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Quality Evaluation of Gluten-Free Protein Enriched Pasta Prepared Using Basmati Rice Flour, Groundnut Meal and Carrot Pomace

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ABSTRACT

Experiments were conducted for the quality evaluation of developed gluten-free protein enriched pasta. The pasta was formulated by taking a different proportion of Pre-gelatinized broken basmati Rice Flour, freeze-dried Carrot Pomace, and Groundnut Meal in the ratios of T_1 (100:0:0::PRF:CP:GM), T_2 (97:1:2::PRF:CP:GM), T_3 (94:2:4), T_4 (91:3:6), T_5 (88:4:8), T_6 (85:5:10), T_7 (82:6:12), and T_8 (79:7:14) respectively. Pre-gelatinized broken basmati rice flour (T_1) was considered as the control pasta. Each pasta sample after drying was packaged in polypropylene bags and stored for 3 months at ambient conditions (28±2°C). Results revealed that the Lightness (L*) value of gluten-free protein enriched pasta decreased, while a* and b* values increased with the increase in the incorporation level of freeze-dried carrot pomace and groundnut meal to broken basmati rice flour. Also, water activity, bulk density, swelling power (g g^{-1}), water absorption index (g g^{-1}), and cooking time were greatly influenced by the increased incorporation level. There was a significant decrease in cooking time and smoothness of gluten-free protein enriched pasta because of fibre addition. On the other hand, incorporation resulted in little clumpiness and disintegration.

Keywords: Broken rice flour, Improving nutritional value, Spaghetti.

INTRODUCTION

Pasta has been a staple food throughout the world for many centuries and comes in various shapes. Some of the common pasta are spaghetti (round-rod), ribbon cut noodles (fettuccini, lasagna) and short cut extruded (macaroni, fusilli) (Kahlon *et al.,* 2013). It is one of the popular products that can be prepared from rice flour (Raina *et al*. 2005), and is popular amongst children and adults (Mridula *et al.,* 2017). The lack of gluten affords an extra advantage that makes rice an appropriate substitute for wheat in bakery products, particularly for persons suffering from a physiological disorder of gluten-sensitive enteropathy (Prasad *et al.,* 2010). In the present days, rice flour has been used for various extruded food products because of its poor resistance to shear force, low elastic gel formation, loose viscosity, and thickening power during cooking. Various hydrothermal treatments have been successfully applied to enhance the physicochemical and functional properties of rice flour and starches. For the preparation of extruded snacks, pre-gelatinized flours give a hard and stable texture with reduced cooking time. For good-quality pasta with a firm texture and low stickiness, hydration of the protein fraction before the beginning of starch gelatinization is important (Raina *et al*.,

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2005).

The nutritional value of pasta is not very high as it is rich in starch, significantly low concentration of protein and is devoid of dietary fibre (Badwaik *et al*., 2014). Incorporation of protein rich and high fibre material can enhance the nutritional and functional quality of pasta (Chalamaiah *et al*., 2011; Sudha and Leelavathi, 2011). The utilization of by-products such as broken rice, carrot pomace and groundnut meal in food product development is very important for enhancing their consumption, particularly among children. Being a rich source of protein and other nutrients, oilseed meals can be exploited for developing a product like pasta, one of the popular products among children to combat protein calorie malnutrition and other nutritional deficiencies among the vulnerable population. Groundnut meal is a partially defatted cake that contains 35-45 per cent crude protein, 20–30 per cent carbohydrate and 6.5 per cent crude fibre and 4-6 per cent minerals (Mridula *et al*., 2017) obtained after oil extraction, dried and ground to get the flour (Zhao *et al*., 2012) so as to incorporate into food products. It is best suited to enhance the nutritive value of wheat and other flour. It is likely to be used as low-fat groundnut concentrates, composite flour, bakery products, breakfast cereal flakes, snack foods, multipurpose supplements, infant and weaning foods, extruded foods or fabricated foods.

In recent years, the consumption of carrots and nutritious food products utilizing carrot pomace have been developed and accepted by consumers (Badwaik *et al*., 2014). Therefore, carrot residue can be utilized for preparing bread, cake, dressing and pickles and for the production of functional drinks. Because of the high water content (70%) of fresh pomace, it is susceptible to a rapid increase in microbial contamination (Tarko *et al*., 2012). Drying is one of the major methods to prevent this process.

