Optimization of food materials for development of nutritious pasta utilizing groundnut meal and beetroot

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Abstract Present study was undertaken to optimize the level of food materials viz. groundnut meal, beetroot juice and refined wheat flour for development of nutritious pasta using response surface methodology. Box-benken design of experiments was used to design different experimental combinations considering 10 to 20 g groundnut meal, 6 to 18 mL beetroot juice and 80 to 90 g refined wheat flour. Quality attributes such as protein content, antioxidant activity, colour, cooking quality (solid loss, rehydration ratio and cooking time) and sensory acceptability of pasta samples were the dependent variables for the study. The results revealed that pasta samples with higher levels of groundnut meal and beetroot juice were high in antioxidant activity and overall sensory acceptability. The samples with higher content of groundnut meal indicated higher protein contents in them. On the other hand, the samples with higher beetroot juice content were high in rehydration ratio and lesser cooking time along with low solid loss in cooking water. The different level of studied food materials significantly affected the colour

quality of pasta samples. Optimized combination for development of nutritious pasta consisted of 20 g groundnut meal, 18 mL beetroot juice and 83.49 g refined wheat flour with overall desirability as 0.905. This pasta sample required 5.5 min to cook and showed 1.37 % solid loss and rehydration ratio as 6.28. Pasta sample prepared following optimized formulation provided 19.56 % protein content, 23.95 % antioxidant activity and 125.89 mg/100 g total phenols with overall sensory acceptability scores 8.71.

Keywords Beetroot juice · Groundnut meal · Optimization · Pasta

Introduction

Development of nutritious products with oilseeds protein such as defatted soy flour, peanut and cotton seed protein have been extensively studied and reported by various scientists (Khan and Lawhon 1980; Yadav et al. 2012). Peanut isolate, concentrates and protein rich flour have received a great attention in recent years to fulfil the increasing demand for high protein food products at affordable price. Groundnut meal, a by-product obtained after oil extraction is low in oil, and contains 35–45 % crude protein, 20 to 30 % carbohydrate, 6.5 % crude fiber and 4 to 6 % minerals (Desai et al. 1999). The oilseed meals are mainly used in animal feed but they are also used to some extent for human consumption. Groundnut meal can be dried and ground to get flour for its further utilization in various daily consumed foods (Zhao et al. 2011). Groundnut meal is suitable to enhance the nutritive value of wheat and other flour. It has potential to be used as low fat groundnut concentrates, composite flour, in bakery products, breakfast cereal flakes, snack foods, multipurpose supplement, infant

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and weaning foods, extruded foods or fabricated foods (Gopala Krishna 2007; Purohit and Rajyalakshmi 2011).

Pasta, a ready-to-cook food, moulded into desired shape after the addition of water by means of cold extrusion or sheeting. The term pasta usually refers to dried pasta, produced from durum wheat (*Triticum durum*) semolina without adding other food materials or additives. The worldwide acceptance of pasta is attributed to its low cost, ease of preparation, versatility, good sensory quality and long shelf life. Pasta being a wheat based product, is a good source of carbohydrates (74–77 %, dry basis) (Monge et al. 1990) and proteins (11–15 %, db) but deficient in lysine and threonine (limiting amino acids), common to most cereal products (Abdel-Aal and Hucl 2002). This provides an opportunity for the use of non-traditional raw materials to increase the nutritional quality of pasta (Del Nobile et al. 2005). Nowadays health conscious consumers also demand food products, which contain health promoting food materials or ingredients. Realizing the awareness of the consumers towards the nutrimental and health constituents present in processed products, it is important to develop the product which could satisfy the nutritional need as well as the health promoting properties in the processed products. Beetroot is a good source of protein, dietary fibre, important vitamins and minerals. It is rich in carbohydrates and betaine (Kanner et al. 2001) but very low in fat. Beetroot has been advocated as a material with cancer preventative properties and providing a way to bolster immune system (Rasic et al. 1984). Specific anti-carcinogens are bound to the red colouring matter of beetroot, helping in fighting against cancer (Edenharder et al. 1994; Kapadia et al. 1996). Beetroot juice contains a high level of biologically accessible antioxidants (Wootton-Beard et al. 2011) as well as many other health promoting compounds such as potassium, magnesium, folic acid, iron, zinc, calcium and phosphorus. It is also rich source of a number of polyphenolic compounds (Kaur and Kapoor 2002; Pitalua et al. 2010). Vegetable juices are also considered to be a viable method for bridging the gap between actual and observed vegetable intake (Shenoy et al. 2010) and for production of fortified pasta (Mridula et al. 2015). Beetroot consumption may not be found popular as of other fruits and vegetables such as tomato, carrot, apple or mango, perhaps due to perceived issues of taste and texture. But in recent years, consumption of beetroot is also increasing steadily due to the recognition of antioxidant and anticancer properties in it. Nutritious food products utilizing beetroot had been developed and accepted by consumers (Mridula et al. 2009, 2010, 2011). Pasta, being popular amongst children and adults, if enriched with protein and antioxidants using groundnut meal and beetroot, will help in improving the quality of the diet of the consumers. In

view of this, present study has been carried out to optimize the level of groundnut meal, beetroot juice and refined wheat flour for development of nutritious pasta.

