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Original Research Article

Development of Low Glycemic Index Noodles by Legume and Cereal By-products Incorporation

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ABSTRACT

Agro-industrial waste is often utilized as feed or as fertilizers on farms. In the food industry the recovery and modification of the by-products is becoming increasingly important as they are considered as a promising source of functional ingredients. Hence an attempt was made to develop legume and cereal by-products based value added low glycemic index noodles. Among the developed by-product incorporated noodles namely Type-I (bengal gram seed coat+broken rice) and Type-II (bengal gram brokens+broken rice) scored high scores in terms of organoleptic acceptability. The best accepted variation of control, bengal gram seed coat, bengal gram brokens alone and in combination with broken rice were evaluated for its nutrient composition and glycemic index. The findings indicated significant increase in total, soluble and insoluble dietary fibre content and decrease in starch and sugar content in by-products supplemented noodles. The glycemic index of Type-I noodles (56.13) and Type-II noodles (45.78) were significantly less than control noodles (66.43). Thus, inclusion of legume and cereal by-products, as an ingredient in noodles, evidently provides a food with low glycemic response for the consumers use.

Keywords: Bengal gram and rice by-products. Noodles. Nutritional composition. Glycemic response

INTRODUCTION

By-products that are either a direct or an indirect result of legume and cereal processing or utilization have economic and social as well as nutritional importance. These by-products are often utilized as feed or as fertilizers on farms. Bengal gram is also called Chickpea or Gram (Cicer arietinum L.) in South Asia and Garbanzo bean in most of the developed world, is a major pulse crop in India. A large amount of by-products are produced during bengal gram processing in regions where this is a major food legume (Southern Europe, North Africa, India and Middle East countries). [1] These comprises of legume seed coat, powder, large and small brokens, shriveled and under-processed grains. Presently, these are disposed off only as feed grade material, fetching low remunerative prices. [2] Broken rice is also a by-product of rice milling industry is mainly used as feed and as a brewing adjunct. Most of these by-products are rich in protein, calcium, iron, zinc and fibre, so these can be utilized for making health foods for different age groups. [3] In recent years, the uses of legume husks gain importance as the ingredients in the formulation of various food products. The legume husks are rich in dietary fiber (80-93%) and calcium (32-50%), where the dietary fiber consists of about 27-47%, crude fiber and 47-60% nitrogen-free carbohydrate, [4] hence they plays significant role in preventing of certain disease such as constipation, diverticulitis, colon cancer, diabetes and coronary heart disease. These types of food fall in the category of low glycemic index.

Noodles are widely consumed throughout the world and their global consumption is second after bread. This is because noodles are convenient, easy to cook, low cost and have a relatively long shelf-life. Thus, noodle products which represent a major end-use of wheat, are suitable for enhancing the health after incorporating sources of fiber and essential nutrients. [5] The development of new products is a strategic area of the food industry. This provides an opportunity for the use of non-traditional raw materials to increase the nutritional quality of pasta. [6] Today's, consumers are demanding foods which are not only nutritionally superior but, also has health benefits, these kinds of food products are often called nutraceutical foods. The number of low-GI foods is very limited, and so a much wider range of low-GI products will be required to make a well-balanced low-GI diet practicable. [6] The objective of this work was to make a common type of noodles by substituting bengal gram seed coat alone and in combination broken rice as an ingredient, to achieve a nutritious, rich in dietary fibre, in order to diversify the range of available foods with low glycemic index. By keeping these facts in view, the present investigation was, therefore undertaken to explore the utilization of bengal gram and rice by-products for development of fibre enriched noodles and evaluated for their nutritional composition and glycemic response.

MATERIALS AND METHODS

Sample Collection & Processing Bengal gram (*Cicer arietinum* L.) seed coat, bengal gram brokens and broken rice were procured in a single lot from legume and cereal processing mills. Other ingredients for development of noodles were procured from local market. All the samples of by-products were cleaned and washed under running water and dipped in rolling boiling water for 10 min. These were dried in hot air oven at 50-60°C for 6 h. The dried samples were milled to fine powder and stored in air proof plastic ↓containers till further use.

Formulation of noodles Noodles prepared from refined wheat flour served as control. For formulation of by-products noodles various levels of replacement of control flour were made with various levels of seed coat and brokens of milled bengal gram along with broken rice flour.