Hence, to improve the nutritional value of gluten-free pasta, it was formulated using different amounts of groundnut meal and carrot pomace to provide a better alternative to the consumers. The study comprised of quality evaluation of the protein enriched gluten-free pasta using pregelatinized broken basmati rice flour, groundnut meal and freeze-dried carrot pomace.

MATERIALS AND METHODS

The present study was conducted in the Division of Food Science and Technology, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, Chatha.

Source of Raw Materials

The broken basmati rice variety 370 was procured from SKUAST-Jammu. The groundnuts and carrots were taken from the local market of Jammu for further processing.

Preparation of Pre-gelatinized Basmati Rice Flour

The polished broken basmati rice was cleaned manually by removing extraneous materials. For pre-gelatinization, polished broken rice was soaked in tap water with a ratio to the water of 1:1 at 30ºC for 3 hours. Soaked rice grains were steeped in the hot water bath at different temperatures and times (60, 70 and 80ºC for 30 minutes) followed by steam cooking in a pan for 5, 10 and 15 minutes. Afterwards, pre-gelatinized basmati broken rice was dried at 60ºC in a tray drier up to desired moisture level (Raina *et al*., 2005). Finally, the pre-gelatinized basmati broken rice was ground into rice flour by using a laboratory scale grinder.

Preparation of Groundnut Meal

Groundnut meal was prepared from peanuts that were procured from the local market of Jammu, India. Later, a de-oiled meal was obtained from the pressed cake after oil extraction and dried at 60˚C for 4-6 hours to remove moisture content and to enhance the grinding of the meal (Mridula *et al*., 2017). The meal was then ground into powder and packed in polyethylene bags.

2.4 Preparation of Freeze-Dried Carrot Pomace

For the preparation of the freeze-dried carrot pomace, fresh carrots were procured and sorted for colour and physical damage. Afterwards, carrots were manually peeled and washed with potable water to remove impurities, followed by juice extraction using a juicer. Prior to freeze-drying, carrot pomace was placed in a freezer overnight. The pomace was then placed in a plastic container (uncapped) and the drying process was carried out at a temperature of -50°C and a pressure of 52 Pa for 48 hours, under vacuum conditions. Finally, freeze-dried carrot pomace was ground into fine powder sieved (300 mesh sieve) and packed in polyethylene bags.

Formulation Used for Pasta Preparation

The pasta was prepared as per the method of Badwaik *et al*. (2014). Control Pasta was prepared from 100 per cent pre-gelatinized basmati rice flour. The pasta was prepared by using pre-gelatinized basmati rice flour and incorporating groundnut meal as a protein source from 2-14% and freeze-dried carrot pomace as a source of fibre from 1-7% for the preparation of gluten-free protein enriched pasta at different ratios. To improve the textural qualities of rice pasta, hydrocolloids, namely, xanthan gum (2%) and Glycerol Monostearate (GMS) (1%) were added to all the treatments. The pre-gelatinized basmati rice flour, groundnut meal, carrot pomace and hydrocolloids were mixed followed by the addition of dissolved xanthan gum (2%) and glycerol monostearate (1%), salt (1%), refined oil (5 mL) and optimum level of water was used to prepare the dough and allowed to rest for 10 minutes. The prepared dough was then steamed for 10 minutes by placing it in a kitchen steamer (Udachan and Sahoo, 2017). Again, the steamed dough was kneaded to distribute gelatinized starch. The cold extrusion of the steamed dough was carried out in a laboratory-scale pasta extruder (Marcato Regina) to get macaroni shape pasta. After extrusion, the shaped pasta (about 1 inch) was dried in a tray drier at 60°C for 4 hours to reduce moisture content up to 11% (Figure 1). The prepared gluten-free pasta samples were packaged in polypropylene bags and stored for 3 months under ambient conditions (28±2°C). The stored pasta samples were analyzed for quality evaluation after 30 days using the following standard procedures.

