Development and Quality Evaluation of Fibre Enriched Broken Basmati Rice Based Noodles

Abstract

Broken rice is fragmented but it cannot be considered as defective because it has equal nutrition as unbroken rice contains. Also, if the broken rice contains all germ and bran, then it has nutrition as brown rice, otherwise it has nutrition as white rice. In the present investigation, protein and fiber rich noodles were prepared by incorporation of groundnut meal (GM) and green leaf powder (GLP). The quantity of GM and GLP was varied from 0 to 12 and 0 to 18 per cent, respectively for the formulation of rice noodles. The developed products were stored for 90 days in polyethylene bags to ascertain the changes in cooking characteristics, proximate composition and sensory parameters. Weight increase and volume increase showed an increasing trend with the incorporation of green leaf powder and groundnut meal from 142.89 to 183.52 and 144.73 to 218.98 per cent, respectively whereas the cooking time and cooking loss significantly decreased from 12.10 to 10.77 minutes and 7.23 to 6.31 per cent, respectively. On the basis of sensory evaluation, noodles prepared from 8 per cent GLP and 12 per cent GM were adjudged the best with regard to their acceptability and storability having mean crude protein, crude fat, crude fibre and ash content of 17.46, 2.00, 2.17 and 1.01 per cent, respectively.

Keywords: Broken rice, groundnut meal, green leaf powder, cooking properties, sensory parameters

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1. Introduction

One of the most widely farmed crops in the world, rice provides a basic staple for more than half of the population and is essential to global food security (1). Asia consumes approximately 85 Kg of rice year on average, while the global average is approximately 65 kg per person (2). China, India, and Indonesia are the three main producers of rice; the United States, Thailand, Vietnam, India, and Pakistan are the main exporters. The byproduct of the rice milling business is broken rice, and the flour made from it is a valuable component of many breakfast cereals and snacks that are ready to eat. In India, the percentage of broken rice in the milling sector is comparatively high, ranging from 22 to 30 percent (3). Asian nations, particularly those in the east, such as Japan, Vietnam, and northern India, which includes Maharashtra, are big fans of Broken. Worldwide, broken rice is widely used for a variety of distinctive regional cuisines, animal feed, and beverage industries (4). Broken rice has a different and softer texture than unbroken rice because of the differences in grain size and shape. As a result, it absorbs flavours more readily, cooks faster, uses less fuel, and may be used to make rice porridges and congees.

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Groundnut (*Arachis hypogea*) is the fourth important oilseed in the world also commonly called as poor man's almond (5). Groundnuts after oil extraction leaves a lot of meal called as defatted groundnut flour which contains 50–55 per cent of high-quality protein. This partially defatted cake contains 35–45 per cent crude protein, 20–30 per cent carbohydrate, and 6.5 per cent crude fiber and 4–6 per cent minerals (6). Peanut meal is low in lysine but an excellent source of arginine (National Research Council, 1994). Peanut meal obtained after oil extraction can be dried and ground to get the flour (7), which can be incorporated into food products. It is best suited to enhance the nutritive value of wheat and other flour breakfast cereal flakes, snack foods, multipurpose supplement, infant and weaning foods, extruded foods or fabricated foods.

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According to Joshi *et al.* (8), dehydrated unconventional leafy greens are a concentrated source of bioactive chemicals and micronutrients that can be added to conventional recipes, commercially available convenience foods, and the formulation of health foods. There are many different kinds of noodles available on the market these days, including buckwheat, rice, wheat, and mung-bean starch noodles. Since wheat gluten offers an additional benefit that makes extrusion easier and gives the noodles a smooth, fracture-free texture. Because rice dough does not contain gluten, it cannot function as continuous visco-elastic dough. As a result, rice flour must be pre-gelatinized in order to serve as a binder for the remaining flour. The degree of pre-gelatinization is a critical factor in giving the noodles' strands the desired texture (Ahmed, 2016).

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As a result of consumer expectations for foods with more fibre, high-fiber components are now employed in products to provide them functional features including increased oil and/or water retention capacity, emulsification, and/or gel formation. Traditional noodles are deficient in several critical components, including dietary fibre, vitamins, and minerals, which are lost during the refining process of wheat flour. Therefore, after adding sources of fibre and other nutrients, noodle products—a common usage for wheat—are appropriate for improving health (10). Thus, the goal of this study was to investigate how the addition of groundnut meal and green leaf powder affected the chemical, sensory, and cooking characteristics of dried salted noodles.