Materials and methods

Experimental design Response surface methodology (RSM) was adopted to design the experimental combinations for development of the nutritious pasta samples for this study. Response surface methodology (RSM) is an important tool for optimization which reduces the number of experiments runs needed to provide sufficient information for statistically acceptable results. The independent variables included the proportion of groundnut meal (10–20 g), beetroot juice (6–18 mL) and refined wheat flour (80–90 g). Response variables were protein content, total phenols, antioxidant activity, cooking time, rehydration ratio, solid loss, overall acceptability and colour quality ('L', 'a', 'b' and 'YI' value).

Raw materials preparation Refined wheat flour, partially deoiled groundnut meal and beetroot juice were used for development of nutritious pasta. Refined wheat flour (*Shakti bhog brand*; particle size 0.336 mm) was procured from local market, Ludhiana. Partially de-oiled groundnut meal was prepared by extracting the oil from de-skinned groundnut using mechanical expeller having fat content 12.60 %. The meal was dried in the tray drier at 50 °C to get the moisture content about 10 %. The meal with final moisture content 9.92 % (wet basis) was ground and sieved using BSS sieve (48 mesh size) having 0.336 mm width of opening size. Beetroot juice was prepared just before the experiments from freshly procured beetroot from local market, Ludhiana. Right from extraction to pasta making, the beetroot juice was stored at a low temperature i.e., at 10 °C.

Pasta preparation Pasta samples were prepared by mixing of food materials i.e., partially de-oiled groundnut meal and refined wheat flour with beetroot juice as per experimental combinations (Table 1). Pasta samples were prepared using a laboratory scale pasta making machine (Model: Le monferrina Masoero Arturo and C.S.N.C., Italy) fitted with an adjustable die. In order to mix the liquid portion (beetroot juice and distilled water) uniformly throughout the food formulation, it was added in the mixing chamber of pasta extruder for 10 min. The amount of distilled water to be added was variable for the different samples to get the final moisture content 28 % (wet basis) before extruding the pasta. The moist flour aggregate was then extruded using a twisted die at room temperature (26 °C). After preparation, the pasta samples were dried in the tray dryer (Macro Scientific Works Pvt. Ltd., New Delhi) at 40±2 °C until the moisture content reached to approximately 6.5 %. The tray dryer

Table 1 Experimental data of nutritious pasta samples for response surface analysis

S. No.	Independent variables						Responses							
	Groundnut meal (g)		Beetroot juice (mL)		Refined wheat flour (g)		Yellowness index (YI)	Cooking time (min)	Rehydration ratio	Solid Loss (%)	Protein content (%)	Total phenols (mg/100 g)	Antioxidant activity (%)	Overall acceptability
	Coded	Actual	Coded	Actual	Coded	Actual	Y ₁	Y ₂	Y ₃	Y ₄	Y ₅	Y ₆	Y ₇	Y ₈
1	1	20	0	12	1	90	140.51	7.0	3.50	1.75	15.70	114.425	16.325	7.9
2	0	15	0	12	0	85	140.51	7.0	3.50	1.75	14.12	124.018	14.054	7.2
3	1	20	1	18	0	85	134.17	5.5	6.62	1.75	18.91	124.523	24.648	8.6
4	−1	10	1	18	0	85	172.89	6.0	8.75	3.75	13.83	126.942	22.138	8.0
5	0	15	1	18	−1	80	175.18	6.5	5.75	1.62	15.65	128.225	20.869	8.4
6	1	20	−1	6	0	85	150.20	7.5	3.25	3.50	16.24	113.331	10.401	7.0
7	1	20	0	12	−1	80	154.49	6.0	3.00	1.50	17.50	115.603	16.275	7.8
8	0	15	1	18	1	90	150.70	6.0	5.88	2.63	15.77	127.720	19.032	8.3
9	0	15	0	12	0	85	132.42	8.5	4.25	2.12	11.37	117.890	13.087	7.3
10	0	15	0	12	0	85	149.30	7.5	3.50	1.75	14.72	112.742	18.032	7.2
11	0	15	−1	6	−1	80	172.74	7.5	3.50	3.62	11.27	101.382	10.402	6.8
12	−1	10	0	12	−1	80	179.05	8.5	4.25	2.12	11.26	109.376	15.517	7.1
13	0	15	0	12	0	85	162.16	7.0	4.25	2.12	13.13	120.652	15.185	8.0
14	−1	10	−1	6	0	85	127.65	9.0	4.25	2.12	11.66	108.261	11.418	6.9
15	0	15	0	12	0	85	144.90	7.5	3.75	1.87	14.72	123.008	16.777	7.5
16	0	15	−1	6	1	90	127.99	8.5	3.50	1.75	11.37	116.613	11.950	6.9
17	−1	10	0	12	1	90	142.48	7.5	3.50	1.75	12.51	124.628	15.350	7.5

