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Color, texture, cooking properties and nutritional composition of extruded pasta incorporated with germinated horse gram (*Macrotyloma uniflorum*) flourc

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Abstract

Present study investigated the effect of germination of horse gram on the nutritional, physical and cooking characteristics of extruded pasta products. Horse gram seeds were germinated for 48 hrs at 20 ºC ± 2 ºC and subjected to drying in a force convention tray drier for 6 hrs at 50ºC. Germinated horse gram flour was mixed with refined flour and rice flour separately at 90%, 80% and 70% levels and pasta was prepared using single screw extruder at an extrusion temperature 40 ± 2 ºC with a pressure of 400 rpm. Physical parameters like pasting, color, texture and cooking characteristics were carried out to select best quality pasta. Extruded pasta with 70% germinated horse gram flour and 30% refined flour had minimum cooking loss with high firmness and low stickiness in texture profile. Based on this quality, pasta made with germinated horse gram flour and refined flour (70:30) was analysed for nutritional composition and sensory characteristics. Germinated horse gram flour as an ingredient in pasta composition significantly increased ($p<0.05$) the nutrients such as ash (1.73%), protein (28.99%), fiber (0.93%), vitamin C (3.09 mcg), calcium (27.92 mg) and phosphorus (386.43 mcg). Pasta cooked with 3 gm spice and vegetables scored higher values in sensory analysis. Hence, incorporation of germinated horse gram flour in pasta preparation enhanced the nutritional and sensory qualities of pasta with good acceptability which serve as a suitable food for all age group people.

Key Words: *Cooking properties, Dehydration, Germination, Horse gram, Pasta*

Introduction

Pasta is one of the most ancient nourishments which is considered to be versatile both in nutritive and the gastronomic point of view (Antogenelli, 1980). Dry pasta is a traditional cereal based food that has become increasingly accepted worldwide for the reason of its convenience, palatability and nutritional superiority. It also provides significant quantities of complex carbohydrates, protein, B-vitamins and iron. Pasta products are low in sodium, amino acids and total fat (Doughlass and Mattthews, 1982). By incorporating milled wheat, water, eggs and sometimes other optional ingredients, pasta products are being formulated. Recently, more attempts have been taken to improve the nutritional properties of the product with the addition of various high protein sources which are economical. In this point of view, legumes have occupied the utmost role to make pasta products as nutritionally enriched one with easy digestibility. Furthermore, processing methods like germination, fermentation, soaking, dehydration etc., increase their nutritional composition and decrease the presence of antinutrients (Ghopade & Kadam, 1989).

Germination is a natural biological process which increases starch and protein digestibility rate, amino acids and hence enormously used in the preparation of legume based pasta products (Martin-Cabrejas et al, 2003; Urooj & Puttaraj, 1994). Due to the endearing health benefits of germination process, germinated dry beans are incorporated as high-protein ingredients (up to 10%) in pasta making resulting in products with good acceptability. Legumes subjected to germination process are a superior choice for pasta supplementation when compared with raw legumes since the new technological processes decrease anti nutritional factors (Torres et al, 2007, Vidal Valverde et al, 2002), allergenic protein (Frias et al, 2011) and enhance the presence of number of health promoting bioactive compounds (Zhang, Tatsumi, Ding & Li, 2006).

Horse gram (Macrotyloma uniflorum, previously Dolichos biflorus) is a minor, under-exploited legume of tropics and subtropics grown mostly under dry-land agriculture. Horsegram is popularly called as "Madras Bean" due to the principal cultivation and rural production of this legume before the separation of these states from Madras Presidency state, India (Chinnasawamy, 2010)**.** It is an important source of protein, iron and molybdenum. It has been identified as one of the potential food sources for the future by the US National Academy of Sciences (1979). It is extensively grown in India, mainly for animal feed. Horse gram is however, consumed as sprouts in many parts of India (Kadam and Salunkhe, 1985). Horsegram seeds were extensively used in traditional and ayurvedic medicines to reduce body weight and to treat diseases like jaundice, urolithiasis, skin disorders etc., Due to its good nutritional profile, new food products are being formulated to serve as a supplementary food for the nutritionally vulnerable communities. Food products like sweets and savories including ladoo, kesar, biscut, mathri and khakra were formulated from roasted horse gram flour by incorporating maida, wheat and other additional ingredients scored high nutritive value and sensory qualities (Shashi Jain et al., 2012).

