	11.51 ± 0.06^{f}	6.80	12.44 ± 0.01^{c}	11.54 ± 0.03^{f}	6.48
Iron (mg/100g)	8.91 ± 0.01^{f}	8.41 ± 0.12^{h}	5.61	12.24 ± 0.28^{b}	11.53 ± 0.02^{c}	5.80	9.21 ± 0.02^{e}	8.61 ± 0.02^{g}	6.51	8.92 ± 0.01^{f}	7.69 ± 0.18^{i}	7.01	12.58 ± 0.02^{a}	10.90 ± 0.50^{d}	6.12
Zinc (mg/100g)	2.93 ± 0.01^{f}	2.77 ± 0.01^{g}	5.46	4.88 ± 0.10^{a}	4.61 ± 0.01^{b}	5.53	3.08 ± 0.16^{e}	2.88 ± 0.02^{fg}	6.49	3.13 ± 0.02^{de}	3.01 ± 0.05^{ef}	3.83	3.87 ± 0.01^{c}	3.25 ± 0.03^{d}	5.94
Calcium (mg/100g)	21.66 ± 0.04^{i}	20.48 ± 0.16^{j}	5.45	46.75 ± 0.96^{a}	43.91 ± 1.17^{b}	6.07	40.55 ± 0.02^{c}	38.19 ± 0.00^{e}	5.82	25.92 ± 0.08^{g}	24.19 ± 0.64^{h}	6.67	38.46 ± 0.90^{d}	35.88 ± 0.02^{f}	6.16
AA (mg/100g)	4.94 ± 0.18^{h}	4.59 ± 0.20^{g}	6.33	8.32 ± 0.52^{c}	7.83 ± 0.18^{d}	5.89	6.89 ± 0.09^{e}	6.48 ± 0.18^{f}	5.95	9.10 ± 0.18^{a}	8.58 ± 0.18^{b}	5.71	9.10 ± 0.18^{a}	8.58 ± 0.18^{b}	5.71
TF (mg/100g)	6.30 ± 0.12^{h}	5.94 ± 0.80^{i}	5.71	8.03 ± 0.71^{e}	7.60 ± 0.47^{f}	5.35	7.63 ± 0.27^{f}	7.14 ± 0.48^{g}	6.42	16.53 ± 0.12^{c}	15.48 ± 0.28^{d}	6.35	17.98 ± 0.22^{a}	16.87 ± 0.59^{b}	6.51
TC (mg/100g)	–	–	–	–	–	–	5.86 ± 0.04^{a}	5.48 ± 0.06^{b}	6.48	2.93 ± 0.03^{d}	2.77 ± 0.02^{e}	5.46	3.43 ± 0.18^{c}	2.21 ± 0.01^{f}	6.41
AOA (μmolTrolox/g)	4.78 ± 0.01^{e}	4.54 ± 0.04^{f}	5.02	5.72 ± 0.32^{c}	5.33 ± 0.04^{d}	6.82	7.62 ± 0.13^{a}	7.16 ± 0.01^{b}	6.04	7.77 ± 0.13^{a}	7.27 ± 0.02^{b}	6.44	4.87 ± 0.02^{e}	4.58 ± 0.11^{f}	5.95

(Values are mean ± SE of three replications except color change; mean in the same rows followed by same superscript letter are not differed significantly at $p \leq .05$)
FP = fresh pasta; AC = pasta samples after cooking; MC = moisture content; AA = ascorbic acid; TF = total flavanoids; TC = total carotenoids; AOA = antioxidant activity.

durum semolina increased the protein (from 11.76 to 12.12%), ash (from 0.94 to 1.62%), iron (from 1.63 to 2.92 mg), and calcium (from 10 to 36.96 mg) content of pasta (Singh, 2013). Dachana et al. (2010) emphasized that 2, 3, and 11 fold increase in protein, iron and calcium content, respectively, in cookies was observed with different levels of incorporation of dried MLP (0 to 15%).

3.9 | Nutritional and functional composition of functional pasta before and after cooking

As pasta is consumed after cooking, study was conducted to assess the loss during cooking operation. The samples with 15% DSF, 10% CP, 5% MPP, and 3% MLP were prepared and their nutritional and functional composition before and after cooking was determined. Percentage reduction (5–7%) in nutritional constituents during cooking was observed (Table 5) and the reduction was slightly higher in functional pasta as compared to control.

4 | CONCLUSIONS

Overall results of the study revealed that highly acceptable pasta can be prepared by addition of DSF, CP, MPP, and MLP. Incorporation of 15% DSF, 10% CP, 5% MPP, and 3% MLP was found suitable for making functional pasta with acceptable quality parameters (color, cooking quality, sensory quality). Higher level of substitution of DSF (>15%), CP (>10%), MPP (>5%), and MLP (>3%) improved nutritional properties and bioactive compound present in the pasta, but it also led to deterioration in cooking and sensory qualities of pasta. Among the functional ingredients incorporated, soy flour was found superior with highest overall acceptability. Development and adoption of such functional and nutritional products in the regular diet can improve the nutritional status of the population giving protection toward degenerative diseases.

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