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Wheat-Fenugreek Composite Flour Noodles: Effect on Functional, Pasting, Cooking and Sensory Properties

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Abstract

Composite flour noodles were prepared by blending fenugreek flour (FF) with wheat flour (WF) at a replacement level of 2%, 5%, 7% and 10%, respectively. The chemical, functional, and pasting properties of different flour blends were assessed to check its suitability for noodle making. FF exhibited significantly ($p<0.05$) high protein (28.5%), crude fibre (7.2%), fat (4.9%) and ash content (3.6%) as compared with WF. Water absorption capacity, water solubility index, oil absorption capacity, foaming capacity and emulsion capacity showed an increase in values while the peak viscosity of flour blends decreased with increase in the level of FF. The noodles prepared with wheat-fenugreek flour blends showed higher cooking time, water uptake and cooked weight but less gruel solid loss as compared with control (100% WF) noodles. Noodles prepared with 93% WF+7% FF scored a satisfactory overall acceptability score for their sensory characteristics. Therefore, noodles with satisfactory eating, cooking, texture attributes can be prepared incorporating fenugreek flour up to a level of 7%, helps in exploring the health benefits of fenugreek.

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Introduction

Fenugreek (*Trigonella foenum-graecum*), a *leguminosae* family member, originally belongs to South East Europe and West Asia. But, nowadays it is mainly grown in India and some parts of the world such as the United States and Northern Africa[1]. India contributes over 80% of the total production of fenugreek worldwide, producing and exporting most of this legume in the world. In India, an area of nearly 219,000 ha is occupied by fenugreek, producing approximately 247,000 tonnes in 2015-16 (NHB, 2017)[2]. The seeds are used primarily as spice for flavoring of Indian foods and are slightly bitter and sweet taste with aromatic flavor, have antidiabetic, hypocholesterolemic[3], galactogouge[4,5] and carminative[5] attributes. The seeds also

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extend nutritive as well as remedial properties and stimulate the digestion process[7,8]. Consumer demand has shifted from energy providing diet to the diet with balanced nutrient along with metabolic, physiological, health and functional benefits[9]. The seed contains a hard yellow embryo in the centre; a white, semi transparent, large, corneous endosperm in the middle[10] surrounded by an outer dark brown tenacious husk. Plants are also considered as good source of food proteins (70%) and energy (80%)[11]. Fenugreek seeds mainly constitute of proteins (27.57%), dietary fiber (30.6% soluble and 20.6% insoluble), crude lipids (6.71%)[12] and minerals including iron, calcium and beta-carotene. They are also rich source of many polysaccharides as well as galactomannan[13]. In India, processing of fenugreek seeds (boiling, roasting, germination or pressure cooking) is done to remove the bitterness and make it soft and palatable[14].

Noodles, pasta and other extruded food are gaining wider acceptability due to their versatility, simplicity, organoleptic appeal and satiety[15]. Noodles are one of those convenience foods which are mostly prepared using wheat flour. These gained popularity on account of palatability, taste, sensory attributes, low cost, easy preparation and long term storage stability[16,17]. The information on products developed by blending of wheat flour with fenugreek flour, utilizing its healthful benefits, is scanty. Hooda and Jood[18] prepared acceptable biscuits supplemented with fenugreek flour having good puffing and nutritional value with increased protein, fibre, Ca and Fe content. Hence, by developing and consuming different therapeutic products such as noodles would help to explore the nutritional benefits of fenugreek. This value addition favors the new product development and enhanced market value of commodity[19]. In the present study, efforts were made for preparation of noodles with healthful composite flours by supplementing wheat flour with fenugreek flour and to evaluate functional, pasting and sensorial properties of wheat-fenugreek blended noodles.

Material and Methods

Chemical Composition

The flour samples of wheat and fenugreek were tested for its moisture, protein, fat, ash and fiber content by using the standard methods of analysis[20]. The difference method was used to calculate the carbohydrate content. All the measurements were replicated thrice and reported on the basis of dry weight (dwb).