Preparation of pasta products supplemented with pigeon pea (Torres et al., 2007) lentils (V´ıdal-Valverde and Fr´ıas, 1992), Mexican common bean (Gallegos-Infante et al, 2010), chickpea (Goni and Gamazo, 2003), broad bean and chickpea (Chillo et al, 2008) and split pea and faba bean (Petitot et al, 2010) have already been done whereas formulation of pasta incorporating germinated horse gram flour has not yet carried out. Therefore, the work adopted for this study is to prepare ready to cook pasta using germinated, dehydrated horse gram flour and evaluate its nutritional, physical and cooking properties.

2. Materials and methods

2. 1. Raw materials

Horse gram (*Macrotylomauniflorum*) seeds (brown) were procured from a whole sale rice merchant in the state of Puducherry, India. The raw seeds were cleaned manually to remove the mud particles and other debris. Commercially available rice flour and refined flour were purchased from local market of Puducherry, India. All the chemicals used for the research work were analytical grade from Himedia labs, Mumbai, India.

2.2. Germination

Process of germination was followed according to Machaiah, Pednekar and Thomas (1999). Six hundred grams of clean seeds were soaked in sodium hypochlorite solution (0.07%, w/v) with seed water ratio 1:5 (w/v) in dark condition for 30 min at room temperature to remove the surface contaminants. Then the seeds were washed with distilled water until they reached neutral pH and soaked in distilled water (1:5 w/v) for 5 hours at room temperature. Excess water was drained and the horse gram seeds were allowed to germinate in an incubator at 20 ºC ± 2 ºC for 48 hrs in aluminium trays covered by wet muslin cloth to reduce water evaporation. Once the desirable time reached, the sprouted seeds were immediately subjected to drying to arrest the germination process.

2.3. Preparation of flour

The germinated horse gram seeds were kept in force convection tray drier ('Nova' digital tray drier-Model:DTD-1203191) for 6 hrs at 50ºC. Dried seed sample was milled into fine flour using a mini grain mill

(A11B, IKA, Inc.), sieved to 0.25 mm of particle size. The germinated horse gram flour was tightly packed in polypropylene pouches and kept in refrigerator at 4 ºC for further product development.

2.4. Pasta preparation

Germinated horse gram flour was combined with rice flour and refined flour separately in various proportions by keeping 100% refined flour as the control for pasta preparation. Homogenized flours of different composition as shown in table 1 were prepared as follows. A 100 gm of flour was mixed well with 30 ml of tap water to a moisture content of 30% and the mix was blended for 2 min, covered with a lid and kept aside for 15 min. Then the soft dough was fed into a single screw extruder (La Monferrinsrl Model dolly) at an extrusion temperature 40 ± 2 ºC and pushed or drawn through the die at a pressure of 400 rpm with a desired cross section. After that that extruded pasta was dried in tray drier at 60 ºC for 2 hours.

2.5. Physical properties

2.5.1. Color analysis

Color of processed horse gram flour was analyzed using a Hunter color Lab colorimeter (Model:CX2748, East Match QC, V 4.0, Hunter lab, USA). In the colorimeter, the sample color is denoted by three dimensions (L*, a* and b*) where L* indicate the degree of lightness of the flour from 100 for perfect white to zero for black. The dimensions a* represents degree of redness (+a) to greeenness (-a) and b* represents the degree of yellowness (+b) to blueness respectively.

2.5.2. Pasting properties

Pasting properties of processed horse gram flour was determined using a Rapid Visco Analyser (Starch master -2, Newport Scientific Pvt. Ltd, Warriewood, Australia, N13713, V3.2). Each of 3 gm flour sample was mixed thoroughly with 25 ml of distilled water in canisters and placed in the Rapid Visco Analyser. The prepared slurry was heated to 50 ºC at 160 rpm for 10 s inorder to have complete dispersion. The slurry was held at 50 ºC for 1 min and the temperature was increased to 95 ºC for 7.5 min and then held at 95 ºC for 5 min. finally it was cooled cooled at 50 ºC for 7.5 min and held at 50 ºC for 2 min. Readings were recorded for pasting temperature, peak viscosity, holding viscosity, breakdown viscosity, final viscosity and set back viscosity.

2.5.3. Cooking characteristics

Optimal cooking time: To determine the optimum cooking time, 25 gm of pasta sample was dispersed in 250 ml of boiling water. For every 30 seconds, a piece of pasta was held between a plastic paper and pressed gently until the white color within the pasta strands disappear.