measuring 915 × 840 × 915 mm having two chambers and capacity of 24 trays with heater load of 6.0 KW. It is equipped with Microprocessor Based PID Digital Temperature Indicator-cum-Controller. Besides it has tubular air heaters with temperature ranging from Ambient +5 to 150 °C. After drying, the samples were packed in LDPE bags (thickness 0.065 mm) followed by sealing and wrapping them with black coloured sheet to protect them from light. These pouches were then placed in glass desiccators and kept at ambient temperature (25 ± 2 °C) for quality analysis, which had been completed within three days of pasta production.

Product quality responses

Protein content Protein content for pasta was determined as described by the standard (AOAC 2000) Kjeldahl method using nitrogen estimation system (Model: Kelplus- KES 06L VA DLS, Pelican equipments, Chennai). After determination, the factor 6.25 was used to obtain the protein content of the pasta samples.

Total phenols Total phenol content of pasta samples was estimated by the Folin–Ciocalteu method (Singleton and Rossi 1965; Li et al. 2007). Two hundred microlitres of

pasta sample extract was mixed with 1 mL of 1:10 diluted Folin–Ciocalteu reagent. The mixtures thus prepared was allowed to equilibrate for 5 min. Sample was then neutralised using 800 µL of saturated sodium carbonate followed by incubation at room temperature for 2 h. Finally the absorbance was measured at 725 nm. The results were expressed as gallic acid equivalent (mg/100 g sample dry matter basis).

Antioxidant activity The antioxidant activity of the pasta samples was determined from the radical scavenging activity using 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) (Scherer and Godoy 2009, 2014). Methanolic extract of samples (1 g sample in 10 mL of methanol) was prepared using magnetic stirring for 1 h. Aliquots of 0.1 mL of methanolic extract of samples or standards in different concentrations were added to 3.9 mL of a methanol solution of DPPH (0.2 mM). The determination of antioxidant activity was carried out in triplicate. After a 30 min incubation period at room temperature in a dark place, the absorbance was measured at 517 nm. The results were expressed as percent inhibition of the DPPH radical (% inhibition DPPH), which was calculated according to the following equation:

$$\% \text{ Inhibition DPPH} = \frac{Abs_{DPPH} - Abs_{Sample}}{Abs_{DPPH}} \times 100 \quad (1)$$

where Abs_{DPPH} is the absorbance of the DPPH solution without extracts and Abs_{Sample} is the absorbance of the sample solution.

Instrumental colour quality Colour (L, a, b values and YI) was determined by using Hunter Colorimeter (model no. 45/0 L, made in U.S.A). 'L' is known as the lightness and extends from 0 (black) to 100 (white). The other two coordinates 'a' and 'b' represents redness (+a values) to greenness (−a values) and yellowness (+b values) to blueness (−b values), respectively. Yellowness index (YI) depicts the change in the colour of the samples from clear or white toward yellow.

Cooking quality The Cooking quality viz. cooking time, rehydration ratio and solid loss of pasta were determined as described by Galvez and Resurreccion (1992). Pasta samples were cooked in 500 mL of distilled water to determine the cooking time as described by Kim and Wiesenborn (1995). The beaker was covered during cooking to minimize losses of water through evaporation. The cooking water was drained and cooked pasta samples were rinsed with distilled water in a Buchner funnel and weight of cooked pasta samples were taken to determine the rehydration ratio using the following formula.

$$\text{Rehydration ratio} = \frac{\text{weight of cooked pasta}}{\text{weight of drypasta}} \quad (2)$$

Solid loss in cooking water was determined by evaporating the combined cooking and rinse water in a pre-weighed glass beaker using a hot air oven at 80 °C (Bruneel et al. 2010; Singh et al. 2004). The solid loss was then calculated using the following formula.

$$\text{solid loss} = \frac{\text{weight of residue after evaporation}}{\text{weight of sample}} \quad (3)$$

Sensory evaluation Sensory attributes of developed pasta samples, such as appearance, colour, sensory texture, odour, flavour and taste were evaluated on nine point hedonic scale by a group of 11 semi-trained panelists with 9 for like extremely and 1 for dislike extremely (Lawless and Heymann 1998). The overall acceptability of each sample was then computed as mean value of all the sensory attributes mentioned above. For sensory evaluation, each sample of cooked pasta was mixed with flavoring agents (2 mL refined oil, 1.5 g salt and 0.2 g green chilli powder per 100 g of uncooked sample) and prepared in a shallow pan for two min. Samples (30 g each) were then provided to each panelist for sensory evaluation using hedonic scale. Hedonic scale was in the sequence as like extremely - 9, like very much - 8, like moderately - 7, like slightly - 6, neither like nor dislike - 5, dislike slightly - 4,

dislike moderately - 3, dislike very much - 2, dislike extremely - 1 (BIS 1971).