Preparation of Wheat – Fenugreek Flour (WFF) Blends

Fenugreek cultivar and wheat cultivar were procured from Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. The wheat and fenugreek grains were cleaned before milling to a fine flour by using laboratory grinder (Khera, India) and sieved through 250 mm sieve. Wheat flour (WF) was incorporated with fenugreek flour (FF) and the blends (WFF) were reported as WFF-10% (10% FF+ 90% WF), WFF-7% (7% FF+ 93% WF), WFF 5% (5% FF+ 95% WF) and WFF 2% (2% FF+ 98% WF), respectively.

Functional Properties

Water absorption capacity (WAC) of flours was determined by following the centrifugation method[21] while method described by Anderson[22] was used for calculation of water solubility index (WSI). The oil absorption capacity (OAC) was analyzed following the method of Adeleke and Odedeji[23]. For foaming capacity (FC), the method described by Yasumatsu *et al.,*[24] was followed while emulsion capacity (EC) of flours was determined by the method of Okaka and Potter[25].

Pasting Properties of Flours and Blends

Different flours were analyzed for their pasting properties using a starch cell of Modular Compact Rheometer (MCR 52, Austria). In the cell, flour (1.2 g) and 13.8 g water was thoroughly mixed using plastic paddle to prevent the formation of lump. The pasting analysis involved heating of the suspension firstly from 50 to 95 ^{o}C at a rate of 6 ^{o}C/min, holding at 95 ^{o}C for 5 min, cooling back from 95 to 50 ^{o}C at 6 ^{o}C/min and again holding at 50 ^{o}C for 2 min. Properties recorded (Fig. 1) were pasting temperature, peak (PV), trough (TV) (minimum at 95oC), final (FV at 50 ^{o}C), breakdown (BV) (peak–trough viscosity) and setback viscosity (SV) (final-trough viscosity). All the measurements were replicated thrice.

Preparation of Noodles

The noodles for further analysis were extruded using 100% WF (for control sample) and respective mixtures of WF with fenugreek flour (FF) at different level of substitution, by the method described by Collado and Corke[26]. To prepare the noodles, dough of desirable consistency was prepared by mixing 200 g flour with required amount of deionized water in a laboratory dough mixer and extruded through a manual extruding machine (Sanco, New Delhi, India) and then dried on a polyethylene sheet using a hot air oven (40±2 °C, 12 h). The dried noodles were stored at room temperature i.e. 30±2 °C in air tight containers for further use.

Cooking Properties of Noodles

Cooking time (CT): 10 g of the prepared noodles were cooked in boiling deionized water (200 ml). The cooking was checked by pressing the cooked noodles between two glass slides and judged by disappearance of white core in the centre of the noodles.

Cooked Weight (CW)

The method described by Galvez and Resurreccion[27] was used with minor modifications to determine the noodles cooked weight. Noodles (10 g) firstly soaked (300 ml water for 5 min), then cooked (5 min) and excess water drained. The wet mass of cooked noodles was weighed to determine the cooked weight.

Gruel solid loss (g/100 g) and water uptake percentage (g/100 g) were determined by following the method of Galvez and Resurreccion[27].

Textural Properties of Cooked Noodles

Optimally cooked noodles after rinsing with cold water were evaluated for the hardness using the TA-XT2 Texture Analyzer (Stable Micro Systems, Haslemeres, England) within 5 min after cooking. The cooked noodles (5 strands) were placed parallel on a flat plate of metal. Then, using a 1.5 mm metal blade with a speed of 1.0 mm/s, the noodles were compressed crosswise twice to 70% of their original height. From force-time curves of the texture profile analysis (TPA), hardness was determined using the method described by Baik *et al.,*[28].