Quality Evaluation of Gluten-Free Protein Enriched Pasta

Physical Properties

All physical properties of prepared pasta samples were analysed by replicating thrice for recording the observation.

(a) Colour profile (L*, a* and b*)

The colour of pasta samples was measured using a Hunter Lab Colorimeter (Color Flex Reston VA, USA). The equipment was calibrated using white and black standard ceramic tiles. In Hunter's lab Colorimeter, the colour of a sample is denoted by the three dimensions L*, a* and b*. L* value is the brightness of the colour in the range of values from 0 (black) to 100 (white); the higher the values, the brighter the colour. The value of a* indicates the redness of the sample namely from "-" (green) to "+" (red). The b* value indicates the yellowness of the sample namely from "-" (blue) to "+" (yellow).

(b) Bulk density

The bulk density (g mL^{-1}) of the prepared pasta samples was determined as per the method of Benhur *et al*. (2015) by filling a litre measuring cylinder with the pasta with less than 12% moisture slightly above the litre mark. The cylinder was tapped 10 times

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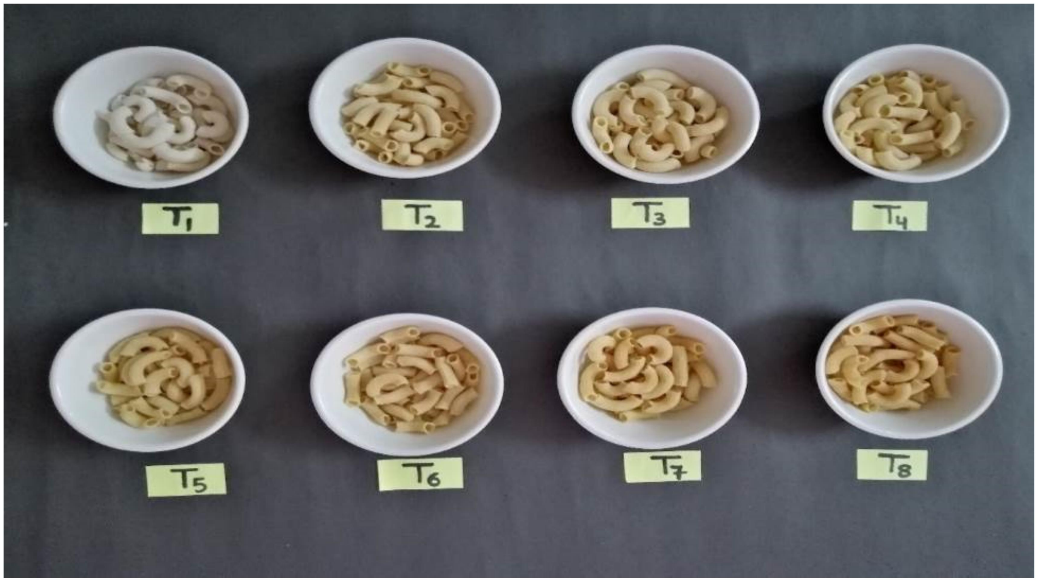

Figure 1. Gluten-free protein enriched pasta samples.

until the products measured up to the litre mark. The weight of the pasta was taken and bulk density was calculated with the following formula:

Bulk density (g mL^{-1})= Weight of the sample (g)/Volume of the sample after tapping (mL)

(c) Water activity

For the determination of the water activity of pasta samples, a water activity meter (Aqua Lab) was used to measure at room temperature (25°C). The device was equipped with a container that was half-filled with ground samples and placed into the device. The water activity was obtained within 3-5 minutes after loading the sample.

Functional Properties

(a) Swelling power

The Swelling power of pasta samples was determined by the method proposed by Seema *et al*. (2016). About 5 g of prepared pasta was cooked in a glass beaker with 20 times its quantity of boiling water (100 mL) for 20 minutes over a water bath maintained at 100ºC. After cooking, the water was strained out and the cooked pasta was dried to remove surface moisture using filter paper and the cooked sample was weighed. Swelling power was calculated as:

Swelling power (g g^{-1})= $W_2 - W_1 / W_1$

Where, W_1 and W_2 (g) are the sample Weight before and after cooking respectively.

