ISSN: 2347-467X, Vol. 10, No. (1) 2022, Pg. 276-286

Current Research in Nutrition and Food Science

www.foodandnutritionjournal.org

Development and Quality Evaluation of Noodles Supplemented with Germinated Horse Gram Flour

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Abstract

Germinated horsegram flour (GHF), refined wheat flour (RWF) and different blends (10, 20, 30, and 40% GHF) were analyzed for their functional properties such as water absorption, oil absorption, swelling capacity, solubility index, color, and pasting properties. The noodles were developed by the incorporation of germinated horse gram flour in refined wheat flour in different proportions (10, 20, 30, and 40% GHF) and analyzed for their textural, cooking, and sensorial properties. The reduction in cooking time, cooked weight and water absorption were noted with the increase in the percentage of substitution of GHF. However, the cooking loss increased with increase in the concentration of GHF in RWF. The noodles from 100% RWF showed the highest value for hardness whereas sample A (90% RWF: 10% GHF) showed the lowest value for hardness. Among the blends, the hardness, chewiness, and springiness of cooked noodles increased with increase in the concentration of GHF. The decreased value of cohesiveness for GHF blended cooked noodles than control noodles described the less sticky nature of noodles. The addition of GHF also affected the sensory properties of cooked noodles. The noodles developed from blends of GHF with RWF were darker in color than control noodles. The noodles prepared from 40% GHF had the lowest score for overall acceptability. The overall acceptance of noodles prepared with 10% and 20% GHFwere similar to the control.

Article History

Received: 19 October 21

Accepted: 24 January 2022

Keywords

Cooking Properties;
Germination;
Horse Gram;
Noodles;
Sensory Properties.

Introduction

Horse gram (*Macrotyloma uniflorum*) is one of the underutilized legumes of the tropics. It has a significantly higher proportion of non-protein nitrogen than other legumes.[1] Horse gram is extensively cultivated in the state of dry regions of South India in the state of Andhra Pradesh, Karnataka, and Tamil Nadu. Horse gram is a good source of protein and generally used in the form of splits or dhal, whole meal and sprouts. The horse gram seed contains carbohydrates (60%), protein (25%), lipid (0.58%), essential amino acids, molybdenum, calcium, and

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Doi: http://dx.doi.org/10.12944/CRNFSJ.10.1.22

iron.[2] Horse gram seeds are also rich in dietary fiber. The health beneficial effects of horse gram include its role in treatment of jaundice, rheumatism, skin disorders, hyperglycemia, abdominal lumps, and bronchitis.[1] The horse gram seeds also contain polyphenols which are responsible for antioxidant activity.[2]

The seeds of horse gram also contain some anti-nutritional factors like phytic acid, tannin, and oxalic acid, which decrease the bioavailability ofiron and calcium.[3] However, significant improvement has been attained through dehulling, soaking, germination, and fermentation to decrease the anti-nutrients and to increase the nutritive quality of pulses.[4] The germination process has been found to decrease the amount of oxalic acid, polyphenols, and phytic acid present in seeds of horse gram.[5] The protein digestibility was also found to be increased after treatment of germination.[6]

As the market of noodles is expanding, the research on the development and fortification of noodles is also increasing. Wheat flour is the basic ingredient for the noodle preparation. The protein content of wheat varies from 10-14% but wheath as low amount of essential amino acids like threonine and lysine.[7] The wheat flour can be fortified with horse gram flour to enhance the nutritive value of noodles. Moktan and Ojha[8] prepared bread by incorporating the germinated horse gram flour and found a significant increase in iron, calcium, antioxidant activity, and polyphenol content. Several research works have been found on the development of noodles from composite flour with the incorporation of peanut flour,[9] malted ragi flour,[10] water-chestnut flour,[11] cowpea flour,[12] and germinated mung bean flour.[13] Since, there is no study on the application of germinated horse gram flour in noodle making, therefore, this study was planned with the objective of development and quality evaluation of noodles fortified with germinated horse gram flour. The physicochemical characteristics of germinated horse gram flour and its blends with refined wheat flour were also studied.