Sensory Analysis of Cooked Noodles

The panel for sensory analysis was comprised of 15 semi-trained members (8 females and 7 males) in the age group of 22-25 years. The attributes evaluated were slipperiness, chewiness, firmness, tooth packing (TP) and overall acceptability (OA). Perceived intensities were scored on a 15 point scale[29]. Line scale was used by the panelist and the perceived intensity of the desired attribute was represented by placing a mark at a point on a horizontal line (15-cm long), with 0 for very low intensity and 15 for very high intensity. The marks from line scales were converted to numbers by manually measuring the position of each mark on the scale[15].

Statistical Analysis

One-way analysis of variance (ANOVA) was applied on the results tabulated in the study by using Minitab Statistical Software version 15 (Minitab Inc., State College, USA).

Results and Discussion

Chemical Composition of Wheat and Fenugreek Flour

The results for chemical composition of WF and FF are shown in the Table 1. The moisture content of flour samples differed significantly ($p<0.05$), the higher value observed for wheat flour (10.0%). The moisture content for WF as well as FF was in acceptable limit for safe storage. The ash and fat content of FF (3.62 and 4.97%, respectively) were also significantly higher than wheat flour (1.7 and 1.8%, respectively). Studies also reported fenugreek as a rich source of minerals[30] and unsaturated fatty acids[31]. Being legume, the protein content of FF was also significantly ($p<0.05$) higher (28.5%) as compared with WF (14.3%). Naidu *et al.,*[32], Srinivasan[8] and Hooda and Jood[33] also reported 27.57%, 30% and 24.7% protein content, respectively, for fenugreek emphasizing their value as a vital source of nutrients. Previous researchers[34,35] also reported proximate composition for hard wheat flour comparable with our results.

Table 1: Proximate composition of wheat and fenugreek flour

Content	Wheat flour	Fenugreek flour
Moisture (%)	10.0± 0.31^b	8.7±1.62^a
Ash (%)	1.7± 0.03^a	3.6±0.05^b
Fat (%)	1.8±0.01^a	4.9±0.09^b
Crude fibre (%)	2.5±0.05^a	7.2±0.95^b
Protein (%)	14.3±0.87^a	28.5±0.19^b
Carbohydrate (%)	78.6±0.27^b	46.93±1.15^a

The values are the mean ± SD of three independent observations. The values with different subscript in a row differ significantly ($p<0.05$).

Functional Properties of Flours

Functional properties of WF and WFF are reported in Table 2. The WAC of WF and WFF varied significantly ($p<0.05$) and ranged from 137 to 170%, the highest for WFF-10% and the lowest for WF was observed. As the concentration of fenugreek was increased, WAC also increased. The higher protein as well as dietary fibre content might have played role in higher WAC of flours[36]. Studies reported high protein[8,32,33] and fibre[32,37] in fenugreek. The water solubility index (WSI) for WF and WFF also differed significantly ($p<0.05$) and ranged from 8.2 to 9.36, with the highest and the least values observed for WFF-10% and WF, respectively. OAC of WF and WFF flours ranged from 138 to 147%. WF showed the lowest OAC (138%) whereas WFF-10% showed the highest OAC (147%). OAC plays an important role in improving the mouth feel and retaining the flavor[38,39,40]. Foaming capacity (FC) of flour samples ranged from 78.2 to 88.2%. WF had the lowest FC whereas WFF-10% had the highest value. FC was, increased as the fenugreek incorporation was increased. WFF also significantly ($p<0.05$) differed in their abilities to emulsify the oil. Emulsion capacity (EC) of different flour blends ranged from 45.5 to 49.3%, the highest score recorded for WFF-10% whereas the lowest was observed for WF.