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2. MATERIALS AND METHODS

***Preparation of Green leaf powder*:** Healthy, tender and fresh fenugreek and coriander leaves were selected for the study. The leaves and broken rice were taken to the Food Processing Laboratory of Division of Food Science and Technology, SKUAST- Jammu for further processing. The leavesof fenugreek and coriander were cut from the stems, damaged leaves (insect attack etc.)and rotten leaves were discarded and healthy leaves were selected for the study. They were washed thoroughly under tap water to remove adhering dust and other type of contaminants. The leaves were subjected to blanching (80℃ for 1min). After blanchingthe leaves were dried for 5-6 hrs at 45℃ in a tray dryer. Dried leaves were then crushedand mixed to prepare green leaf powder in the ratio of 50:50:: fenugreek:coriander green leaf powder.

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***Preparation of noodles*:** The preparation of noodles involved the mixing of broken basmati rice flour (100, 95, 90, 85, 80, 75, 70 per cent), green leaf powder (2, 4, 6, 8, 10, 12 per cent) and groundnut meal (3, 6, 9, 12, 15, 18 per cent) in their respective levels by adding optimum water. All these ingredients were mixed properly to get desirable consistency dough. The prepared dough was smeared with a little of refined oil and then it was extruded by the hand extruder through suitable shaped dies. The product was then dried for 6 hours at 55 ^{0}C. After drying they were cooled and packed in polyethylene bags and stored under ambient temperature (11). Flow chart for the preparation of noodles is shown in Fig. 1.

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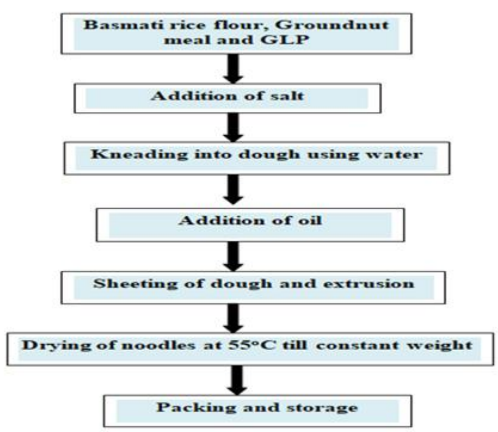

Figure 1: Flowsheet for preparation of broken basmati rice noodles

***Storage*:** The treatment combinations of blended noodles (in triplicate), were packed in low density polyethylene pouches (150 gauge) and then stored for a period of 90 days at room temperature. The stored products were analyzed for physicochemical changes and sensory characteristics at an interval of 30 days.

Cooking properties of noodles:

Optimum cooking time : Optimum cooking time of noodles was evaluated according to method of Singh *et al.* (12). The noodle sample (5 g) was inserted in a beaker containing 75 ml distilled water and one strip was crushed between two glasses in every 30 s. The cooking was continued until white fraction in central core of crushed noodles was disappeared and time that passed was recorded as optimum cooking time.

Volume increase: It was evaluated according to method of Ozkaya and Kahveci (13). 25 g noodle was cooked in boiling water (250 ml) on the basis of their optimum cooking time, rested for 5 min and transferred to a beaker fulfilled with 250 ml water. The volume of water over flowed from beaker was recorded. The same procedure was repeated for uncooked noodle as well. The percent volume increase was calculated on the basis of difference between the volume of overflowed water for cooked and uncooked noodles.

Weight increase : Weight increase was evaluated according to Ozkaya and Kahveci (13). After cooked and drained noodles were rested for 5 min, the weight was recorded and percent weight increase was calculated on the basis of difference between the weight of cooked and uncooked noodles.