Material and Methods

Horse gram (*Macrotyloma uniflorum*) seeds and wheat (*Triticum aestivum*) were procured from the general market of Rohtak. All chemicals required in the study were of scientific grade.

Preparation of Germinated Flour

The horse gram seeds (100 g) were washed and soaked in distilled water (500 mL) at room temperature for 12 hrs. After soaking, water is drained off and seeds were allowed to germinate at room temperature (25 ± 3°C) for 48 h, followed by drying in a tray drier for 5 hat 55°C. The dried seeds were milled in the grinder to get flour, and sieved using a sieve of 100 mesh size.

Proximate Composition

The moisture, ash, fat, protein, and crude fiber of the germinated horse gram flour and refined wheat flour were measured according to the standard methods.[14]

Preparation of Blends

The blends were prepared by incorporating the germinated horse gram flour (GHF) in refined wheat flour (RWF) in different proportion. The blends were noted as control (100% RWF), A (10% GHF + 90% RWF), B (20% GHF + 80% RWF), C (30% GHF + 70% RWF) and D (40% GHF + 60% RWF).

Color Analysis

Color of all the samples were analyzed using a colorflex EZ (Model: 45/0 USA). The color of the sample is indicated by three dimensions i.e.a*,b* and L* where ‘a* ’indicates the degree of redness (+a) to greenness (-a) and ‘b*’ indicates the degree of yellowness (+b) to blueness (-b). The dimension ‘L*’ represents the degree of lightness of the sample (‘0’ for black and 100 for white).

Bulk Density

The method described by Okaka and Potter[15] was used for the determination of bulk density. The flour (50 g) was put into a measuring cylinder of 100 mL capacity, tapped for about 20-30 times to remove the air space, and volume occupied by the flour was noted. The bulk density was determined as the weight/unit volume of the flour sample.

Water Absorption and Oil Absorption Index

The water absorption and oil absorption capacity were measured by applying the standard procedure.[16] The flour samples (0.5 g) were measured in the centrifuge tube and distilled water/oil (10 mL) was poured and remained for 1 hour at ambient temperature. Then the centrifugation of the sample was done for 10 minutes at 3000× g. The water or oil was then decanted. The binding capacity of water or oil by the samples was calculated as:

WAC (%) = (Grams of bound water)/W1×100
OAC (%) = (Grams of bound oil)/W1×100

Where W_1 is the weight of the dry flour sample

Swelling Capacity and Solubility Index

The swelling capacity and solubility index were measured by applying the standard procedure.[16] The distilled water (25 mL) was added to the sample (0.5 g) and mixed mildly. The suspension was then heated in a shaking water bath at 90°C temperature for 15 min. The tubes containing the paste was then removed from the water bath. The paste was centrifuged for 10 min at 3000× g using centrifuge (Sigma 3-18KS, Germany).The weight of sediment was recorded. The supernatant was then dried at 105˚C for 3 hours. Swelling capacity and solubility were measured as follows:

Swelling capacity (g/g) = Weight of swollen granules / Dry weight of a sample

Solubility index (g/g) = Weight of solubles / Dry weight of a sample

Least Gelation Concentration

The method described by Coffmon & Gracia[17] was used for the determination of least gelation concentration. Sample suspensions from 2-10% were made in distilled water (10 mL) with an increment of 2%. The mixture was heated in a water bath for 1 hour and then cooled immediately by immersing the test tubes in cold water. Further, the flour suspensions were refrigerated for 2 hours at 4°C. The tubes were tilted to check the gel concentration. The concentration at which the gel remains as such was termed as least gel concentration.