Cooking loss: Cooking loss was measured by transferring the drained water to a pre weighed petri plate after thorough mixing and evaporating the water to dryness using a water bath. Then the petri dishes were immediately kept inside the hot air oven at 100 ºC ± 2 ºC until it reaches a constant mass as described by AACC method 66-50 (AACC,2000).

Cooking water absorption and cooked weight: The cooked pasta was drained well and weighed to determine the cooking water absorption and cooked weight of the pasta. Water absorption was calculated as the weight increase in pasta and was expressed as % of the sample weight before cooking.

2.5.4. Texture analysis

The texture characteristics of extrudate were measured using a stable Micro Systems HD Plus texture analyser (Goldalming, Surrey, GU71YL, UK) (Plate IIIa,b) (Model No.: 5197) fitted with a 5mm HDP-CFS cylindrical probe. Each pasta sample was placed on the heavy duty platform and the test speed was set to 1mm/sec

and the probe compressed 50% of the sample to measure the hardness. The peak force, i.e, the resistance of extrudate and the area under the curve were chosen to represent the textural properties of extrudate. Maximum breaking force (N) and deformation were measured from the force-deformation curve. Textural parameters like hardness, springiness, cohesiveness, chewiness, gumminess and resilience of the pasta were analysed in triplicate. Based on the textural parameters best quality pasta was selected and analysed for nutritional and sensory characteristics.

2.6. Nutritional composition

Germinated horse gram flour incorporated pasta which was selected basewd on various physical parameters was analysed for nutrients like carbohydrate (anthrn method), protein (Kjeldhal method), fat (soxhlet extraction), fiber (fibra plus) calcium (calorimetric method), vitamin C (2,6 dichlorophenolendophenol) and other standard procedures of AOAC, 2003).

2.7. Sensory analysis

The sensory attributes namely appearance, texture, color, taste, flavor, and overall acceptability were evaluated for developed germinated horse gram pasta using 9 Point Hedonic scale (1=like extremely) to (9=dislike extremely). The samples were coded as A (control), B (100% horse gram flour), C (HG:RF-90:10), D (HG:RF – 80:20), E (HG:RF – 70:30), F (HG:RC – 90:10), G (HG:RC – 80:20) and H (HG:RC–70:30). The sensory assessment was conducted with a semi trained panelists of 15 members under a controlled, cool and peaceful atmosphere. In order to add taste and improve the acceptability of the pasta, three sets of cooked pasta were prepared. A 50 gm of germinated horse gram pasta was cooked and added with 1 gm, 2 gm and 3 gm of spice mix prepared using pepper, cumin, aniseed, chilli powder and served. In another set, 50 gm of cooked pasta was added with 1 gm, 2 gm and 3 gm of sauté vegetables prepared using cabbage, carrot, beans, capsicum and onion. In the third set, both spice mix and vegetable mix were combined together and added to the pasta with a quantity of 1 gm, 2 gm, 3 gm and were served to the panel members for sensory analysis.

2.8. Statistical analysis

Statistical analysis of data was done using statistical software SPSS 18.0 (SPSS Inc, Chicago, USA) by applying ANNOVA and Duncan's multiple range test ($p<0.05$). All the data presented are the mean with the standard deviation of triplicate values.

3. Results and discussion

3.1. Physical properties

3.1. 1. Color values of pasta

Pasta color is an important quality factor for the acceptability by the consumers (Rayas-Duarte et al., 1996). Results of color analysis of pasta is represented in table 2. L* values of germinated horse gram flour pasta incorporated with 10 % to 30 % refined flour (HRF) as well as rice flour (RF) were significantly lower (25.35 – 22.14) than control pasta (56.74). But in contrast, a* value of processed horse gram pasta was significantly higher than the control pasta with no difference within the proportions made with refined flour and rice flour. Decrease in L* value might be due to the brown husk and fiber content of germinated horse gram flour which is not present in the control pasta made of 100 % refined flour. Regarding b* values, control pasta posses significantly higher range

than the pasta produced with germinated horse gram flour, refined flour and rice flour with different proportions. However, there is little difference between incorporation of rice flour and refined flour with germinated horse gram flour which was indicated by the difference in a* values. The change in yellowness b* during extrusion cooking was mostly induced by the effects of non-enzymatic browning and pigment destruction reactions. The total color difference (dE) of 100 % germinated horse gram was higher (35.77) than the pasta made with rice and refined flour in which the value increased as the substitution of germinated horse gram flour increased. All these differences could have also been due to the shear forces generated during extrusion which accelerated the chemical reactions between amino acids and reducing sugars (maillards reaction) that took place during extrusion (Guy, 2001). Similar difference in color values were reported by Gallegos-Infante et al., (2010) for sphegethi incorporated with Mexican common bean flour.