Optimization of process parameters Response surface methodology was applied to the experimental data using a commercial statistical package, Design-Expert software version 8 (Stat-Ease Inc, Minneapolis, MN, USA). The optimization of the food materials aimed at finding the level of independent variables viz. groundnut meal (g), beetroot juice (mL) and refined wheat flour (g), which could give maximum protein content, antioxidant activity and rehydration ratio, and minimum cooking time and solid loss. Desirability, a mathematical method was used for selecting the optimum process values. For several responses and factors, all goals get combined into one desirability function. The numerical optimization finds a point that maximizes the desirability function.

Results and discussion

The values of different experimental combinations of various responses are presented in Table 1, which indicated a wide variation in all the responses for different experimental combinations. The values of different experimental combinations of various responses for coded variables are mentioned in Table 1. A wide variation in all the responses was observed for different experimental combinations i.e., 5.5 to 9.0 min for cooking time, 3 to 8.75 for rehydration ratio, 1.5 to 3.75 for solid loss, 101.382 to 128.225 mg/100 g for total phenols, 10.401 to 24.648 % for antioxidant activity, and 11.26 to 18.91 % for protein content. Among the colour parameters the variation was observed as 11.34 to 21.11 for 'L' value, 17.30 to 19.78 for 'a' value, 5.65 to 8.07 for 'b' value and 127.65 to 179.05 for yellowness index (YI). The developed pasta samples exhibited good overall sensory acceptability both based on their visual appeal as well as sensory appeal.

The pasta samples had distinct light pink colour depending on the level of beetroot juice in the samples. This light pink colour in turn enhances the visual appeal of pasta samples. The colour parameters i.e., 'L' value, 'a' value, 'b' value and yellowness index (YI) were significantly ($P \leq 0.05$) influenced by the level of food materials in the pasta formulation as mentioned in Table 2 and Fig. 1a–h. The results indicated the coefficient of regression for 'L', 'a' and 'b' values as 0.841, 0.835 and 0.894. The lack of fit for all parameters was non-significant thereby indicating that model experimental values were in good agreement with the predicted values. The regression coefficient for yellowness index was $R^2 = 0.8783$, which was moderately high with non-significant lack of fit. Beetroot juice provided a distinct reddish purple colour

Table 2 Analysis of variance of independent variables on quality responses of nutritious pasta

Particulars	L value	a value	b value	Yellowness Index (YI)	Cooking Time, min	Rehydration ratio	Solid Loss, %	Protein content, %	Total Phenols, mg/100 g	Antioxidant activity, %	Overall acceptability
Model	4.11**	3.95**	6.57	5.61**	5.87**	11.32**	18.87**	6.09**	6.92**	8.18**	7.09**
Beetroot Juice (A)	8.13**	0.15	12.92**	4.73*	32.63**	58.25**	4.02*	16.21**	41.98**	69.03**	55.26**
Groundnut meal (B)	3.31	3.88*	12.20**	2.92	11.29**	7.15**	4.08*	31.89**	0.016	0.40	5.51*
Refined wheat flour (C)	7.53**	0.80	0.24	22.96**	0.11	5.368E-003	2.56**	9.242E-003	7.57**	6.302E-003	0.43
A*B	1.39	1.89	3.74*	12.01**	0.90	0.95	59.55**	0.045	1.02	0.95	0.85
A*C	0.60	0.33	0.021	1.31	2.03	0.013	43.22	3.938E-005	4.52*	0.88	0.85
B*C	11.75**	26.75**	28.86**	1.63	3.61*	1.17	2.04	1.63	4.93*	3.606E-003	0.31
A*A	3.90*	0.051	0.86	0.11	1.49	27.55**	48.30**	0.50	0.090	0.65	0.63
B*B	0.23	0.37	0.074	0.062	0.53	1.87	1.18	3.81*	1.15	1.32	0.37
C*C	8.635E-004	1.17	0.20	4.71*	0.059	5.70**	5.92**	0.75	0.91	0.42	0.17
Lack of fit	0.19	0.18	0.44	0.16	0.39	4.11	1.77	0.34	0.22	0.57	0.18
C.V. %	9.51	2.24	4.66	5.88	7.27	13.13	9.91	8.48	3.13	11.33	3.59
R ²	0.8408	0.8354	0.8941	0.8783	0.8830	0.9357	0.9604	0.8867	0.8989	0.9132	0.9011