Pasting Properties

Pasting properties of germinated horse gram flour and its blends with refined wheat flour were measured with a Rapid Visco Analyzer (RVA Starch Master TM, Newport Scientific, Australia). The aqueous flour suspension was obtained by dispersing 3 g of sample in distilled water (25 mL) in an RVA canister and the canister was inserted into the instrument. The heating and cooling cycles were computed automatically. The heating cycle started and the slurry of flour was remained for 1 min at 50˚C, again heated for 3 min 42 s to 95°C and then kept for 2 min at 95°C. After the heating cycle was completed, the cooling cycle started with a decrease in temperature to 50°C in 3 min 48 s and held for 2 min at 50°C, at 160 rpm.

Noodles Preparation

The noodles were prepared using RWF (100%) and blends of GHF with RWF at different concentrations, according to the procedure reported by Collado and Corke.[18] The dough of appropriate consistency was prepared using 50 g flour with distilled water. The noodles were developed with the help of noodle making machine (MARCATO, Italy), then dried in an air oven (40±2°C, 12 h) and packed in air-tight polyethylene bag of 0.02 mm thickness.

Cooking Properties of Noodles

The cooking properties of noodles were determined using the method of Galvez and Resurreccion.[19] The noodles (5 g) were cooked in boiling distilled water (100 mL). The cooking was examined by forcing the cooked noodles in the middle of two glass slides and vanishing of white part in the noodles. The cooking time was noted and weight was measured by weighing the cooked noodles. The cooking loss was measured by drying the water at 105°C for 24 h. The water absorption (%) of noodles was calculated using the formula:

Water absorption (%) =W2 - W1 / W1 × 100

Where, W_1 = Weight of fresh noodle

W_2 = Weight of cooked noodle

The Expansion ratio of noodles was measured as the ratio of the cross-sectional area of noodle (average of 5 readings) to die.

Textural Properties of Cooked Noodles

The cooked noodles were analyzed for their textural properties using a texture analyzer (TA-XTS table Micro Systems, UK). The cooked noodles of 70 mm length were used for analysis. The pasta firmness probe (HDP/PFS) of 35 mm diameter was selected for testing the texture of cooked noodles by using a 5 kg load cell. The pre-test, test, and post-test speed were 1,2, and 5 mm/s respectively. The strain of 80% and trigger force of 8 g were used. The hardness, cohesiveness, springiness, gumminess and chewiness of cooked noodles were measured using the method of Park and Baik.[20]

Sensory Evaluation of Cooked Noodles

The noodles prepared from different blends were analyzed for their sensory properties by a panel of more than 10 semi–trained members using the hedonic scale of 1-9 point (1=very undesirable and 9=very desirable).[12]

Statistical Analysis

The results of the study were analyzed by applying ANOVA (SPSS 19). The significant difference among the mean values was measured at $p \leq 0.05$.

Results and Discussion

Proximate Composition

The moisture content of germinated horse gram flour (GHF) and refined wheat flour (RWF) was noted as 7.68 ± 0.15 and 12± 0.03%, respectively. The fat content in GHF and RWF was observed as 0.65±0.08 and 1.77± 0.01% while protein content was noted as 25.34± 0.86 and 13.1± 0.20%, respectively. A study also reported an increase in protein content and fat content after germination.[21] The crude fiber in GHF and RWF was found as 3.25 ± 0.15 and 0.64± 0.03%, respectively. The ash content in GHF and RWF was observed as 2.87 ±0.07 and 0.87± 0.01% while carbohydrate content was noted as 60.21 and 71.62%, respectively.

Color Analysis

The color value of RWF, GHF, and different blends are given in Table 1. The color value is influenced by testa color, protein content, flavonoids, pigments etc. The L* value of different samples was varied in between 80.85 to 86.86. A significant ($p \leq 0.05$) difference was observed between GHF and RWF. The L* value is affected by protein content present in flour and was also found to be negatively correlated with amount of ash present in flour.[13] GHF was found darker than RWF which might be due to the pigments of its seed coat. Among the blends, Blend A (10% GHF) showed the higher value of L* (85.45), representing the lighter color in comparison to other blends (B, C, D).