(b) Water absorption index

The water absorption index of the sample was determined according to Udachan and Sahoo (2017). About 1 g of ground pasta sample was placed in 20 mL distilled water in pre-weighed 50 mL centrifuge tube, followed by stirring continuously, put in water bath for 30 minutes at 30˚C, later centrifuged at 2,000 rpm for 10 minutes using a centrifuge. At last, the supernatant was placed into dry test tubes and stored overnight at 110°C for the process of evaporation.

Water absorption index (g g^{-1}) = Weight of sediment/Weight of dry solids

Cooking Parameters

(a) Cooking time (Minutes):

The cooking time of prepared pasta samples was determined by the method described by Marti *et al*. (2010). An aliquot of pasta sample was cooked in boiling water

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for cooking time (Pasta: Water ratio, 1:10) with no salt added. The optimum cooking time of pasta was evaluated as the time required for the disappearance of the dry central core when gently squeezed between two glass plates.

(b) Stickiness and Clumpiness (4-Point scale):

The prepared samples were evaluated in the sensory analysis laboratory of the department. Determination of stickiness/clumpiness was adjudged by a panel of nine judges using a 4-point scale as described by Nagi *et al*. (2012).

(c) Smoothness and Disintegration (4-Point scale):

The smoothness and disintegration of prepared pasta were evaluated by nine panellists. The 4- point scale was used in the present study as described by Raina *et al*. (2005)

Statistical Analysis

All the analysis was carried out in triplicate and the data was analysed statistically using suitable tests wherever required. Standard deviation and two-way ANOVA were used. The colour profile, water activity and bulk density data were subjected to ANOVA and Tukey's tests to determine the statistically significant differences. All the pairwise comparisons were carried out using Fisher-LSD at a 5 % level of significance. The Statistical Package used was R software (R version 4.1.3)

RESULTS AND DISCUSSION

Colour Profile (L*, a*, b*)

L* Value: Colour profile in terms of Lightness (L*) value of gluten-free protein enriched pasta showed significant differences with the increase in the incorporation level of carrot pomace and groundnut meal to pre-gelatinized basmati rice flour (Table 1). The mean L* value decreased significantly from 65.68 in treatment T_1 (100:00:00) to 52.99 in treatment T_6 (85:5:10). Udachan and Sahoo (2017) conducted a study on colour analysis of gluten-free broken rice pasta substituted with defatted soy flour. Results revealed that an increase in substitution level of broken rice flour with soy flour in the range from 0-25% significantly influenced the colour values. Reduction in the Lightness (L*) value from 66.82 to 57.01 might be due to an increase in the amount of protein and substitution by defatted soy flour. Similar results were obtained by Marengo *et al*. (2018) in gluten-free rice pasta enriched with sweet potato flour. Moreover, our findings are supported by Bolarinwa and Oyesiji (2021) who found a decline in the L* value of the gluten-free rice soy pasta with an increase in the level of soybean flour enrichment. The decrease in Lightness (L*) value of the pasta samples may possibly be due to an additional amount of fibre and proportionately reduced starch and protein contents (Kaur *et al.,* 2017).

a* Value: The a* (redness) value of gluten-free protein enriched pasta increased significantly from 1.87 to 6.01 for treatment T_1(100:00:00::PRF:CP:GM) and treatment T_8 (79:7:14::PRF:CP:GM), with the incorporation of carrot pomace and groundnut meal (Table1). Our findings are on a par with the findings of Udachan and Sahoo (2017) who also observed an increase in the redness (a*) value ranging from 1.54 to 7.13 in gluten-free broken rice pasta substituted with defatted soy flour. Carini *et al*. (2012) carried out a physicochemical study of pasta and analysed the increase in a* value because of the presence of coloured pigments.

b* Value: All treatments significantly influenced the b* value of gluten-free protein enriched pasta (Table 1). Among treatments, the b* value increased from 13.39 to 20.44 with the increase in the incorporation of carrot pomace and groundnut meal as per formulations. Yu *et al.* (2013) also experienced an increase in b* value by the addition of legume flour while considering colour evaluation. Sadeghi and

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Table 1. Effect of Treatment and storage on colour profile of gluten free protein enriched pasta.[a]