3.1.2. Pasting Properties of developed Product

The results of Rapid Visco Analyser for the germinated horse gram incorporated pasta samples are presented in Table 3. Peak viscosity of control pasta is higher ($p< 0.05$) than germinated horse gram pastas. The peak viscosity of pasta made with germinated horse gram flour and refined flour decreased as the incorporation level of refined flour (10%, 20% and 30%) increased (234.33 cp, 170.33cp and 117.66 cp). Similarly there is significant ($p<0.05$) reductions in the peak viscosity of germinated horse gram pasta samples incorporated with 10%, 20% and 30% rice flour respectively. With regard to final viscosity, the values decreased as the incorporation level of refined flour increased in horse gram flour pastas. But Rice flour incorporation at 10%, 20% and 30% significantly increased (217.33cp. 217.0cp and 306.0cp) the final viscosity of pasta samples. However germinated horsegram flour (100%) pastas exhibited lower pasting properties when compared to control pasta (refined flour 100%). However, addition of refined flour and rice flour with the horse gram flour could have either increased decreased t peak, hold, final and setback viscosities as well as breakdown point. Similarly holding viscosity and setback viscosities of germinated horse gram flour pastas show lower values than control pasta made with 100% refined flour. Similar observation in pasting properties was reported by Jennifer Ann Wood (2009) for chickpea fortified spaghetti at 10 %, 15%, 20%, 25% and 35 % levels. The lower pasting properties might be due to the lower amylose content of germinated horse gram.

3.1.3. Cooking Quality of Developed product

Optimal cooking time of pasta made with 100% germinated horse gram flour was found to be higher than the control as well as pasta made with refined flour and rice flour. Pasta made with germinated horse gram flour and refined flour in the proportions 90:10, 80:20 and 70:30 did not show any significant difference within the samples but the same pasta found to have lower cooking time (7.35min, 7.66min and 8.03min) when compared to the pasta made with horse gram flour and rice flour combination (8.61min, 8.39min and 8.35min).

The cooking loss of pasta made from 100% horse gram was higher (2.92) than the control pasta (2.39) but the addition of refined flour considerably increased he cooking loss with increase in proportion. There was no significant difference in cooking loss with the pasta made from horse gram and rice flour combination. During cooking, soluble parts of starch and non-starch polysaccharides leach into water and the cooking water becomes cloudy and thick. Cooking loss is also associated with pasting properties and protein quality (Batley, 2007). Addition of non-gluten flours in the production of spaghetti was reported to dilute the gluten strength of semolina. This in turn interrupt and weaken the overall structure of the pasta which allowed more leaching out of solids from pasta into cooking water (Rhayas-Duarte et al., 1996). This result is in accordance with the reports of higher cooking loss in spaghetti samples fortified with legume flour like pea, lupin, chickpea and lentil (Nielson et al., 1980; Rayas-Durarte et al., 1996; Torres et al., 2007, Zhao et al., 2005).

The cooked weight of control pasta (51.73 gm/20 gm) was found to more than the pasta made by incorporating refined flour or rice flour with horse gram flour. Addition of refined flour and rice flour with horse

gram flour in the proportions 90:10, 80:20 and 70:30 did not show and significant difference in cooked weight of pasta. This might be attributed to the structural changes in the protein network due to the substitution of either refined flour or rice flour. Results regarding the cooking quality of pasta are presented in Table 4. A high cooking quality can be defined as the result of high water absorption, low cooking losses and good texture which includes high firmness and low stickiness.