Table 2: Functional properties of wheat flour and wheat-fenugreek flour blends

Blends	WAC (%)	WSI (%)	OAC (%)	FC (%)	EC (%)
Wheat flour	137^{a}	8.22^{a}	138^{a}	78.2^{a}	45.5^{a}
98%WF + 2% FF	143^{b}	8.45^{ab}	140^{ab}	80.3^{b}	46.6^{b}
95%WF + 5%FF	155^{c}	8.89^{b}	141^{b}	82.4^{c}	47.3^{c}
93%WF + 7%FF	165^{d}	9.23^{c}	143^{b}	85.5^{d}	48.1^{d}
90%WF + 10%FF	170^{e}	9.36^{c}	147^{c}	88.2^{e}	49.3^{e}

Means followed by the different superscript within a column differ significantly ($p<0.05$)

Pasting Properties

The pasting properties of WF, FF and WFF are summarized in table 3 and the representative graphs are shown in Figure 1. Significant ($p<0.05$) difference in pasting properties of WF and WFF were observed. However, as shown in Figure 1, the pasting profile of the FF do not showed any change within the temperature range studied, so no data regarding pasting properties of FF is given. Peak viscosity (PV) and final viscosity (FV) of WF and WFF blends varied significantly ranging from 510 to 626 mPa.s and 780 to 1041 mPa.s, respectively, the highest were observed for WF. Incorporation of 2 to 10% FF in WF decreased PV and FV which can be attributed to decrease in the starch content with increasing FF concentration in blends[41]. PV is the starch ability to freely swell before its physical breakdown[42] and measures the break down ability of paste during cooking. Trough viscosity (TV) measures the ability of paste to withstand breakdown during cooling[42], ranged between 379 to 471 mPa.s. SV also decreased as the proportion of FF was increased in blends and the values ranged from 570 to 401 mPa.s. As proportion of FF in WF increased, a progressive decrease in PV, FV and BV was observed. Pasting temperature (PT) is the maximum temperature required to cook the starchy sample[43]. Pasting temperature of wheat flour was 89.6 °C and at increased level of incorporation of FF, PT was observed to be decreased.

Cooking Quality of Noodles

The cooking properties of noodles prepared with WF and WFF are presented in Table 4. The cooking properties of noodles such as CT, CW, percent water uptake, solid loss were analyzed for all prepared noodles. The degree of cooking can be observed either by eye or image analysis as shown by Ahmed *et al.,*[44]. In the present study, it was determined as the central hard core of the test noodle strand disappeared during cooking. Short time of cooking and low solids loss in the water used for cooking is desirable for good quality noodles. Also, insufficient water uptake by the noodles results in harder and coarser texture while excess uptake of water may results in too softer and sticky noodles[45].

The cooking time for all four types of WFF noodle samples was significantly ($p<0.05$) higher than WF (control) noodles and it ranged from 7.5 to 9 min with WF and WFF-10% showing the lowest and highest values, respectively. Cooked weight of noodles was increased linearly with increase in FF, with values ranging from 27.2 to 40.2 g. This increase can be attributed to increase in protein and dietary fibre content present in fenugreek owing to increased water uptake by the noodles. The maximum water uptake of 212.1 g/100 g was observed for WFF-10% noodles; whereas WF noodles showed the least water uptake (172.9 g/100 g). Water uptake is an indicator of the degree of hydration of noodles and may influence the noodles eating quality. Cooking loss indicates resistance of noodles to cooking[46], so its low levels are desirable. The gruel solid losses were observed in the range of 1.2 to 2.2 g/100 g for various blend noodles. Lesser cooking losses might be due to better binding of starch granules and fibers in gluten network[47]. Nevertheless, the gruel solid loss was well within acceptable limit of 10 g/100 g in all types of noodles.

The hardness of cooked noodle was studied using texture analyzer, the TPA is depicted in Figure 2 and the values for the hardness are presented in Table 4. The hardness value of WF and WFF noodles varied significantly ($p<0.05$) and the value ranged from 9.9 to 27.0 N. As the concentration of fenugreek increased in blends, hardness also increased and reported to be highest for WFF-10% (27 .0N). Studies negatively correlate hardness with WAC[48,49].