Significance: **($P \leq 0.05$), * ($P \leq 0.1$)

to the pasta formulation due to the presence of betanins, which are natural colorants (Stintzing and Carle 2007) present in beetroot. The samples containing higher level of beetroot juice indicated lower 'L' and 'b' values with higher 'a' values.

$$\begin{aligned}
 \text{'L' value} &= +15.46 - 1.57 * A + 1.00 * B + 1.51 * C + 0.91 * AB - 0.60 * AC - 2.66 * BC + 1.49 * A^2 + 0.36 * B^2 + 0.022 * C^2 \\
 \text{'a' value} &= +18.31 - 0.057 * A + 0.29 * B + 0.13 * C - 0.29 * AB + 0.12 * AC - 1.07 * BC + 0.046 * A^2 + 0.12 * B^2 + 0.22 * C^2 \\
 \text{'b' value} &= +6.64 - 0.40 * A + 0.39 * B - 0.054 * C - 0.30 * AB + 0.022 * AC - 0.84 * BC + 0.14 * A^2 - 0.042 * B^2 + 0.069 * C^2 \\
 \text{YI value} &= +145.86 + 6.80 * A - 5.34 * B - 14.97 * C - 15.32 * AB + 5.07 * AC + 5.65 * BC + 1.44 * A^2 - 1.08 * B^2 + 9.35 * C^2
 \end{aligned}$$

The cooking quality i.e., cooking time, rehydration ratio and solid loss was significantly ($P \leq 0.05$) affected due to variable amount of studied food materials (Table 2 and Fig. 2a–f). The cooking time varied from 5.5 to 9.0 min for all the pasta samples. The coefficient of regression for cooking time ($R^2 = 0.8830$) was high with non-significant lack of fit, which was in agreement with the fitted model. The samples containing maximum beetroot juice and groundnut meal required lesser time to cook the sample. The regression coefficient for rehydration ratio ($R^2 = 0.9357$) was very high with non-significant lack of fit. The rehydration ratio of different beetroot juice incorporated pasta samples varied from 3 to 8.75. Almost all the pasta samples indicated little (1.5 to 3.75 %) solid loss ($R^2 = 0.9604$). As shown in Fig. 2e and f, the solid loss increased with the increase in the content of groundnut meal in the sample. For a given content of beetroot juice (6 mL), the solid loss increased from 2.24 % at 10 g groundnut meal content to 3.60 % at 20 g groundnut meal content. These

could be due to lower gluten and higher oil content in the pasta formulation with higher level of groundnut meal, which in turn reduced the binding properties of the sample.

$$\begin{aligned}
 \text{Cooking Time (min)} &= +7.50 - 1.06 * A - 0.62 * B + 0.063 * C + 0.25 * AB - 0.38 * AC + 0.50 * BC - 0.31 * A^2 - 0.19 * B^2 - 0.062 * C^2 \\
 \text{Rehydration Ratio} &= +3.85 + 1.56 * A - 0.55 * B - 0.015 * C - 0.28 * AB + 0.033 * AC + 0.31 * BC + 1.48 * A^2 + 0.39 * B^2 - 0.67 * C^2 \\
 \text{Solid Loss (\%)} &= +1.92 - 0.15 * A - 0.16 * B - 0.12 * C - 0.84 * AB + 0.72 * AC + 0.16 * BC + 0.74 * A^2 + 0.12 * B^2 - 0.26 * C^2
 \end{aligned}$$

The protein content varied in the range from 11.26 to 18.91 % for different pasta combinations with an average value of 14.10 % (Fig. 3a and b). At a given concentration of beetroot juice (6 mL), protein content indicated an increase from 11.19 % at 10 g groundnut meal to 11.90 % at 14 g, which further increased to 15.71 % at 20 g. The maximum protein content (18.91 %) was observed in pasta samples prepared from formulation having 20 g groundnut meal along with 18 mL beetroot juice and 85 g refined wheat flour while minimum protein content (11.26 %) was found at 10 g groundnut meal with 12 mL beetroot juice and 80 g refined wheat flour. Groundnut meal is considered as a rich source of proteins, which in turn influenced the total protein content of the pasta samples (Basha and Pancholy 1982). The regression model indicated significant ($P \leq 0.05$) impact of groundnut meal on protein content of pasta with coefficient of regression (R^2) as 0.887 and non significant lack of fit (Table 2).

$$\text{Protein Content (\%)} = +13.61 + 1.70 * A + 2.39 * B - 0.041 * C + 0.13 * AB + 3.750E-003 * AC - 0.76 * BC + 0.41 * A^2 + 1.14 * B^2 - 0.50 * C^2$$

Total phenol content in the different groundnut meal and beetroot juice incorporated pasta samples ranged from 101.38

Fig. 1 Effect of groundnut meal and beetroot juice on colour quality of nutritious pasta