3.1.4. Texture analysis of developed product

Instrumental readings for texture evaluation showed that pasta toughness increased logarithmically with the deformation rate used to cut the sample. Hardness is the height of the peak force of the first compression cycle (Brennan, 2004). In this study, germinated horse gram incorporated pasta with rice blended samples (2220, 2220, 2245) had more hardness than refined flour samples (1531, 1737, 2188). These results are similar to those found by Petitot (2010) for pasta fortified with 35% legume flours (split pea or faba bean). Significant increase in the hardness of pasta might be due to increased protein content and decreased water uptake. Similar result was also observed for the pasta products with the addition of chickpea and quinoa flours. Spinginess value of control pasta is higher than 100 % germinated horse gram pasta whereas it increased as the incorporation level of refined flour as well as rice flour increased (0.73 – 0.78). When the proteins are polymerized too strongly during processing (in particularly during harsh drying conditions), they lack resilience to cope with starch swelling during cooking. Gumminess of the control pasta was comparatively higher (1023.68) than other pasta samples incorporated with germinated horse gram flour, refined flour or rice flour. Low cooking losses, and good texture (high firmness and low sticikiness) the good characteristics of pasta as observed through number of studies. When stick on to this concept, pasta formulated using 70 % germinatded horse gram flour and 30 % refined flour (HM - 70:30) found to possess the required quality characteristics with minimum cooking loss. Therefore, this pasta was finalized as the best pasta product and was taken for further quality analysis. Results regarding the texture properties of pasta are presented in Table (15).

3.2. Nutritional composition

Nutrient composition of germinated horse gram pasta is given in table 5. The presence of germinated horse gram flour as an ingredient in pasta composition significantly increased (p<0.05) the nutrients such as ash (1.73%), protein (28.99%), fiber (0.93%), vitamin C (3.09 mcg), calcium (27.92 mg) and phosphorus (386.43 mcg). This might be due to the high protein content of horse gram and improved mineral content in horse gram during germination process. This result is in accordance with the nutritional contents of germinated pigeonpea incorporated pasta as reported by Vidal-Valverde (2007) and cowpea incorporated spaghetti pasta by Granito et al., (2002). In contrast, moisture, fat and carbohydrate levels of germinated horse gram pasta reduced significantly (p<0.05) when compared to the control pasta as a reflection of the reduced starch and fiber composition of germinated horse gram flour. similar results were observed by Vasanthakumari and Sangeetha (2014) in germinated multilegume composite flour incorporated pasta.

3.3. Sensory evaluation

The 9 point hedonic test on parameters such as appearance, texture, color, taste, flavor and over all acceptability of cooked pasta with spice mix, vegetables, spice and vegetables were presented in figure 2. With regard to appearance, the pasta cooked with 3 gm vegetable and spice mix scored higher when compared to 1 gm spice and 1 gm vegetable. Similarly, taste and flavor of pasta cooked with 3 gm

vegetable and spice mix retained the highest values than any other cooked pasta. But taste shows similar values except for 3 gm spice and 3 gm vegetable and spice mixed pasta. However, 3 gm spice and vegetable mix increased the overall acceptance of the pasta among the panel. This might be due to the addition of equal amount of vegetables like carrot, beans, cabbage, capsicum and spices like pepper, cumin, aniseed and chilli powder which could have added more taste and flavor to germinated horse gram pasta with good acceptability.

4. Conclusion

Germination of horse gram appears to be an effective process for the enhancement of the nutritional parameters of this underutilized legume. Incorporation of germinated horse gram flour (up to 70%) with refined flour (30%) in pasta making improved the pasting, textural and cooking qualities of pasta. Addition of spice mix and vegetables to be cooked pasta enhanced the sensory characteristics and acceptability. Significant changes induced by germination would make the horse gram as one of the suitable legume food to be incorporated in the daily diet of all age group people. It is highly essential to carryout innovative marketing strategies among consumers to make use of the food products and educate the public with regard to their beneficial aspects in addition to the development of technologies for the manufacture horse gram based convenient food products.

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Table 1. Optimization of flour mix for pasta preparation

Sample	Germinated horse gram flour (%)	Refined flour (%)	Rice flour (%)
A (control)	-	100	-
B	100	-	-
C	90	10	-
D	80	20	-
E	70	30	-
F	90	-	10
G	80	-	20
H	70	-	30