The +a* value (redness) of GHF, RWF, and various blends was varied in between 1.20-3.22. The different blends showed a significant ($p \leq 0.05$) difference with RWF. The +b* value (yellowness) was varied from 11.85-14.19, lowest for RWF and highest for GHF. The increase in a* and b* values were observed with increase in the concentration of GHF in blends whereas the decrease in L* value was found with the increase in concentration of GHF in blends.

Table 1: Color parameters of refined wheat flour, germinated horse gram flour and their blends

Samples	L*	a*	b*
RWF	86.86 ± 0.02^{d}	1.20 ± 0.01^{a}	11.85 ± 0.07^{a}
GHF	80.85 ± 0.08^{a}	3.22 ± 0.04^{e}	14.19 ± 0.03^{d}
A	85.45 ± 0.48^{c}	1.74 ± 0.06^{b}	12.93 ± 0.14^{b}
B	84.62 ± 0.18^{c}	2.16 ± 0.04^{c}	13.50 ± 0.12^{c}
C	84.12 ± 0.40^{bc}	2.45 ± 0.02^{d}	14.00 ± 0.06^{d}
D	83.54 ± 0.08^{b}	2.52 ± 0.02^{d}	14.11 ± 0.05^{d}

The values are expressed as the mean ±SD of three independent determinations. Where, A=10% GHF: 90% RWF; B = 20% GHF: 80% RWF; C = 30% GHF: 70% RWF; D = 40% GHF: 60% RWF; RWF= Refined wheat flour; GHF= Germinated horse gram flour.

Values in the same column with different superscripts are significantly different ($p \leq 0.05$).

Physicochemical Properties

The data related to the physicochemical characteristics i.e., the bulk density, water absorption (WAC), oil absorption (OAC), swelling capacity (SC), water solubility (WS), and least gelation concentration (LGC) of refined wheat flour and its blends with germinated horse gram flour (GHF) are presented in Table 2. WAC of various samples varied from 161 to 227%. The highest value of WAC was found for sample D (40% GHF) and a low value was observed for refined wheat flour (RWF). WAC describes the ability of a material to combine with water under the condition when water is in a limited amount. The low WAC value is correlated to the lower number of polar amino acids present in the flour.[22] Therefore, the high value of WAC of different blends might be due to the high protein content of horse gram flour. WAC is useful in the production of ready-to-eat products and a high value of WAC may provide cohesiveness to the product.[23] WAC is important in several food products such as baked products and soups.[24]

The oil absorption capacity (OAC) was ranged from 140.66 to 156.53%. The OAC value of all flour blends was found to be higher as compared to RWF and increased with the increase in percentage of GHF in RWF. Subagio[25] stated that the high value of OAC might be due to hydrophobic groups presenton protein molecules. The OAC is useful in enhancing the mouth-feel and retention of flavor. The greater OAC of blends makes the noodles more palatable and acceptable.The bulk density (BD) value of different flour samples varied from 0.54 to 0.76 g/cm^3, the minimum (0.54g/cm^3) was noted for GHF and maximum (0.76 g/cm^3) was noted for RWF. The bulk density was found to be decreased with increase in concentration of GHF.

Swelling capacity (SC) measures the amount by which the flour expands in volume in comparison to the initial volume after soaking in water. It shows the water absorption index (WAI) of flour during heating. The SC value of various samples ranged from 1.80 to 3.42 g/g; the highest (3.42 g/g) for RWF and the lowest (1.80 g/g) for GHF. The SC value of blends was noted to be reduced significantly ($p \leq 0.05$) with the increase in the concentration of GHF. The difference in swelling capacity shows the extent of exposure of the inner arrangement of starch granules present in the flour by the action of water. The solubility varied from 0.05 to 0.09 g/g and the maximum (0.09 g/g)value was reported in the sample having 40% GHF and minimum (0.05 g/g) for RWF. However, the difference in SI of different flour samples was non-significant.