Fig 2 Effect of groundnut meal and beetroot juice on cooking quality of nutritious pasta

to 128.23 mg/100 g. Beetroot concentration influenced the total phenol content of different pasta samples. The response surface plot (Fig. 3c and d) showed that the total phenol content of groundnut meal and beetroot juice incorporated pasta, increased with increasing level of beetroot juice as also

observed in other studies (Wootton-Beard and Ryan 2011). On the contrary, increasing level of groundnut meal showed no significant impact on the total phenols content in the pasta samples. The maximum phenol content (128.225 mg/100 g) was found at maximum level of beetroot juice (18 mL) in

Fig. 3 Effect of groundnut meal and beetroot juice on protein, total phenol and antioxidant activity in pasta

Fig. 4 Effect of beetroot juice and groundnut meal on overall acceptability of nutritious pasta

combination with 15 g groundnut meal and 80 g refined wheat flour, while minimum phenol content (101.382 mg/100 g) was observed at lowest concentration of beetroot juice viz. 6 mL along with 15 and 80 g of groundnut meal and refined wheat flour. At a given value of groundnut meal viz. 10 g, total phenols indicated an increase from 108.096 mg/100 g at 6 mL beetroot juice to 117.871 mg/100 g at 12 mL beetroot juice concentration, which further increased to 128.775 mg/100 g at 18 mL beetroot juice concentration. Thus, concentration of beetroot juice in the product remarkable affected the total phenol contents of pasta. The regression model for total phenols was found significant ($R^2=0.898$) with non-significant '*F*-value' for the lack of fit, which indicated the adequacy of model to the experimental data (Table 2).

$$\text{Total Phenols (mg/100g)} = +1196.62 + 84.78^* A - 1.66^* B + 36.00^* C - 18.72^* AB - 39.34^* AC - 41.08^* BC + 5.40^* A^2 - 19.37^* B^2 - 17.17^* C^2$$

Beetroot juice concentration had the most significant impact on the antioxidant activity of pasta samples (Fig. 3e and f). There was a wide variation in range of antioxidant activity for pasta products from 10.401 to 24.648 % with an average value of 15.9684 %. Results indicated that increasing beetroot juice concentration significantly increased the antioxidant activity of pasta samples. The antioxidant activity peaked to maximum at 18 mL beetroot juice concentration along with 20 g groundnut meal and 85 g refined wheat flour. This observation can be explained by the fact that beetroot juice has very high antioxidant activity (Wootton-Beard and Ryan 2011). On the other hand, the minimum value was recorded at 6 mL, 20 g and 85 g beetroot juice, groundnut meal and refined wheat flour, respectively. For a given value of groundnut meal viz. 10 g, the antioxidant activity increased from 12.322 % at 6 mL beetroot juice concentration to 16.031 % at 12 mL and further 21.173 % at 18 mL beetroot juice concentrations. The regression model indicated significant impact ($R^2=0.9132$) of

beetroot juice on antioxidant activity of different pasta samples (Table 2).

$$\text{Antioxidant Activity (\%)} = +15.43 + 5.31^* A + 0.40^* B - 0.051^* C + 0.88^* AB - 0.85^* AC + 0.054^* BC + 0.71^* A^2 + 1.01^* B^2 - 0.57^* C^2$$

Sensory acceptability of groundnut meal and beetroot juice incorporated pasta samples was significantly ($P \leq 0.05$) affected by the level of studied food materials (Table 2 and Fig. 4). The overall sensory acceptability of pasta samples varied from 6.8 to 8.6 with an average value of 7.55. The overall acceptability was found increased with increasing level of groundnut meal and beetroot juice in pasta samples. The maximum overall acceptability (8.6) was recorded for pasta samples developed from formulation having 18 mL beetroot juice, 20 g groundnut meal and 85 g refined wheat flour while the minimum overall acceptability (6.8) was recorded at 6 mL beetroot juice with 15 g groundnut meal and 80 g refined wheat flour. At a given value of groundnut meal viz. 10 g, the overall acceptability increased from 6.81 at 6 mL to 7.98 at 18 mL beetroot juice level. On the other hand, at the given value of beetroot juice viz. 6 mL, overall acceptability of the product increased from 6.81 to 7.01 with the increase in groundnut meal concentrations from 10 to 20 g, respectively. The coefficient of regression (R^2) for overall acceptability was 0.9011 with non-significant lack of fit.

$$\text{Overall Acceptability} = +7.44 + 0.71^* A + 0.23^* B + 0.063^* C + 0.12^* A^2 - 0.050^* A^3 - 0.075^* B^2 + 0.10^* A^2 + 0.080^* B^2 + 0.055^* C^2$$

Optimum combination for groundnut meal and beetroot juice for nutritious pasta

In order to optimize the level of studied food materials for pasta formulation by numerical optimization, which finds a point to maximize the desirability function; equal importance