Table 2. Color values of developed pasta

Samples	L*	a*	b*	dE
Control	56.74±0.38a	2.28±0.14c	15.94±0.75a	-
100 % HG	22.14±0.38b	7.22±0.13a	10.64±0.20bc	35.77±0.46b
HRF 90:10	24.19±0.73b	7.05±0.06ab	11.54±0.31b	33.54±0.74a
HRF 80:20	24.16±2.44b	6.82±0.32ab	11.09±0.23bc	33.58±2.42a
HRF 70:30	24.84±2.25b	6.69±0.62b	11.09±0.81bc	32.91±2.23a
HR 90:10	23.53±1.25b	6.53±0.23b	10.14±0.41c	34.31±1.25a
HR 80:20	24.35±3.04b	6.60±0.19b	10.21±0.46c	33.50±3.02a
HR 70:30	25.35±1.63b	6.68±0.21b	10.36±0.50c	32.51±1.63a

All values are means of triplicate determinations± standard deviation (SD)
Column followed by different letters are significantly different (p≤0.05)

Table.3. Cooking quality of Developed product pasta

Samples	Optimal Cooking time	Cooked weight	Cooking loss
Control	8.26 ± 0.05^{cd}	51.73 ± 3.60^{a}	2.39 ± 0.22abc
100 % HG	9.24 ± 0.24^{a}	47.53 ± 1.41^{b}	2.92 ± 0.52a
HM 90:10	7.35 ± 0.08^{d}	47.80 ±1.70^{b}	1.94 ± 0.41c
HM 80:20	7.66 ± 0.11^{d}	47.03 ± 1.00	2.56 ±0.32ab
HM 70:30	8.03 ± 0.05^{d}	44.03 ±1.95^{b}	2.63 ± 0.23ab
HR 90:10	8.61 ± 0.28^{b}	46.16 ±2.25^{b}	2.21 ±0.14bc
HR 80:20	8.30 ± 0.08^{cd}	44.76 ±1.07^{b}	2.53 ± 0.27abc
HR 70:30	8.35 ± 8.06^{c}	45.50 ±1.32^{b}	2.10 ± 0.11bc

All values are means of triplicate determinations± standard deviation (SD)
Column followed by different letters are significantly different (p≤0.05)

Table 4. The texture analysis of Developed Product

Samples	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience	Hardness
Control	0.75±0.00^{c}	0.41±0.00^{a}	1023.68±35.24^{a}	750.14±21.34^{a}	0.19±0.00^{a}	2507.62±71.23^{a}
100 % HG	0.63±0.02^{d}	0.35±0.30^{b}	659.20±70.99^{cd}	422.15±69.99^{c}	0.16±0.00^{b}	1839.35±95.45^{c}
HM (90:10)	0.73±0.01^{c}	0.43±0.01^{a}	620.79±24.49^{d}	450.73±18.32	0.19±0.00^{a}	1531.55±22.81^{d}
HM (80:20)	0.76±0.00^{ab}	0.42±0.00^{a}	725.00±44.31^{c}	558.41±42.45^{b}	0.19±0.00^{a}	1737.34±85.63^{c}
HM (70:30)	0.78±0.01^{a}	0.42±0.00^{a}	925.12±66.46^{b}	737.89±30.98^{a}	0.19±0.00^{a}	2188.63±13.98^{b}
HR (90:10)	0.76±0.00^{ab}	0.42±0.00^{a}	941.92±21.06^{b}	720.36±15.39^{a}	0.19±0.00^{a}	2220.94±36.60^{b}
HR (80:20)	0.77±0.00^{ab}	0.42±0.00^{a}	953.67±14.42^{ab}	733.45±9.52^{a}	0.19±0.00^{a}	2274.89±27.65^{b}

HR (70:30)	0.76±0.00^{ab}	0.42±0.00^{a}	936.03±25.04^{b}	704.80±18.69^{a}	0.19±0.00^{a}	2245.52±59.47^{b}

Table 5. Nutrient composition of germinated horse gram pasta

Nutrients	Control pasta	Germinated horse gram pasta	*p* value
Ash (%)	0.46±0.11	1.73±0.11	0.00*
Moisture (%)	11.60± 0.20	8.93 ± 0.30	0.00*
Carbohydrate (%)	71.63± 1.79	54.37± 0.83	0.00*
Protein (%)	13.13± 0.42	28.99± 1.06	0.00*
Fat (%)	0.63±0.01	0.07± 0.10	0.00*
Fiber (%)	0.16±0.05	0.93±0.11	0.01*
Vitamin C (mcg)	0.89±0.03	3.09±0.03	0.00*
Calcium (mg)	22.27 ±3.72	27.92 ±2.5	0.00*
Phosphorus (mcg)	113.55±1.67	386.43±6.63	0.00*