Cooking loss : It was evaluated according to method of Ozkaya and Kahveci (13). 25 g noodle was cooked in boiling water (250 ml) on the basis of their optimum cooking time. The cooked noodles were drained from funnel and placed cooking beaker again. Cooked and drained noodle washed by adding 90 ml water and drained again. The cooking water was fulfilled with fresh water (350 ml) and mixed completely. Then 50ml of cooking water was transferred into another beaker and dried in an oven at 98oC. The cooking loss was calculated according to following formula:

$$\% \text{ Cooking Loss} = \frac{G \times 28 \times 100}{100 - W}$$

G is the weight (g) difference between beakers before and after the drying; and W is noodle moisture.

***Proximate analysis of noodles*:** Moisture, ash and crude fibre were determined according to AOAC (14). Crude protein was estimated by using micro-kjeldahl method, AOAC (1995) using the factor 6.25 for converting nitrogen content into crude protein. For fat content of noodles, 5 g sample was placed in Soxhlet extraction apparatus and subjected to extraction for 6 h using petroleum ether as solvent and percent fat content of noodle samples were calculated on a weight basis. Amount of carbohydrates was calculated from the sum of moisture, crude protein, crude fat, ash and crude fibre and lastly subtracting it from 100 (AOAC, 14).

***Sensory evaluation of noodles*:** The samples were evaluated on the basis of colour, texture, taste and overall acceptability by semi-trained panel of 7-8 judges by using 9 point hedonic scale assigning scores 9- like extremely to 1- dislike extremely. A score of 5.5 and above was considered acceptable (15).

***Statistical analysis*:** The data obtained (in triplicate) were evaluated statistically with OPSTAT package program by variance analysis.

3. RESULTS AND DISCUSSION

Cooking properties of green leaf powder (GLP) and groundnut meal (GM) blended noodles

Noodle quality could be estimated from cooking attributes such as cooking loss, volume and weight increase. Table 1 reflects the effect of green leaf powder (GLP) and groundnut meal (GM) on corporation on the cooking properties of noodles. With the increase in addition of GLP and GM level, the cooking time gradually decreased and the control (T_1) noodles had highest cooking time (12.10 min.) whereas, T_7 (70:12:18::BBRF:GLP:GM) recoded lowest cooking time of 10.77 minutes. This might be attributed to the fact that ingredients other than wheat flour/rice flour such as leaf powder may cause discontinuity in gluten network resulting in faster moisture penetration and therefore, leading to optimum cooking time. Similar findings were reported by Veena and Shivaleela (16) on pasta incorporated with radish and carrot leaf powder. The weight increase varied from 142.89 to 183.52 per cent and the highest value was observed for T_7. Sood *et al.* (17) also showed that cooked weights of noodles increased when cooking time increased. Volume increase values of cooked noodles varied from 144.73 to 218.98 per cent. As the cooking loss is an indicator of noodle's resistance to cooking low levels are preferable. A progressive reduction in the cooking loss with increase in the level of GLP and GM-enriched noodles was noted, which was statistically significant at $P < 0.05$ level. This is due to better binding of starch granules with added vegetable puree in gluten matrix (18) The cooking loss was the highest in control sample (7.23 per cent) and lowest was observed in blended noodles containing 12 percent GLP and 18 per cent GM. The results of present study for cooking loss levels agree with Turkish noodle standard which states that cooking loss should not exceed the level of 10 per cent on dry matter basis. This variation observed may be due to changes in optimal degree of protein polymerization during drying and/or the subsequent cooking as reported by Shere *et al.* (19). They reported that increased volume and weight in noodles supplemented with spinach puree

Proximate composition of GLP and GM blended noodles

With incorporation of GLP and GM, a gradual decrease in the water activity and moisture content was observed for blended noodles and the values decreased from mean values 0.479 to