Table 3 Optimum values of nutritious formulation and quality of pasta

	Target	Experimental range		Optimum value	Desirability
		Min	Max		
Beetroot juice (mL)	range	10	20	18.00	
Groundnut meal (g)	range	6	18	20.00	
Refined wheat flour (g)	range	80	90	83.49	
Quality responses				Predicted values	
Total phenols (mg/ 100 g)	maximize	101.38	128.22	125.89	0.905
Antioxidant activity (%)	maximize	10.40	24.65	23.95	
Protein content (%)	maximize	11.26	18.91	19.56	
Cooking time (min)	minimize	5.5	9.0	5.5	
Rehydration ratio	maximize	3.00	8.75	6.28	
Solid loss (%)	minimize	1.50	3.75	1.37	
Overall acceptability	maximize	6.8	8.6	8.71	

was given to all the studied three food materials i.e., refined wheat flour, groundnut meal and beetroot juice (Table 3). Out of all the responses some important responses viz. cooking time, rehydration ratio, solid loss, protein content, antioxidant activity, total phenols and overall acceptability were used to optimize the combination for making nutritious pasta utilizing groundnut meal and beetroot juice. The optimum combination of beetroot juice, groundnut meal and refined wheat flour for preparation of pasta was 18 mL, 20 g and 83.49 g, respectively. The overall desirability, which ranges from zero outside of the limits to one at the goal, was 0.905. Corresponding to these values of beetroot juice, groundnut meal and refined wheat flour, protein content, total phenols and antioxidant activity were 19.56 %, 125.89 mg/100 g, 23.95 %, respectively with 5.5 min cooking time, 6.28 rehydration ratio, 1.37 % solid loss and 8.71 overall acceptability.

Conclusion

The level of different studied food materials i.e., refined wheat flour, groundnut meal and beetroot juice significantly influenced the instrumental colour, cooking quality as well as nutritional parameters of pasta samples. Increasing level of beetroot juice increased the antioxidant activity while protein content was increased with increasing level of groundnut meal but overall acceptability increased with increasing level of both the food materials i.e., groundnut meal and beetroot juice in pasta samples. The groundnut meal and beetroot juice incorporated nutritious pasta with good sensory acceptability can be developed using 80.67 % refined wheat flour, 19.33 % groundnut meal and 17.4 mL/ 100 g pasta formulation beetroot juice. This pasta sample provided 19.56 % protein content, 23.95 % antioxidant activity and 125.89 mg/100 g total phenols. It can be inferred from the study that ground meal and beetroot juice could be rightfully exploited as useful food

materials for development of nutritious pasta to fulfil the demand of antioxidant rich nutritious products for health conscious consumers. The pasta thus developed would also fulfil 50 % of the protein requirement of a 10–12 years old Indian child as per recommended dietary allowances (RDA) and also enhances the intake of less familiar nutritious vegetables among children, a potential group of consumers of pasta products.

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References

- Abdel-Aal ESM, Hucl P (2002) Amino acid composition and in vitro protein digestibility of selected ancient wheats and their end products. *J Food Compos Anal* 15:737–747
- AOAC (2000) Official methods of analysis, 17th edn. The Association of Official Analytical Chemists, Washington DC
- Basha SM, Pancholy SK (1982) Composition and characteristics of basic proteins from peanut (*Arachis hypogaea* L.). *J Agric Food Chem* 30: 1176–1179
- BIS (1971) IS: 6273 Part I and Part II. Guide for sensory evaluation of foods. Indian Standard Institution, New Delhi
- Bruneel C, Pareyt B, Brijs K, Delcour JA (2010) The impact of the protein network on the pasting and cooking properties of dry pasta products. *Food Chem* 120:371–378
- Del Nobile MA, Baiano A, Conte A, Mocchi G (2005) Influence of protein content on spaghetti cooking quality. *J Cereal Sci* 41:347–356
- Desai BB, Kotecha PM, Salunkhe DK (1999) Composition and nutritional quality. In: Introduction science and technology of groundnut: biology, production, processing and utilization. Naya Prokash Publ, New Delhi, pp 185–199
- Edenharder R, Kurz P, John K, Burgard S, Seeger K (1994) In vitro effect of vegetable and fruit juices on the mutagenicity of 2-amino-3-methylimidazo[4,5-f] quinoline, 2-amino-3,4-dimethylimidazo[4,5-f] quinoline and 2-amino-3,8-dimethylimidazo[4,5-f] quinoxaline. *Food Chem Toxicol* 32(5):443–459