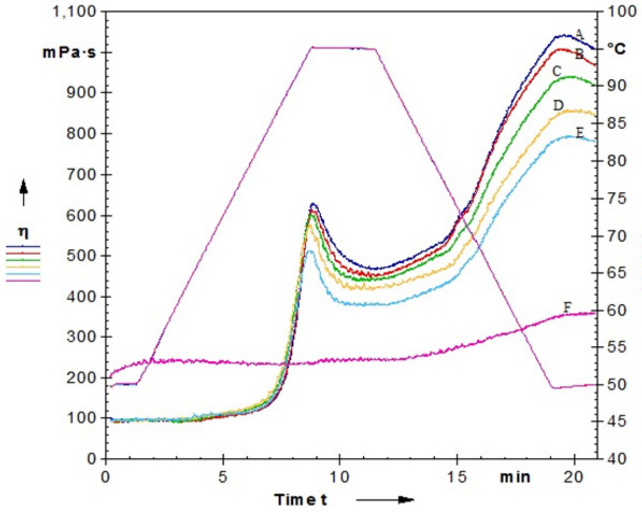

Fig.1: Pasting properties of wheat flour, fenugreek flour and wheat-fenugreek flour blends: A-100% WF; B- 98% WF+2% FF; C- 95% WF+ 5% FF; D- 93% WF + 7% FF; E- 90% WF + 10% FF; F- 100% FF

Table 3: Pasting properties of wheat flour and wheat-fenugreek flour blends

Blends	PV (mPa.s)	TV (mPa.s)	BV (mPa.s)	FV (mPa.s)	SV (mPa.s)	PT (°C)
Wheat flour	626^{e}	471^{e}	155^{b}	1041^{e}	570^{e}	89.6^{b}
98%WF + 2% FF	611^{d}	452^{d}	159^{c}	968^{d}	516^{d}	84.8^{ab}
95%WF + 5%FF	600^{c}	440^{c}	160^{c}	919^{c}	479^{c}	84.8^{ab}
93%WF + 7%FF	575^{b}	419^{b}	156^{b}	845^{b}	426^{b}	84.2^{a}
90%WF + 10%FF	510^{a}	379^{a}	131^{a}	780^{a}	401^{a}	84.2^{a}

Means followed by the different superscript within a column differ significantly ($p<0.05$)

Table 4: Cooking properties and hardness of wheat and wheat-fenugreek flour blend noodles

Properties	100% WF	98%WF+ 2% FF	95%WF+ 5%FF	93%WF+ 7%FF	90%WF+ 10%FF
Cooking time (min)	7.5[a]	8.0[b]	8.5[c]	8.5[c]	9.0[d]
Cooked weight (g)	27.2[a]	30.3[b]	35.8[c]	38.1[d]	40.2[e]
Water uptake (g/100 g)	172.9[a]	178.9[b]	190.4[c]	201.1[d]	212.1[e]
Gruel solid loss (g/100 g)	2.2[d]	1.8[c]	1.5[b]	1.2[a]	1.3[ab]
Hardness (N)	9.95[a]	14.5[b]	17.3[c]	19.3[d]	27.0[e]

Means followed by the different superscript within a row differ significantly ($p<0.05$)