0.329 and 10.35 to 8.09, respectively as the ratio of GLP and GM increased. However, with the progression of storage period, a general increase in moisture content and a_w (Table 2) took place and it was found that mean moisture content increased from its initial value of 9.59 to 10.61 per cent and a_w from 0.290 to 0.541, respectively during 3 months of storage. The maximum mean moisture content of 10.35 per cent was recorded in treatment T1 (control) and minimum of 9.56 per cent was observed in treatment T7 (70:12:18::BBRF:GLP:GM). This might be owing to the low amount of moisture content GLP and GM. The similar results for decrease in the moisture were reported by Islam *et al.* (20) for noodles supplemented with green banana flour. Trilokia *et al.*, (21) reported that with the increase in the supplementation level of groundnut meal and carrot pomace powder, water activity consequently decreased resulting in prolonged shelf life of blended pasta as compared to the control pasta. Crude protein content (Table 3) of different treatments decreased during storage period of 90 days from the initial mean value of 16.53 to 15.05 per cent which might be due to breakdown of amino acids (22) during storage. Maximum mean crude protein content of 22.24 per cent was found in treatment T7 (control) and minimum of 8.37 per cent in treatment T1. With the progression of storage period, the fat content (Table 3) decreased from its initial value of 2.13 to 1.77 per cent. The decrease in crude fat content might be due to increase in the activity of lipase enzyme (lipolytic oxidation). The lowest mean crude fat content of 1.43 per cent was reported in treatment T1 (10% JSP) and the highest of 2.54 per cent was recorded in T7 (control) and this might be due to higher fat content in the groundnut meal. During storage of blended noodles for 3 months, the mean ash content (Table 4) decreased from the initial level of 1.14 to 0.84 per cent. Treatment T7 recorded highest mean ash content of 1.32 per cent and lowest (0.61%) was recorded by treatment T1 (control). This might be due to increased fiber content with the addition of green leaf powder and groundnut meal. Similar results have been reported by Shere *et al.*, (19) in spinach puree blended noodles. The mean crude fibre (Table 4) content during 90 days of storage declined significantly from the initial level of 2.15 to 1.82 per cent. However, with the incorporation of GLP and GM, the crude fibre content increased because of their higher crude fibre contents. It was observed that with the advancement of storage period, the mean carbohydrate content (Table 5) increased from its initial level of 68.45 to 69.98 per cent. Treatment T7 recorded lowest mean carbohydrate content of 60.57 per cent and highest 78.10 per cent was recorded by treatment T1 (control). Microbial evaluation is a prime factor to determine the shelf life of any food products the microbial growth was measured at 30 days interval up to 90 days (Table 5). The microbial study was conducted by undertaking total plate count (TPC) and no microbial growth was observed for blended noodles upto two months which might be as a result of good packaging functionalities and low water activity levels however, after 90 days of storage the total plate count was observed in the blended noodles. The highest count of 0.78×10^4 c.f.u/g was observed for T1 whereas lowest count of 0.33×10^4 c.f.u/g was observed for T7. According to Pakhare *et al.*, (23), nutritious noodles prepared by incorporation of defatted rice bran and soy flour realized lower microbial growth in HDPE packing in comparison to LDPE packed noodles.

Sensory characteristics of green leaf powder and groundnut meal blended noodles

The effect of green leaf powder and groundnut meal addition on sensory properties of broken basmati rice flour noodles is shown in Figure 2. Noodles had comparatively higher sensory scores for colour, flavour, softness and taste when GLP and GM levels increased in the noodle formulation upto the level of 8 and 12 per cent, respectively thereafter sensory scores decreased significantly. Initially, the highest score for colour, flavour, softness and taste were recorded as 8.06, 8.26, 8.19 and 8.13 in T4, whereas lowest scores of 7.52, 7.39, 7.47 and 7.56 were obtained for treatment T7. The colour score declined significantly beyond 8 per cent level of GLP incorporation because the higher concentration imparted dark green colour to the noodles. Due to characteristic flavour of GM (groundnut meal) and GLP powder (coriander and fenugreek leaves), 12 and 8 per cent incorporation level was well accepted for its sensory characteristics after 90 days of storage. All sensory attributes for broken basmati rice flour noodles were statistically significant at $P < 0.01$ level. Nouri *et al.* (24) opined that 15 per cent incorporation of betel leaf extraction was preferred more by the panelist for its flavor. Similarly Mangai and Divya (18) reported that noodle variation five with (25 g of cauliflower leaves) in cooked form tasted good as it was "liked very much" by the panelists as compared with its raw form.

In the present study, GM and GLP was incorporated at different levels to the accepted control noodles formulated out of broken basmati rice flour. The weight and volume of the noodles increases with increased whereas cooking time and cooking loss showed a progressive reduction with the increase in the GM and GLP levels and the findings are statistically significant at $P < 0.05$ level. With regard to sensory evaluation, all the variations of blended noodles were well accepted by the panelists Owing the nutritive value of pearl millet and green leaf powder, these noodles can replace the commercial noodles in household with minimum cost and can be popularized among foodies especially children and teenagers.