- Galvez FCF, Resurreccion AVA (1992) Reliability of the focus group technique in determining the quality characteristics of mung bean noodles. *J Sens Stud* 7:315–326
- Gopala Krishna AG (2007) Edible oilseed, oil and meal need for quality control. *Beverage Food World* 34(1):42–44
- Kanner J, Harel S, Granit R (2001) Betalains—a new class of dietary cationized antioxidants. *J Agric Food Chem* 49(11):5178–5185
- Kapadia GJ, Tokudab H, Konoshimac T, Nishino H (1996) Chemoprevention of lung and skin cancer by Beta vulgaris (beet) root extract. *Cancer Lett* 100(1–2):211–214
- Kaur C, Kapoor HC (2002) Anti-oxidant activity and total phenolics content of some Asian vegetables. *Int J Food Sci Technol* 37:153–161
- Khan MN, Lawhon JT (1980) Baking properties of oilseed protein and isolates produced with industrial membrane systems. *Cereal Chem* 57(6):433–436
- Kim YS, Wiesenborn DP (1995) Starch noodle quality as related to potato genotypes. *J Food Sci* 61:248–252
- Lawless HT, Heymann H (1998) Sensory evaluation of foods, principles and practices. Springer, New York
- Li HB, Cheng KW, Wong CC, Fan KW, Chen F, Jiang Y (2007) Evaluation of antioxidant capacity and total phenolic content of different fractions of selected microalgae. *Food Chem* 102:771–776
- Monge L, Cortassa G, Fiochi F, Mussino G, Carta Q (1990) Glyco-insulinaemic response, digestion and intestinal absorption of the starch contained in two types of spaghetti. *Diabetes Nutr Metab* 3: 239–246
- Mridula D, Kumar N, Jain D, Tyagi SK, Rai DR (2009) Effect of addition of beetroot powder on physical properties and acceptability of defatted soya flour fortified biscuits. *Indian J Nutr Diet* 46(2):59–69
- Mridula D, Singh KK, Patil RT (2010) Value added health mix from extrudates, beetroot and carrot powder. *Indian J Nutr Diet* 47:453–462
- Mridula D, Jain D, Singh KK, Patil RT, Gupta MK (2011) Physico-chemical and sensory quality of extruded snack foods developed from rice and defatted soy flour/ chickpea splits supplemented with dried beetroot. *J Agric Eng* 48(4):17–23
- Mridula D, Gupta RK, Khaira H, Bhadwal S (2015) Groundnut meal and carrot fortified pasta: optimization of ingredients level using RSM. *Proc Natl Acad Sci India Sect B Biol Sci*. doi:10.1007/s40011-015-0586-x
- Pitalua E, Jimenez M, Vernon-Carter EJ, Beristain CI (2010) Antioxidative activity of microcapsules with beetroot juice using gum arabic as wall material. *Food Bioprod Process* 88:253–258
- Purohit C, Rajyalakshmi P (2011) Quality of products containing defatted groundnut cake flour. *J Food Sci Technol* 48(1):26–35
- Rasic JL, Bogdanovic G, Kerenji A (1984) Anti-cancer properties of lactic acid-fermented beetroot juice. *Fluss Obst* 51(1):25–28
- Scherer R, Godoy HT (2009) Antioxidant activity index (AAI) by the 2, 2-diphenyl-1-picrylhydrazyl method. *Food Chem* 112:654–658
- Scherer R, Godoy HT (2014) Effects of extraction methods of phenolic compounds from *Xanthium strumarium* L. and their antioxidant activity. *Rev Bras Pl Med* 16(1):41–46
- Shenoy SF, Kazaks AG, Holt RR, Chen HJ, Winters BL, Khoo CS (2010) The use of a commercial vegetable juice as a practical means to increase vegetable intake: a randomized controlled trial. *Nutr J* 9: 38–49
- Singh S, Raina CS, Bawa AS, Saxena DC (2004) Sweet potato based pasta product: optimization of ingredient levels using RSM. *Int J Food Sci Technol* 39:191–200
- Singleton VL, Rossi JA (1965) Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents. *Am J Enol Vitic* 16:144–158
- Stintzing FC, Carle R (2007) Betalains - emerging prospects for food scientists. *Trends Food Sci Technol* 18:514–525
- Wootton-Beard PC, Ryan L (2011) A beetroot juice shot is a significant and convenient source of bioaccessible antioxidants. *J Funct Foods* 3:329–334
- Wootton-Beard PC, Moran A, Ryan L (2011) Stability of the total antioxidant capacity and total polyphenol content of 23 commercially available vegetable juices before and after in vitro digestion measured by FRAP, DPPH, ABTS and Folin–Ciocalteu methods. *Food Res Int* 44:217–224
- Yadav DN, Thakur N, Sunooj KV (2012) Effect of partially de-oiled peanut meal flour (DPMF) on the nutritional, textural, organoleptic and physico chemical properties of biscuits. *Food Nutr Sci* 3(4): 471–476
- Zhao G, Liu Y, Zhao M, Ren J, Yang B (2011) Enzymatic hydrolysis and their effects on conformational and functional properties of peanut protein isolate. *Food Chem* 127(4):1438–1443