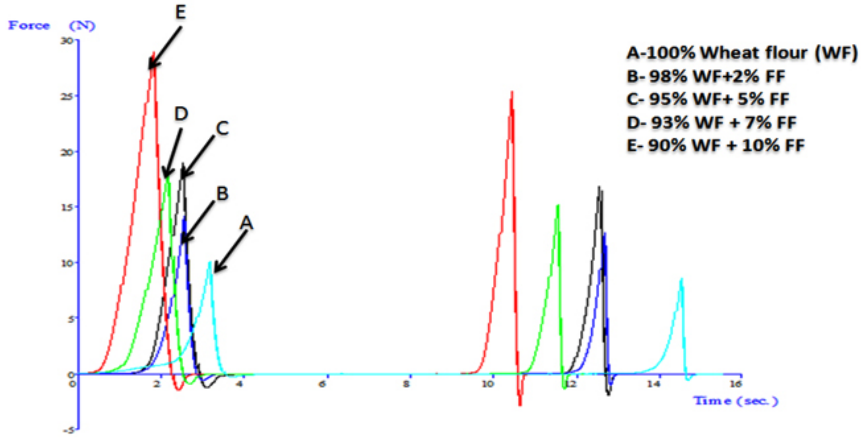

Fig. 2: TPA of noodles prepared with wheat flour and wheat-fenugreek flour blends. Sensorial attributes of noodles

Sensorial Attributes of Noodles

The sensorial scores reported by the test panel by following 15 point scale are shown in Figure 3. Statistically significant ($p<0.05$) variations were observed for various sensory attributes slipperiness, firmness, chewiness, tooth packing and overall acceptability of noodles by semi-trained panel of judges. The sensory results showed that the chewing properties, firmness and overall acceptability of noodles were best for noodles made only from wheat flour (WF). Increasing levels of FF slightly decreased all of the scores for sensorial attributes. The results showed that FF supplementation at increasing levels (2, 5, 7 and 10%) into the formulation considerably affected the noodle quality. FF supplementation has negatively affected chewiness, taste, aroma and overall acceptability. Up to 7% incorporation of FF into WF scored a satisfactory score for noodles, but after that color became darker as well as slightly bitter taste of noodles was not acceptable. Gumminess increased for noodles made by FF incorporation to WF. Incorporation more than 7% resulted in low score and the noodles were not acceptable. Incorporation of FF to WF at levels of 10% and more decreased the sensory scores drastically and noodles were unacceptable due to their irregular shape, dilution of gluten, gummy mouthfeel, fenugreek characteristic flavor/aroma, bitter taste and darker color.

According to sensory analysis, overall acceptability of noodles was observed the best for the WF (control) noodle sample. Although the liking by panelists decreased slightly with increase in the level of FF to WF, but addition up to 7% FF in WF was found satisfactory in terms of overall acceptability.

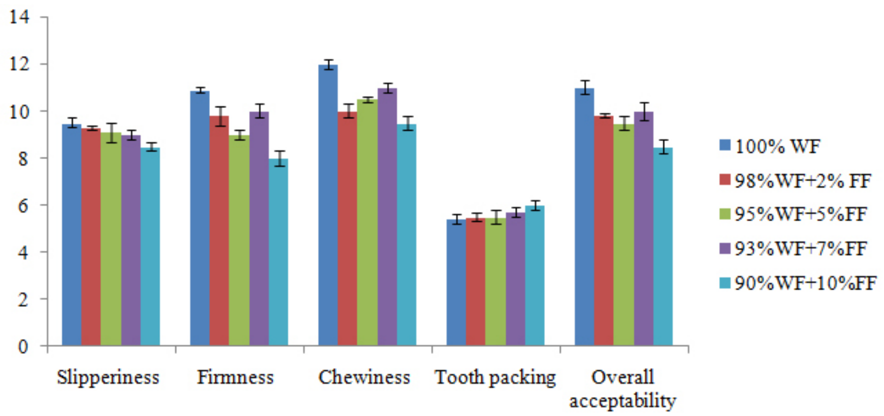

Fig. 3: Sensory properties of wheat and wheat-fenugreek flour blend noodles

Conclusion

From the results of present investigation, it can be concluded that WF and FF blends can be used in developing noodles up to 7% replacement level with good sensory, texture and cooking quality attributes. Also, the study could encourage the use of fenugreek in other products such as bread, biscuits, rusk etc. Further research on the processing of fenugreek to reduce its bitterness and some anti-nutrient content is required to increase its incorporation level in different products.

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Conflict of Interest

The authors have no conflict of interest.

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