Treatments	Lightness (L* value) Storage period (Months)				Redness (a* value) Storage period (Months)				Yellowness (b* value) Storage period (Months)			
	0	1	2	3	0	1	2	3	0	1	2	3
T_1 (100:0:0::PRF:CP:GM)	67.56^{a}	66.50^{b}	65.48^{c}	63.20^{d}	1.63^{v}	1.72^{v}	1.95^{u}	2.19^{t}	13.59^{u}	13.51^{uv}	13.42^{v}	13.05^{w}
T_2 (97:1:2::PRF:CP:GM)	57.25^{e}	57.21^{e}	57.16^{e}	55.14^{k}	2.18^{t}	2.26^{st}	2.33^{s}	4.31^{kl}	16.15^{s}	16.22^{rs}	16.31^{r}	16.57^{p}
T_3 (94:2:4::PRF:CP:GM)	56.68^{f}	56.60^{fg}	56.51^{g}	54.49^{m}	3.02^{r}	3.94^{n}	4.01^{mn}	4.23^{l}	16.62^{p}	16.54^{p}	16.43^{q}	14.42^{t}
T_4 (91:3:6::PRF:CP:GM)	56.27^{h}	56.19^{hi}	56.08^{j}	54.03^{p}	3.07^{r}	3.18^{q}	3.26^{q}	4.02^{mn}	17.36^{o}	17.43^{no}	17.51^{n}	19.50^{g}
T_5 (88:4:8::PRF:CP:GM)	56.08^{j}	56.16^{ij}	56.25^{hi}	54.36^{n}	3.59^{p}	3.67^{p}	3.79^{o}	4.04^{m}	17.91^{m}	17.99^{m}	18.88^{j}	20.89^{c}
T_6 (85:5:10::PRF:CP:GM)	54.80^{l}	53.0^{1u}	52.07^{v}	52.11^{v}	4.26^{kl}	4.35^{jk}	4.44^{j}	6.46^{c}	18.69^{l}	18.76^{kl}	18.84^{jk}	20.87^{c}
T_7 (82:6:12::PRF:CP:GM)	54.26^{o}	53.47^{s}	53.20^{t}	51.19^{x}	4.76^{i}	4.87^{h}	5.03^{g}	7.06^{b}	19.22^{i}	19.34^{h}	19.48^{g}	21.52^{b}
T_8 (79:7:14::PRF:CP:GM)	53.75^{q}	53.62^{r}	53.53^{rs}	51.51^{w}	5.32^{f}	5.45^{e}	5.62^{d}	7.66^{a}	19.79^{f}	19.90^{e}	20.02^{d}	22.08^{a}
CD ($P \leq 0.05$)												
Treatments			0.05				0.05				0.05	
Storage			0.03				0.04				0.04	
Treatments×Storage			0.10				0.10				0.10	

[a] Mean values in the column with different superscripts are significantly different at $P \leq 0.05$. PRF: Pre-gelatinized basmati Rice Flour; CP: Carrot Pomace; GM: Groundnut Meal; CD: Critical Difference.

Bhagya (2008) observed an increase in the b* value of pasta incorporated with mustard protein isolates.

Water Activity: Water activity (a_w) is an important factor that helps in regulating and predicting the shelf-life of food products. Generally, most bacteria can grow well when a_w is over 0.91. On the other hand, yeast and moulds can survive only when water activity falls in the range of 0.85 - 0.90 (Li *et al*., 2011). The water activity of gluten-free protein enriched pasta decreased as the amount of carrot pomace and groundnut meal increased (Table 2). The gluten-free protein enriched pasta recorded the highest water activity (a_w) value of 0.478 and the lowest mean a_w value of 0.315. This might be due to the presence of more fibre content and the pasta hold a greater amount of water on account of its polymeric nature. Similarly, the moisture content of the pasta was also significantly affected by the incorporation of carrot pomace and groundnut meal reflecting the same trend as observed for water activity. Our findings are at par with the results concluded by Kamble *et al*. (2020) who analyzed the water activity value of 0.33 in the control pasta samples. Getachew and Admassu (2020) reported that with the increase in the supplementation level of dried moringa leaves and oats flour the water activity consequently decreased. Thus, a decrease in the water activity (a_w) level of the blended pasta resulted in prolonged shelf life as compared to the control pasta.