Type of noodles	RF (g)	BGSC (g)	BRF (g)	Salt (g)	Water (ml)
Control (100% RF)	100	-	-	2	50
RF:BGSC					
90:10	90	10	-	2	54
80:20	80	20	-	2	58
70:30	70	30	-	2	62
RF:BGSC:BRF					
85:5:10	85	5	10	2	52
70:10:20	70	10	20	2	54
55:15:30	55	15	30	2	56
RF:BGB:BRF					
80:10:10	80	10	10	2	52
60:20:20	60	20	20	2	54
40:30:30	40	30	30	2	56

RF = Refined flour, BGSC = Bengal gram seed coat, BGB = Bengal gram brokens, BRF = Broken rice flour

Organoleptic evaluation of noodles The developed noodles were boiled till cooked, which was determined when there was no visible core in the noodle strand when pressed between two Plexi-glass sheets. [8] All the cooked noodles were organoleptically evaluated in terms of colour, appearance, flavor, texture and taste by the trained judges using 9-point Hedonic scale. On the basis of mean scores of sensory attributes, the most acceptable supplemented noodles were selected for further study.

Noodles were processed in a noodle making machine as described below:

Refined flour
↓
Dough making with the required level of water
↓
Roller compression: Dough passed through the noodle extruder
↓
Sheeting
↓
1. I Stage (4 mm thickness)
↓
2. II Stage (2 mm thickness)
↓
Cutting: dough sheet passed through noodle cutting machine
↓
Drying (at 55°C for 5 hrs)

Fig 1. Flow diagram of noodle processing

Sample Preparation for nutritional study: Freshly prepared samples of organoleptically most acceptable by-products supplemented and control noodles were dried in oven to a constant weight at 60^0C. The dried by-products and their control noodles were ground to fine powder in an electric grinder and stored in an air tight plastic container for further nutritional study.

Nutritional composition: Moisture and ash were estimated by using the standard methods of AOAC (2000). [9] Crude protein, crude fat and crude fibre were estimated using the Automatic instruments such as KEL PLUS, SOCS PLUS and FIBRA PLUS (Pelican Equipments, Chennai, India) by employing standard method of AOAC (2000). [9] Total soluble sugars were extracted by refluxing in 80% ethanol. [10] Starch from sugar free pallet was extracted in 52% perchloric acid at room temperature. [11] Quantification determinations of total soluble sugar and starch were carried out accordingly to colorimetric method. [12] Reducing sugars were estimated by Somogyi's modified method. [13] Non-reducing sugars were determined by calculating the difference between total soluble sugars and reducing sugars. Total, soluble and insoluble dietary fibre contents were determined by following the enzymatic method. [14] The sum of insoluble dietary fibre and soluble dietary fibre contents were calculated as total dietary fibre.

Glycemic response: Ten healthy adult volunteer aged 25 to 35 years, with normal Body Mass Index (BMI) calculated by the formula weight (kg) per height (m^2) [15] took part in this study. None of the subjects were under medication and all the subjects were also informed beforehand about the experiment and their voluntary consents were taken before conducting the experiment. Each subject consumed all the four test foods (glucose, control noodles, Type-I noodles and Type-II noodles) after an overnight fast. Each volunteer took part in the experiment on three non-successively days. On the first experimental day, subjects consumed glucose dissolved in 250 ml water (50 g carbohydrate). The second day, they ingested boiled control noodles (50 g carbohydrate), third day they ingested boiled

Type-I noodles (50 g carbohydrate) and last day they ingested boiled Type-II noodles (50g carbohydrate). Foods were eaten within 10–12 min and 250 ml of water was drunk with the meals. The blood samples were drawn and checked after 30, 60, 90 and 120 min for the postprandial glucose level. Blood samples were taken on test strips and analysed, with Accutrend-Sensor, for glucose. The glycemic index were calculated following the procedure of Jenkins et al. (1981) from the incremental blood glucose area in relation to the corresponding area obtained after glucose intake used as reference food. [16]

$$\textbf{Glycemic Index food products} = \frac{\textbf{Area under glucose curve of test meal}}{\textbf{Area under glucose curve of reference meal}} \times \textbf{100}$$

Statistical analysis: The data were statistically analyzed for analysis of variance in a completely randomized design to determine the critical difference (CD) among the products. [17]

RESULTS AND DISCUSSION

Proximate composition: Moisture content of both types of by-products supplemented noodles was higher than that of control noodles. In control noodles, it was 58.16% which increased to 59.28% in Type-I and 60.13% in Type-II supplemented noodles. Type-II supplemented noodles had significantly ($P<0.05$) higher (12.39%) protein content as compared to Type-I and control noodles. It might be due to high protein content of bengal gram brokens. Fat content of control noodles was 1.46%, which decreased significantly on blending with bengal gram seed coat and broken rice flour i.e. Type-I noodles.