Table 2: Physicochemical properties of refined wheat flour, germinated horse gram flour and their blends

Samples	WAC (%)	OAC (%)	LGC (%)	Bulk density (g/cm^3)	Swelling capacity (g/g)	Solubility (g/g)
RWF	161.00 ± 2.08^a	140.66 ± 0.88^a	6	0.76 ± 0.01^d	3.42 ± 0.01^f	0.05 ± 0.01^a
GHF	224.00 ± 1.45^b	156.53 ± 1.21^d	6	0.54 ± 0.01^a	1.80 ± 0.04^a	0.07 ± 0.01^a
A	221.00 ± 0.57^b	144.00 ± 0.91^b	6	0.71 ± 0.01^c	3.15 ± 0.20^e	0.06 ± 0.06^a
B	226.00 ± 1.15^b	146.02 ± 1.33^b	6	0.70 ± 0.01^c	3.04 ± 0.01^d	0.07 ± 0.01^a
C	225.00 ± 0.01^b	150.00 ± 1.88^c	8	0.62 ± 0.01^b	2.64 ± 0.06^c	0.08 ± 0.01^a
D	227.00 ± 1.45^b	152.00 ± 0.78^c	10	0.60 ± 0.01^b	2.53 ± 0.08^b	0.09 ± 0.01^a

The values are expressed as the mean ±SD of three independent determinations.
WAC =Water absorption capacity; OAC = Oil absorption capacity; LGC = Least gelation concentration.
Values in the same column with different superscripts are significantly different ($p \leq 0.05$).

The least gelation concentration (LGC) of different samples ranged from 6 to 10% whereas D (40% GHF) recorded the highest value. The variation in LGC of flour could be associated to the relative percentage of carbohydrates, lipids, and protein present in the flour and the interaction between these constituents.[26] The legume flour contains high starch and protein content and the gelation property of flour is affected by competition for water among gelatinization of starch and protein gelation.[27]

Pasting Properties

The data of pasting properties of RWF, GHF and their blends are presented in Table 3. The pasting temperature of RWF was observed to be 72°C and it significantly increased ($p \le 0.05$) after incorporating the horse gram flour in RWF. The GHF-RWF blends showed a significant ($p \le 0.05$) reduction in the hot paste viscosity (HPV), peak viscosity (PV), setback viscosity (SB), and cold paste viscosity (CPV) (Fig. 1). The PV of RWF was reported to be 1313 cP and a significant decrease ($p \le 0.05$) in PV was observed for different blends. The reduction in PV of various blends might be due to their low amount of starch in comparison to the RWF. The viscosity of GHF-RWF blends was reduced with increase in the concentration of GHF. The starch is considered to be the main component responsible for the development of the viscosity of flour during pasting.[28,29] The incorporation of germinated horse gram flour decreased the pasting viscosity of the flour blends due to the increased enzymatic activity of amylases like β-amylase andα-amylase in the germinated horse gram flour.[30, 31]

Table 3: Pasting properties of refined wheat flour, germinated horse gram flour and their blends

Sample	PV (cP)	HPV (cP)	BD (cP)	CPV (cP)	SB (cP)	PT (°C)
RWF	1,313 ± 1.15^{f}	882 ± 1.44^{f}	431 ± 2.08^{b}	1,742± 1.42^{f}	860 ± 0.57^{f}	72.4 ± 0.01^{a}
GHF	457 ± 1.52^{a}	317± 1.73^{d}	140± 0.57^{a}	432 ± 1.45^{b}	115 ± 1.15^{a}	84.0 ± 1.15^{c}
A	910± 0.89^{e}	452 ± 1.15^{e}	458 ±2.02^{c}	1,007 ± 1.46^{e}	555 ± 2.88^{e}	83.1 ± 0.08^{c}
B	817± 1.19^{d}	259 ± 0.57^{c}	558 ± 2.08^{f}	544 ± 1.44^{d}	285 ± 0.88^{d}	80.2 ± 0.40^{b}
C	757 ± 1.44^{c}	220 ± 1.15^{b}	537 ± 0.67^{e}	456 ±2.30^{c}	236 ± 1.45^{c}	79.1 ± 0.00^{b}
D	661 ± 2.08^{b}	149 ± 0.57^{a}	512 ± 1.52^{d}	297 ±1.45^{a}	148 ± 1.45^{b}	78.7 ± 0.31^{b}