All values are means of triplicate determinations± standard deviation (SD)
Column followed by different letters are significantly different ($p \leq 0.05$)

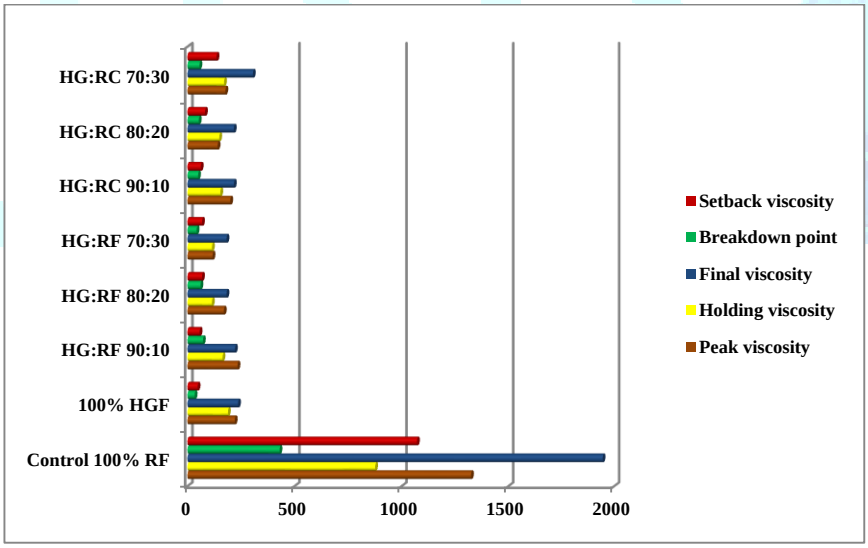
Table 6. Sensory evaluation of germinated horse gram pasta

Composition of different taste mix	Appearance	Texture	Color	Taste	Flavor	Overall acceptability
1 gm spice	5.41 ± 0.48^{bc}	5.51 ± 0.23^{ab}	5.04 ± 0.27^{ab}	4.12 ± 0.57^{bc}	4.22 ± 0.77^{b}	4.84 ± 0.30^{b}

2 gm spice	5.53 ± 0.20^{bc}	5.28 ± 0.54^{ab}	4.84 ± 0.53^{ab}	3.95 ± 0.60^{bc}	4.04 ± 0.73^{b}	4.35 ± 0.10^{b}
3 gm spice	5.33 ±0.29^{bc}	5.37 ± 0.36^{ab}	4.37 ± 0.55^{b}	3.31 ± 0.19^{c}	3.68 ± 0.36^{b}	3.90 ± 0.38^{b}
1 gm Veg.	4.97 ± 0.26^{c}	5.04 ± 0.21 ^{b}	4.95 ± 0.58^{ab}	4.53 ± 1.23^{bc}	4.35 ± 0.88^{b}	4.86 ± 0.90^{b}
2 gm Veg.	4.97 ± 0.27^{c}	5.33 ± 0.40^{ab}	4.93 ± 1.10^{ab}	4.75 ± 1.36^{abc}	4.44 ± 0.90^{b}	4.99 ± 1.02^{b}
3 gm Veg.	5.75 ± 0.38^{b}	5.99 ± 0.59^{a}	4.99 ± 1.01^{ab}	4.42 ± 1.42^{bc}	4.62 ± 1.06^{b}	4.86 ± 1.16^{b}
1 gm Veg.+Spice	5.39 ± 0.23^{bc}	5.08 ± 0.26^{b}	4.86 ± 0.41^{ab}	4.88 ± 0.73 ^{abc}	4.18 ± 0.32^{b}	4.69 ± 0.16^{b}
2 gm Veg.+Spice	5.51 ± 0.37^{bc}	4.84 ± 0.27^{b}	4.86 ± 0.40^{ab}	5.50 ± 0.36^{ab}	4.82 ± 0.97^{b}	4.49 ± 0.16^{b}
3 gm Veg.+Spice	6.46 ± 0.44^{a}	5.51 ± 0.37 ^{ab}	5.93 ± 0.39^{a}	6.37 ± 0.37^{a}	6.35 ± 0.09^{a}	6.61 ± 0.32^{a}

All values are means of triplicate determinations± standard deviation (SD)
Column followed by different letters are significantly different ($p \leq 0.05$)

Figure 1. Pasting properties of germinated horse gram pasta



HG – Germinated Horse gram flour, RC – Rice flour, RF – Refined flour