Table 1. Proximate composition of noodles supplemented with by-products (%, dry weight basis)

Types of noodles	Moisture*	Crude protein	Crude fat	Crude fibre	Ash
Control	58.16±1.49	10.52±1.42	1.46±0.09	1.09±0.14	0.83±0.18
Type-I	59.49±1.03	9.53±1.12	1.25±0.12	2.54±0.17	1.64±0.21
Type-II	60.13±1.02	13.10±1.08	2.64±0.08	2.16±0.10	1.31±0.13

Values are mean ± SE of three independent determinations
*Moisture on fresh weight basis
Control (RF 100%) Type-I (RF:BGSC:BRF 85:5:10) Type-II (RF:BGB:BRF 60:20:20)
RF = Refined flour BGSC = Bengal gram seed coat BGB = Bengal gram brokens BRF = Broken rice flour

Whereas, fat content of Type-II noodles was significantly higher than control and Type-I noodles. Similarly, crude fibre content also increased significantly upon supplementation of by-products. The values for crude fibre in Type-I and Type-II noodles were 2.54 and 2.16%, respectively. Ash content was also found significantly higher in Type-I noodle. Similar results were also reported by earlier workers in noodles supplemented with legume seed coat or legume flour. [18,19]

Sugars and starch: The data regarding total, reducing and non-reducing sugars and starch content of noodles supplemented with bengal gram and rice by-products are shown in Table 2. Control and by-products supplemented noodles exhibited significant differences in the sugars content. The total, reducing and non-reducing sugar content of control noodles were 1.75, 0.26 and 1.49 g/100g, respectively. Type-II noodles contained significantly ($P<0.05$) lowest amounts of total soluble (1.35 g/100g), reducing (0.15 g/100g) and non-reducing (1.20 g/100g) sugar content. While, Type-I noodles had 1.53, 0.19 and 1.34 g/100g total soluble, reducing and non-reducing sugar content, respectively which were significantly lower than control noodles but, higher than Type-II noodles. Starch content of control noodles was 54.32 g/100g, which increased significantly on supplementation of bengal gram and rice by-products. The values of starch content were observed 49.43% in Type-I noodles and 64.41% in Type-II noodles. Lowest amount of starch content in Type-I noodles might be due to the supplementation of bengal gram seed coat.

Table 2. Carbohydrate content of noodles supplemented with by-products (g/100g, dry matter basis)

Parameters	Control noodles	Type-I noodles	Type-II noodles
Total soluble sugar	1.75±0.18	1.53±0.21	1.35±0.10
Reducing sugar	0.26±0.11	0.19±0.14	0.15±0.02
Non-reducing sugar	1.49±0.14	1.34±0.10	1.20±0.09
Starch	54.32±1.12	49.43±1.28	64.41±2.10
Total dietary fibre	5.86±0.20	9.10±0.47	8.98±0.35
Soluble dietary fibre	2.27±0.13	2.30±0.16	3.95±0.19
Insoluble dietary fibre	3.59±0.12	6.80±0.35	5.03±0.21

Values are mean ± SE of three independent determinations
Control (RF 100%) Type-I (RF:BGSC:BRF 85:5:10) Type-II (RF:BGB:BRF 60:20:20)
RF = Refined flour BGSC = Bengal gram seed coat BGB = Bengal gram brokens BRF = Broken rice flour