The values are expressed as the mean ±SD of three independent determinations.
PV= Peak viscosity, HPV= Hot paste viscosity, BD= Breakdown viscosity, CPV= Cold paste viscosity, SB= Set back viscosity, PT= pasting temperature.
Values in the same column with different superscripts are significantly different ($p \le 0.05$).

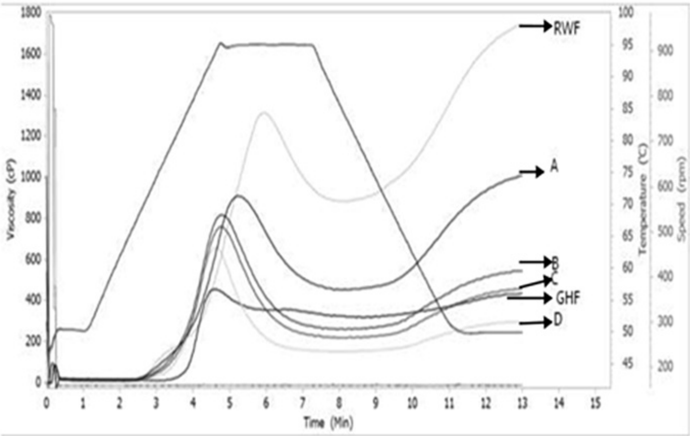

Fig. 1: Pasting profile of refined wheat flour (RWF), germinated horse gram flour (GHF) and their blends: A = 10% GHF: 90% RWF; B = 20% GHF: 80% RWF; C = 30% GHF: 70% RWF; D = 40% GHF: 60% RWF

Cooking Characteristics of Noodles

The cooking parameters of noodles developed from different blends of refined wheat flour (RWF) and germinated horse gram flour (GHF) are shown in Table 4. The cooking characteristics of noodles such as water absorption capacity (WAC), cooking time (CT), cooking loss, cooked weight (CW) and expansion ratio (ER) were observed for all the samples.The short cooking time and minimum solids loss in cooked water are desired for noodles. The inadequate water gain by noodles is responsible for coarser and harder texture where as excess gain of water may responsible for sticky and softer noodles. The cooking time ranged from 7 to 11 min for noodles prepared from different blends. The noodles developed from RWF showed maximum cooking time (11 min) whereas noodles developed from 40% GHF showed the lowest time (7 min). The reduction in cooking time was noted with the increase in the percentage of substitution of GHF.

Table 4: Cooking characteristics of noodles developed from different blends

Sample	Cooking time (min)	Cooked weight (g)	Cooking loss (%)	WAC (%)	Expansion ratio (mm)
Control	11.00 ± 0.57^{a}	13.93 ± 0.04^{b}	10.00 ± 0.04^{a}	174.74 ± 0.93^{c}	0.85 ± 0.07^{a}
A	9.66 ± 0.66^{a}	13.67 ± 0.03^{b}	10.50 ± 0.01^{a}	173.46 ±0.74^{c}	0.83 ± 0.09^{a}
B	8.33 ± 0.66^{a}	12.59 ±0.29^{a}	13.30 ± 0.02^{b}	150.36 ± 5.90^{b}	0.83 ± 0.09^{a}
C	7.33±0.33^{a}	12.00 ± 0.57^{a}	15.80 ± 0.01^{c}	131.76 ± 2.10^{a}	0.83 ±0.04^{a}
D	7.00±0.57^{a}	11.30 ± 0.05^{a}	16.40 ± 0.01^{c}	125.09 ±1.15^{a}	0.84 ± 0.20^{a}

The values are expressed as the mean ±SD of three independent determinations.
Values in the same column with different superscripts are significantly different (p≤0.05).