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Table 1: Cooking properties of GLP and GM blended noodles

Treatment	**Cooking time (min.)**	**Weight increase (%)**	**Volume increase (%)**	**Cooking loss (%)**
T1 (100:00:00::BBRF:GLP:GM)	12.10	142.89	144.73	7.23
T2 (95:2:3::BBRF:GLP:GM)	11.91	147.40	157.00	6.92
T3 (90:4:6::BBRF:GLP:GM)	11.63	149.54	170.00	6.85
T4 (85:6:9::BBRF:GLP:GM)	11.32	156.60	186.00	6.72
T5 (80:8:12::BBRF:GLP:GM)	11.05	165.47	195.00	6.54
T6 (75:10:15::BBRF:GLP:GM)	10.98	174.52	210.00	6.40

T7 (70:12:18:BBRF:GLP:GM)	10.77	183.52	218.98	6.31
MEAN	**11.39**	**159.78**	**182.42**	**6.68**

Table 2: Effect of treatment and storage on water activity (a_w) and moisture content (%) of blended rice noodles

Treatment	Water activity (a_w)					Moisture (%)				
	Storage periods (Days)					Storage periods (Days)				
	0	**30**	**60**	**90**	**MEAN**	**0**	**30**	**60**	**90**	**MEAN**
T1 (100:00:00::BBRF:GLP:GM)	0.350	0.419	0.515	0.632	**0.479**	9.95	10.13	10.48	10.84	**10.35**
T2 (95:2:3::BBRF:GLP:GM)	0.338	0.404	0.511	0.617	**0.467**	9.80	9.97	10.35	11.01	**10.28**
T3 (90:4:6::BBRF:GLP:GM)	0.314	0.387	0.474	0.575	**0.438**	9.77	9.85	10.23	10.62	**10.12**
T4 (85:6:9::BBRF:GLP:GM)	0.284	0.355	0.445	0.546	**0.408**	9.59	9.74	10.16	10.44	**9.98**
T5 (80:8:12::BBRF:GLP:GM)	0.265	0.338	0.405	0.512	**0.380**	9.47	9.58	9.80	10.27	**9.78**
T6 (75:10:15::BBRF:GLP:GM)	0.252	0.326	0.399	0.479	**0.364**	9.35	9.50	9.69	10.11	**9.66**
T7 (70:12:18:BBRF:GLP:GM)	0.229	0.294	0.365	0.426	**0.329**	9.19	9.45	9.58	9.96	**9.56**
MEAN	**0.290**	**0.360**	**0.445**	**0.541**		**9.59**	**9.75**	**10.08**	**10.61**	
	Effects C.D(p=0.05) Treatment 0.04 Storage 0.02 Treatment × Storage 0.03					Effects C.D(p=0.05) Treatment 0.05 Storage 0.02 Treatment × Storage 0.03				

BBRF: Broken basmati rice flour**; GM:** groundnut meal**; GLP:** Green leaf powder.

Table 3: Effect of treatment and storage on crude protein (%) and crude fat content of blended rice noodles

Treatment	Crude protein (%)					Crude fat (%)				
	Storage periods (Days)					Storage periods (Days)				
	0	**30**	**60**	**90**	**MEAN**	**0**	**30**	**60**	**90**	**MEAN**
T1 (100:00:00::BBRF:GLP:GM)	8.53	8.49	8.37	8.09	**8.37**	1.57	1.49	1.37	1.29	**1.43**
T2 (95:2:3::BBRF:GLP:GM)	13.41	13.25	13.03	12.12	**12.95**	1.75	1.59	1.57	1.48	**1.60**
T3 (90:4:6::BBRF:GLP:GM)	15.79	15.54	15.12	14.51	**15.24**	1.95	1.82	1.74	1.66	**1.79**
T4 (85:6:9::BBRF:GLP:GM)	16.17	16.01	15.78	15.02	**15.75**	2.16	1.96	1.83	1.74	**1.92**
T5 (80:8:12::BBRF:GLP:GM)	18.55	17.69	17.22	16.36	**17.46**	2.32	2.01	1.89	1.76	**2.00**
T6 (75:10:15::BBRF:GLP:GM)	19.94	19.39	18.85	17.78	**18.99**	2.51	2.32	2.20	2.07	**2.28**
T7 (70:12:18:BBRF:GLP:GM)	23.32	22.67	21.81	21.16	**22.24**	2.68	2.59	2.49	2.41	**2.54**
MEAN	**16.53**	**16.15**	**15.74**	**15.05**		**2.13**	**1.97**	**1.87**	**1.77**	
	Effects C.D (p=0.05) Treatment 0.12 Storage 0.03 Treatment × Storage 0.05					Effects C.D (p=0.05) Treatment 0.07 Storage 0.03 Treatment × Storage 0.05				