Bulk Density: In the present study, the bulk density of gluten-free protein enriched pasta was estimated. The results revealed significant differences in treatment and storage duration of 90 days (Table 2). The gluten-free protein enriched pasta representing treatment T_8 (79:7:14) indicated the highest mean bulk density of 0.584 g mL^{-1} and the lowest bulk density value was observed in treatment T_1 (100:00:00) as 0.451 g mL^{-1}. Results from other scientific work also coincided with ours as they observed the bulk density of gingelly incorporated sorghum pasta ranged from 0.44 to 0.48 g mL^{-1} (Rao *et al*., 2018). Badwaik *et al.* (2014) evaluated the bulk density of peanut-based fibre rich pasta and found that it increased with the increased peanut and carrot powder ratio in semolina.

Functional Properties

Functional properties like the swelling power (g g^{-1}), water absorption index (g g^{-1}), and cooking time of gluten-free protein enriched pasta were affected with the incorporation of carrot pomace and groundnut meal (Figure 2). The maximum value of swelling power was recorded as 1.82 (g g^{-1}) in treatment T_8 (79:7:14) and the minimum value of swelling power was recorded as 1.40 (g g^{-1}) in T_1. Ahmad *et al.* (2016) observed the swelling power of carrot pomace powder incorporated in cookies and revealed that swelling power increased with an increase in the level of carrot pomace powder. Wojtowicz and Moscicki (2014) evaluated the impact of legume type and addition level on the quality characteristics of pasta and found that addition of legumes significantly increased the swelling index of pasta. Moreover, addition of dietary fibre and legumes significantly increased the swelling index of pasta (Wojtowicz and Moscicki, 2014 and Foschia *et al.,* 2015). A significant increase in swelling power was observed by Zouari *et al*. (2016) in wheat flour blended with sesame peel flour.

The highest water absorption index of 6.56 (g g^{-1}) was exhibited by T_8 (79:7:14) and the least value of 3.18 g g^{-1} was exhibited by treatment T_1(100:0:0). This considerable increase in water absorption index might be due to an increase in the fibre content of the resultant pasta (Kaur *et al.,* 2012). According to Kaur *et al.* (2013), water absorption per cent in pasta increased due to the increased level of Bengal gram flour in semolina.

Cooking time was also affected by the incorporation of carrot pomace and groundnut meal. A significant decrease in

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Table 2. Effect of treatment and storage time on water activity and bulk density of gluten free protein enriched pasta.

Treatments	Water activity (a_w) Storage period (Months)				Bulk density (g mL^{-1}) Storage period (Months)			
	0	1	2	3	0	1	2	3
T_1 (100:0:0::PRF:CP:GM)	$0.349^{klmnopqr}$	$0.417^{fghijklm}$	0.514^{bcdef}	0.631^{a}	$0.512^{fghijklm}$	$0.474^{jklmnop}$	0.435^{opqr}	0.38^{1r}
T_2 (97:1:2::PRF:CP:GM)	$0.336l^{mnopqr}$	$0.402^{hijklmn}$	0.508^{cdefg}	0.610^{ab}	$0.537^{defghij}$	0.480^{jklmno}	0.442^{nopqr}	0.394^{qr}
T_3 (94:2:4::PRF:CP:GM)	0.313^{nopqrs}	$0.385^{ijklmno}$	0.473^{fghide}	0.574^{abc}	0.556^{cdefgh}	$0.501^{hijklmn}$	0.450^{mnopq}	0.412^{pqr}
T_4 (91:3:6::PRF:CP:GM)	0.288^{opqrst}	$0.354^{klmnopq}$	$0.442^{efghijk}$	0.545^{abcd}	0.573^{bcdef}	$0.512^{fghijklm}$	0.471^{klmnop}	0.445^{nopqr}
T_5 (88:4:8::PRF:CP:GM)	0.265^{qrst}	$0.338^{lmnopqr}$	$0.427e^{fghijklm}$	0.523^{bcde}	0.585^{bcde}	$0.534^{efghijk}$	$0.503^{ghijklmn}$	$0.473^{jklmnop}$
T_6 (85:5:10::PRF:CP:GM)	0.252^{rst}	$0.323^{mnopqrs}$	$0.406^{hijklmn}$	0.498^{cdefgh}	0.602^{abcd}	$0.553^{cdefghi}$	$0.519^{fghijkl}$	0.456^{lmnopq}
T_7 (82:6:12::PRF:CP:GM)	0.227^{st}	0.299^{opqrst}	$0.365^{jklmnop}$	$0.454^{defghij}$	0.634^{ab}	0.577^{bcdef}	$0.536^{efghijk}$	0.487^{jklmno}
T_8 (79:7:14::PRF:CP:GM)	0.214^{t}	$0.286p^{qrst}$	$0.349k^{lmnopqr}$	$0.412^{ghijklm}$	0.661^{a}	0.616^{abc}	0.567^{cdefgh}	$0.490^{ijklmno}$
CD ($P \leq 0.05$)								
Treatments	0.049				0.033			
Storage	0.035				0.023			
Treatments×Storage	N/S				N/S			