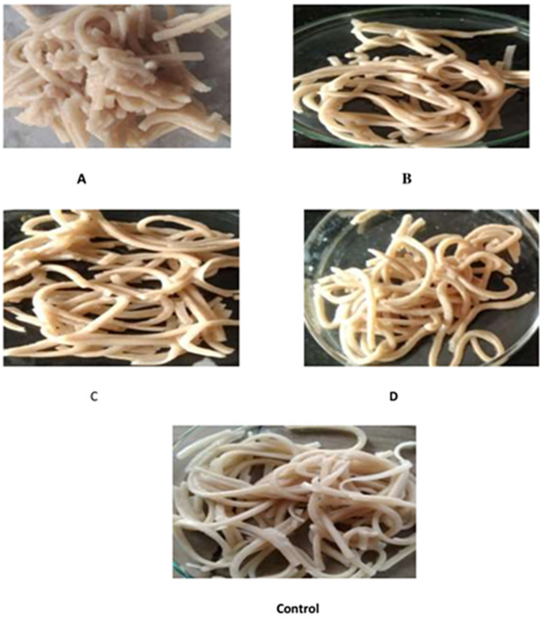

Fig. 2: Cooked noodles prepared from blends of RWF and GHF: A = 10% GHF:90% RWF; B = 20% GHF:80% RWF; C = 30% GHF:70% RWF; D = 40% GHF:60% RWF; Control = 100% RWF

The cooked weight of the control noodle (100% RWF) was found to be more than the noodles developed from different blends of GHF and RWF. The difference in cooked weight might be ascribed to structural variations in the protein network due to the substitution of germinated horse gram flour in refined wheat flour. The cooking loss of noodles ranged from 10 (control noodles) to 16.4 % (40% GHF). The cooking loss increased with the increase in the concentration of GHF in RWF. The lower value of cooking loss of control noodles may be due to the good binding of starch in the gluten network.[11] The increased cooking loss of noodles prepared from blends might be due to the enhanced amount of smaller molecules of sugar and soluble protein in the germinated flour.[13] Water uptake by noodles shows the extent of hydration and may affect the eating attribute of noodles. The water absorption ranged from 125.09 to 174.74 g/g with control sample (RWF 100%) and GHF (40%) having highest and lowest values, respectively. A non-significant (p≤0.05) difference in values of expansion ratio was noted for different noodles.

Texture Analysis

The influences of GHF incorporation in different proportions i.e., 0, 10, 20, 30, and 40% on the textural characteristics of cooked noodles are presented in Table 5. The noodles from 100% RWF showed the highest value (4662.15g) for hardness whereas sample A (90% RWF: 10% GHF) showed the lowest value (2041.64 g) for hardness. The value of cohesiveness was noted as 0.62, 0.57, 0.48, 0.43, and 0.51 for RWF, A (10% GHF), B (20% GHF), C (30% GHF), and D (40% GHF), respectively. It describes that the noodles developed from GHF blended flour were less sticky than RWF noodles and the noodles with 30% GHF showed the lowest value for cohesiveness. The springiness value of control noodles (100% RWF) was significantly ($p \le 0.05$) higher than GHF blended noodles and it increased with the increase in the percentage of GHF flour. The chewiness value for GHF blended noodles was lower than control noodles and the noodles with 10% GHF showed the lowest value. It has been observed that the textural characteristics i.e., adhesiveness and stickiness are directly related to the amount of protein present in flour.[32] The decrease in chewiness and springiness of GHF blended noodles may be due to the protein denaturation during cooking. Also, the high value of cooking loss in the case of GHF blended noodles shows the loss of soluble protein that might be responsible for a change in textural characteristics of noodles. The decrease in chewiness, cohesiveness, and springiness was also reported for cooked noodles developed with the addition of germinated mung-bean flour.[13]