BBRF: Broken basmati rice flour**; GM:** groundnut meal**; GLP:** Green leaf powder.

Table 4: Effect of treatment and storage on total ash (%) and crude fibre content (%) of blended rice noodles

Treatment	Total ash (%)					Crude fibre (%)				
	Storage periods (Days)					Storage periods (Days)				
	0	30	60	90	MEAN	0	30	60	90	MEAN
T1 (100:00:00::BBRF:GLP:GM)	0.74	0.66	0.55	0.49	**0.61**	0.98	0.91	0.87	0.81	**0.89**
T2 (95:2:3::BBRF:GLP:GM)	0.87	0.75	0.69	0.62	**0.73**	1.07	1.02	0.96	0.87	**0.98**
T3 (90:4:6::BBRF:GLP:GM)	0.99	0.87	0.81	0.71	**0.85**	1.15	1.07	1.00	0.92	**1.04**
T4 (85:6:9::BBRF:GLP:GM)	1.16	1.06	0.94	0.85	**1.00**	2.15	2.04	1.93	1.81	**1.98**
T5 (80:8:12::BBRF:GLP:GM)	1.31	1.23	1.11	1.01	**1.17**	2.31	2.25	2.12	2.01	**2.17**
T6 (75:10:15::BBRF:GLP:GM)	1.40	1.28	1.17	1.07	**1.23**	3.40	3.25	3.10	2.89	**3.16**
T7 (70:12:18:BBRF:GLP:GM)	1.53	1.37	1.24	1.14	**1.32**	4.02	3.80	3.62	3.45	**3.72**
MEAN	**1.14**	**1.03**	**0.93**	**0.84**		**2.15**	**2.05**	**1.94**	**1.82**	
	Effects C.D (p=0.05) Treatment 0.05 Storage 0.02 Treatment × Storage 0.03					Effects C.D (p=0.05) Treatment 0.03 Storage NS Treatment × Storage 0.05				

BBRF: Broken basmati rice flour**; GM:** groundnut meal**; GLP:** Green leaf powder.

Table 5: Effect of treatment and storage on available carbohydrate (%) and microbial count ($\times 10^4$ c.f.u/g) of blended rice noodles

Treatment	Available carbohydrate (%)					Microbial count ($\times 10^4$ c.f.u/g)			
	Storage periods (months)					Storage periods (months)			
	0	30	60	90	MEAN	0	30	60	90
T1 (100:00:00::BBRF:GLP:GM)	78.23	78.32	78.36	77.48	**78.10**	ND	ND	ND	0.78
T2 (95:2:3::BBRF:GLP:GM)	73.10	73.42	73.40	74.13	**73.51**	ND	ND	ND	0.71
T3 (90:4:6::BBRF:GLP:GM)	70.35	70.85	71.10	71.58	**70.97**	ND	ND	ND	0.62
T4 (85:6:9::BBRF:GLP:GM)	68.77	69.19	69.36	70.14	**69.37**	ND	ND	ND	0.55
T5 (80:8:12::BBRF:GLP:GM)	66.04	67.24	67.86	68.59	**67.43**	ND	ND	ND	0.46
T6 (75:10:15::BBRF:GLP:GM)	63.40	64.26	64.99	66.08	**64.68**	ND	ND	ND	0.40
T7 (70:12:18:BBRF:GLP:GM)	59.26	59.88	61.26	61.88	**60.57**	ND	ND	ND	0.33
MEAN	**68.45**	**69.02**	**69.48**	**69.98**					
	Effects C.D (p=0.05) Treatment 0.05 Storage 0.02 Treatment × Storage 0.03					Effects C.D (p=0.05) Treatment 0.04			

BBRF: Broken basmati rice flour**; GM:** groundnut meal**; GLP:** Green leaf powder.