[a] Mean values in the column with different superscripts are significantly different at $P \leq 0.05$. PRF: Pre-gelatinized basmati Rice Flour; CP: Carrot Pomace; GM: Groundnut Meal; CD: Critical Difference; **N/S**: Non-Significant.

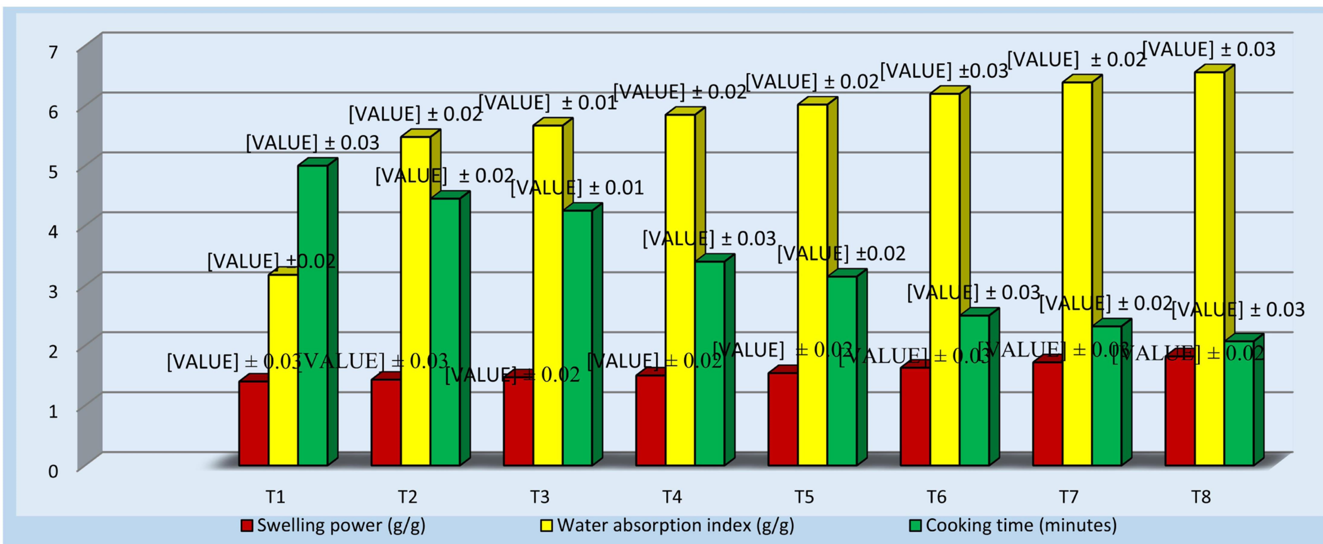

Figure 2. Effect of treatment on swelling power (g g^{-1}), water absorption index (g g^{-1}) and cooking time (minutes) of gluten-free protein enriched pasta.

cooking time was obtained in all treatments. The highest value of cooking time was shown by treatment T_1 (100:0:0) as 5.00 (minutes) and the lowest value was reflected in treatment T_8 (79:7:14) as 2.07 (minutes). The reason might be that enrichment resulted in a relevant decrease in the cooking time. Marengo *et al*. (2018) found a decrease in the cooking time of gluten-free rice pasta that may be ascribed to the lower amount of starch in the system and to increased fat content. Our findings coincided with those of Mishra and Bhatt (2018) who reported that pasta prepared with carrot pomace powder showed decreased cooking time because of an increase in fibre content leading to the softness of pasta when compared to the control sample.