Table 5: Textural parameters of noodles developed from different blends

Samples	Hardness (g)	Springiness (mm)	Cohesiveness	Gumminess (g)	Chewiness	Resilienece
Control	4662.15±1.14[e]	0.90±0.01[e]	0.62±0.01[e]	2,768.04±1.44[d]	2495.44±1.15[e]	0.40±0.01[d]
A	2041.64±0.19[a]	0.21±0.01[a]	0.57±0.01[d]	1172.98±1.45[c]	252.00±1.15[a]	0.32±0.01[c]
B	2235.27±0.19[b]	0.31±0.01[b]	0.48±0.01[b]	1139.59±0.54[a]	352.95±1.35[b]	0.27±0.01[b]
C	2359.42±1.08[c]	0.70±0.01[c]	0.43±0.01[a]	1172.98±1.45[c]	673.42±1.42[c]	0.21±0.01[a]
D	3427.91±1.40[d]	0.79±0.01[d]	0.51±0.01[c]	1752.68±1.46[b]	1393.48±1.43[d]	0.32±0.01[c]

The values are expressed as the mean ±SD of three independent determinations.
Values in the same column with different superscripts are significantly different ($p \le 0.05$).

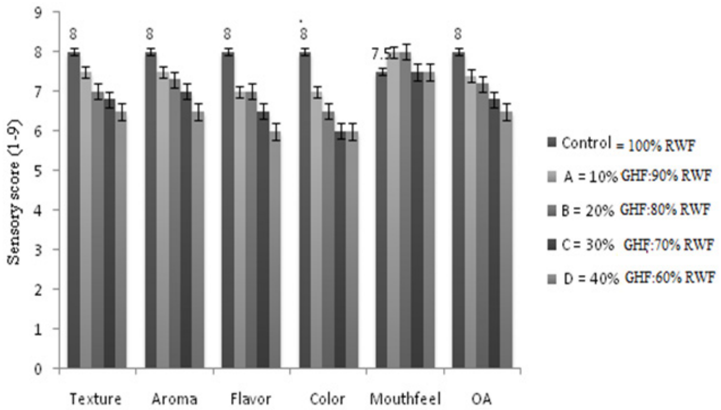

Fig. 3: Sensory scores of noodles prepared from blends of RWF and GHF

Sensory Properties

The cooked noodles prepared from different blends were analyzed for their sensory parameters (Fig. 3). The results of the study showed a significant ($p \le 0.05$) reduction in scores of sensory characteristics with increase in concentration of GHF. The noodles developed from blends of GHF with RWF were darker in color which might be due to the high content of fiber.[33] The lower value of flavor can be related to beany flavor of horse gram.[34] The incorporation of GHF also affects the texture of noodles. The decrease in texture score with the increase in the concentration of GHF was noted. Moktan and Ojha[8] also noted a decrease in sensory scores after the incorporation of GHF in bread. However, the mouthfeel of GHF blended noodles was good and they were softer than control noodles which may be linked with a decrease in hardness.

Conclusion

The incorporation of germinated horse gram flour in refined wheat flour had a significant effect on physicochemical properties, pasting properties and color of the flour. The water absorption and oil absorption capacity improved (41, and 8.06 %, respectively) but the pasting viscosity of flour reduced with the increase in the concentration of germinated horse gram flour. The incorporation of germinated horse gram flour in refined wheat flour at different concentration levels had a significant impact on the cooking, textural, and sensory properties of cooked noodles. The noodles developed from GHF blended flour were less sticky than control noodles. The mouthfeel of GHF blended cooked noodles was also good and they are softer than control noodles which may be linked with a decrease in hardness. The results of this research describe the potential for expanding the application of germinated horse gram flour for noodle making.

Acknowledgement

The authors are thankful to Maharshi Dayanand University, Rohtak (Haryana).

Funding

This research received no specific grant from any funding agency.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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