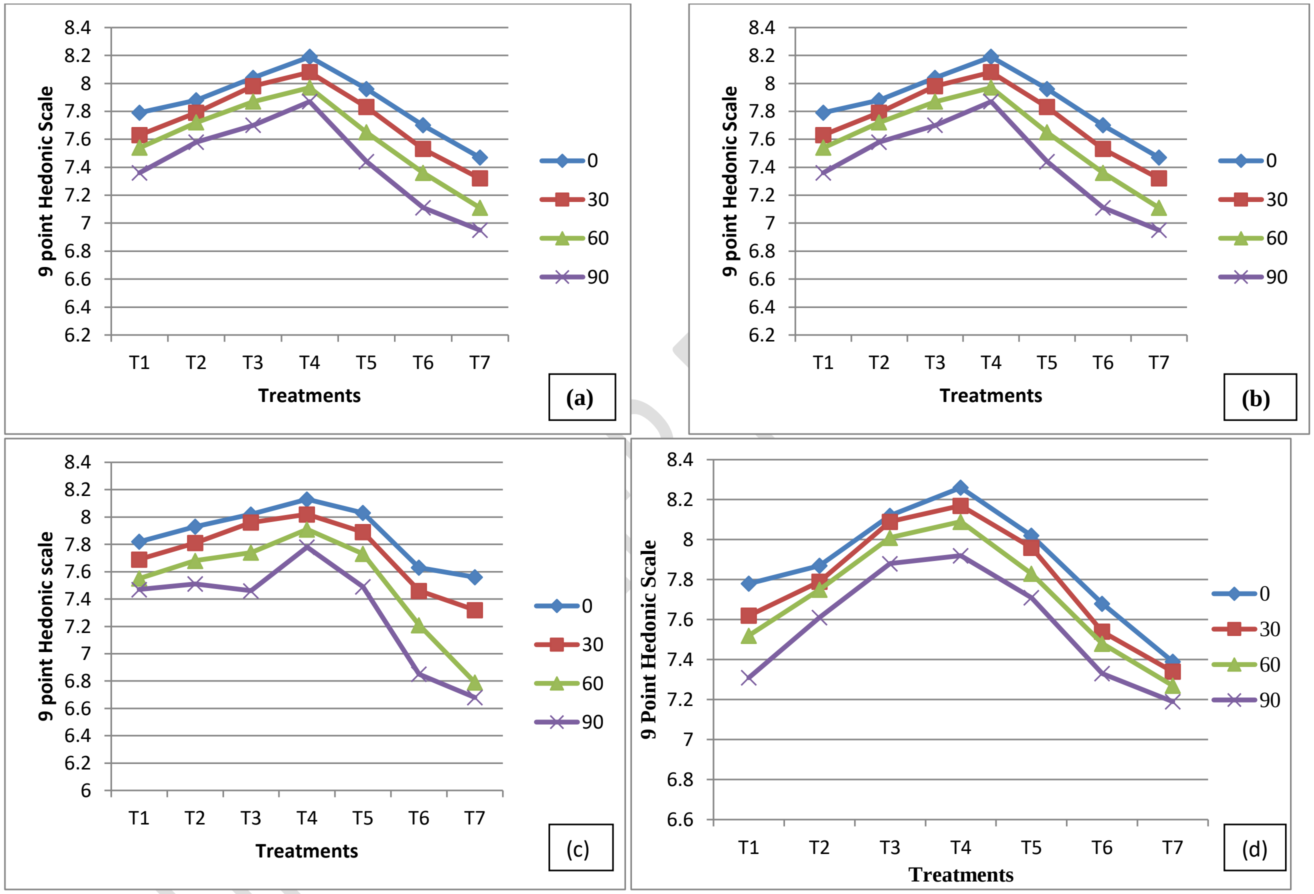

Fig 2: Effect of treatment and storage on a) colour, b) flavour c) softness and d) taste scores of blended rice noodles