Cooking Parameters

The cooking parameters such as stickiness, smoothness, clumpiness and disintegration of gluten-free protein enriched pasta was studied under white light and showed visible variation. As evaluated by the panellists, addition of fibre and protein had positive effect on stickiness and the score for stickiness decreased as compared to the control pasta. This reduction could be due to starch replacement in the pasta blends (Piwinska *et al*., 2015). Our findings are similar to Sule *et al*. (2019) who found reduction in the stickiness of wheat-oat pasta. Similarly, addition of fibre further indicated positive responses for smoothness score of gluten free protein enriched pasta. On the other hand, enrichment of the pasta resulted in little clumpiness and disintegration of cooked pasta. Raina *et al.* (2005) also reported positive changes in the stickiness and smoothness of pasta containing glycerol mono-stearate and carboxy methyl-cellulose.

CONCLUSIONS

It is evident that the physical, functional and cooking properties of gluten-free protein enriched pasta was greatly influenced as the ratio of incorporation increased. The incorporation of rice pasta with groundnut meal and freeze-dried carrot pomace produced better colour than the control rice pasta. Moreover, it increased the swelling power and water absorption index, but reduced the cooking time. Thus, utilization of by-products such as locally available broken basmati rice, carrot pomace and groundnut meal can reduce environmental load. Development of such products at a commercial level and their consumption, particularly among children, can be used to combat protein-calorie malnutrition, celiac disease, and other nutritional deficiencies among the vulnerable population.

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ارزیابی کیفیت ماکارونی غنی شده با پروتئین بدون گلوتن تهیه شده با استفاده از آرد برنج باسماتی، کنجاله بادام زمینی و تفاله هویج

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چکیده

در این پژوهش، آزمایش‌هایی برای ارزیابی کیفیت ماکارونی غنی‌شده با پروتئین بدون گلوتن انجام شد. پاستا با مصرف نسبت متفاوتی از آرد برنج باسماتی شکسته از پیش ژلاتینه شده(PRF)، تفاله هویج خشک‌-شده و یخ‌زده (CP) و پودر بادام زمینی (GM) در نسبت‌های مختلف(PRF:CP:GM::100:0:0) T1، T2 (PRF:CP:GM::97:1:2)، T3 (94:2:4)، T4 (91:3:6)، T5 (88:4:8)، T6 (85:5:10)، T7 (82:6:12)، و(79:7:14) T8 فرموله شد. آرد برنج باسماتی شکسته پیش‌ژلاتینه شده (T1) به عنوان ماکارونی

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شاهد در نظر گرفته شد. هر نمونه پاستا پس از خشک شدن در کیسه های پلی پروپیلن بسته بندی و به مدت ۳ ماه در شرایط محیط (۲±۲۸ درجه سانتی گراد) نگهداری شد. نتایج نشان داد که عدد سبکی (L*) ماکارونی غنی شده با پروتئین بدون گلوتن کاهش یافت، در حالی که مقادیر a* و b* با افزایش مقدار تفاله هویج خشک شده یخ زده و پودر بادام زمینی به آرد برنج باسماتی شکسته افزایش یافت. همچنین، فعالیت آب (water activity)، چگالی ظاهری (bulk density)، قدرت تورم (g/g)، شاخص جذب آب (g/g)، و زمان پخت تا حد زیادی تحت تاثیر افزایش سطح اختلاط (incorporation) قرار داشت. به دلیل افزودن فیبر، کاهش قابل توجهی در زمان پخت و صافی (smoothness) پاستاهای غنی شده با پروتئین بدون گلوتن پدید آمد. از سوی دیگر، اختلاط منجر به انباشتگی و فروپاشی (clumpiness and disintegration) کمی شد.

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