Dietary fibre: The results regarding total, soluble and insoluble dietary fibre content of noodles supplemented with bengal gram and rice by-products are shown in Table 2. All the dietary fibre constituents were found significantly (P<0.05) differed in all the three types of noodles. Control noodles exhibited 5.86, 2.27 and 3.59 g/100g, respectively total, soluble and insoluble dietary fibre contents. However, on incorporation of bengal gram seed coat, bengal gram brokens and broken rice flour in refined wheat flour significantly (P<0.05) increased the total, soluble and insoluble dietary fibre contents. Significantly higher amount of total (9.10 g/100g) and insoluble (6.80 g/100g) dietary fibre was found in Type-I noodles (bengal gram seed coat and broken rice flour) as compared to Type-II noodles (bengal gram brokens and broken rice). Whereas, soluble dietary fibre (3.95 g/100g) was found higher in Type-II noodles. The increase in insoluble dietary fibre content of Type-I noodles might be due to the fact that these by-products are rich in seed coat fractions which contained more insoluble type of dietary fibre. Likewise earlier study also reported that the addition of cereal brans resulted an increase in the dietary fibre contents of pasta. [20]

Glycemic response Data in respect to area under glucose curve and glycemic index of noodles supplemented with by-products is presented in Table 3 and blood glucose response of subjects to noodles in comparison to glucose load of 50 g is shown in Fig 1. The area under blood glucose response curve ranged from 3531 to 4738, 2991 to 4066 and 2243 to 3257 mg min/100ml in case of control, Type-I and Type-II noodles, respectively. The mean values of glycemic index of control, Type-I and Type-II noodles were observed as 66.43, 56.13 and 45.78, respectively. The glycemic index of both supplemented noodles was significantly (P<0.05) lower than the control noodles. The peak rise in blood glucose curve occurred at 30 minutes after the consumption of glucose as well as control, Type-I and Type-II noodles. The peak rise in blood glucose on feeding of glucose load was 173 mg/100 ml which was higher than the peak rise in blood glucose with control noodles (118.2 mg/100 ml), Type-I noodles (98.3 mg/100 ml) and Type-II noodles (103.4 mg/100 ml). After the peak rise, the blood glucose values started declining and reached the baseline value after 120 min.

Table 3. Clinical data of healthy subjects upon admission to the study, experimental fasting glucose levels and glycemic index (GI) of control and by-products supplemented noodles

Number of subjects	10 (5 males, 5 females)
Age (yrs)	28.5
Height (cm)	164
Weight (kg)	69.3
BMI (kg/m^2)	25.46
Fasting glucose (mg min/100ml)	5950.5
$GI_{control\ noodles}$	66.43
$GI_{Type\text{-}I\ noodles}$	56.13
$GI_{Type\text{-}II\ noodles}$	45.78

Values are mean of ten independent determinations

Both by-products supplemented noodles reduced the hyperglycemia peak and the total hyperglycemia phase (area under curve). Maximum plasma glucose was reached during the first 30 min, but the values were significantly lower for 45 min after by-products supplemented noodles consumption. This helped to keep glucose levels moderate for up to 120 min. This can be attributed to the fact that the by-products supplemented noodles are rich in complex carbohydrates and total dietary fiber as these compounds are more slowly digested, absorbed and metabolized, have been associated with a reduced risk of type- II diabetes and cardiovascular disease. [20,21]

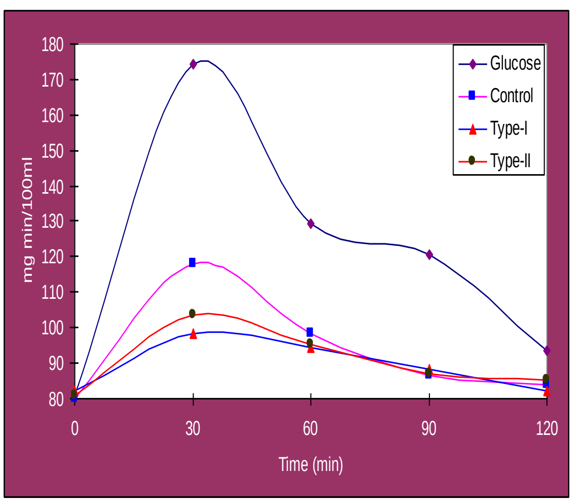

Fig. 2. Mean blood glucose concentration in healthy subjects after ingestion of control noodles, Type-I noodles and Type-II noodles in comparison to glucose load of 50 g.

CONCLUSION

Noodles incorporated bengal gram and rice by-products exhibited significantly higher values of protein, and dietary fibre also presenting a low glycemic response which could help broaden the range of low-GI foods available to the consumer. As consumers are becoming increasingly health conscious and are demanding natural and health-promoting foods. Therefore, utilization of unconventional sources like legume and cereal processing by-products needs further more exploitation in this direction.

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