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Glycemic response of *chapati* (Indian flat bread) developed from cereal pulse blends

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Abstract

The study was conducted to develop culturally acceptable low glycemic *chapati* (Indian flat bread) for diabetic patients. The acceptability, nutritional composition and glycemic index (GI) of the developed *chapati* were assessed. Oat, barley, soybean and chickpea flour were incorporated into the whole wheat flour, by using ten different flour combinations. The developed *chapati* was compared with corresponding control *chapatti*. The overall acceptability of *chapati* prepared from the blend of whole wheat flour with soybean (75 and 25%) and with whole wheat flour, barley and soybean in the proportion of 50, 25 and 25% was significantly ($p < 0.05$) higher as compared to control (whole wheat flour). The results of proximate analysis revealed a significantly ($p \leq 0.05$) higher fibre, protein and a significantly ($p \leq 0.05$) lower carbohydrate content in the developed *chapati*. The Glycemic Index of *chapati* prepared from whole wheat flour, barley and soy flour (50, 25 and 25%), had significantly ($p \leq 0.05$) lower GI (52). Increased protein and crude fiber content and decreased carbohydrates resulted in a significant ($p \leq 0.05$) reduction in the GI of *chapati*. It came in the category of low glycemic foods (< 55) as per WHO classification of low GI foods, hence it can be included in the regular diets of the diabetic patients to prevent further complications.

Keywords: Oat flour, barley flour, soy flour, chickpea flour, *chapati*, blood glucose, glycemic index

Introduction

Diabetes mellitus has become an important public health challenge. It is the main cause of death and disability throughout the world. Global prevalence of diabetes has doubled between 1980 and 2014 (IDF, 2013) [8]. According to the International Diabetes Federation, one in 11 adults had diabetes during 2015 and the number is expected to be one in 10 in 2040 (IDF, 2015) [7]. India is the member country one of the International Diabetes Federation SEA (South East Asia) region. International Diabetes Federation, 2017 has shown that globally 425 million people have diabetes and in the SEA region 82 million people have the disease; it could go up to 151 million by 2045. India is at the 2nd position after China with 72.9 million cases of Type 2 diabetes in the age group of 20-79 years and there are estimates that India will be at first position with 134.3 million cases of Type 2 diabetes by 2045 (IDF, 2017) [9].

Intake of refined carbohydrates has been increased over the years and it has shown the upward trend in the prevalence of obesity and type 2 diabetes in the US, indicating that the type of carbohydrate consumed may impact disease risk through alterations in postprandial blood glucose and insulin concentrations (Augustin *et al.* 2002 and Gross *et al.* 2004) [3, 5].

To account for these qualitative differences in carbohydrate type, the concept of glycemic index (GI) was developed by Jenkins *et al.* (2008) [10] as a physiologic rather than a structural approach for classifying carbohydrates. Glycemic index (GI) describes the blood glucose response after consumption of a carbohydrate containing test food relative to a carbohydrate containing reference food, typically glucose or white bread. GI was originally designed for people with diabetes as a guide to food selection, advice being given to select foods with a low GI. The amount of food consumed is a major determinant of postprandial hyperglycemia, and the concept of glycemic load (GL) takes account of the GI of a food and the amount eaten (Venn and Green 2007) [14]. The physiologic effect of a carbohydrate refers to the rate and magnitude in which dietary glucose enters the bloodstream after a meal, as well as the subsequent demand placed on the pancreas to secrete sufficient amounts of insulin to

normalize blood glucose levels. Thus, postprandial plasma glucose and insulin concentrations following consumption of carbohydrate is highly governed by the quality and quantity of carbohydrate consumed (Augustin *et al.* 2002 and Aston 2006) [3, 2]. A positive association was found between increased dietary GI and risk for coronary heart disease (Liu *et al.* 2000) [11], whereas lower dietary GI was associated with a reduced risk for the development of type 2 diabetes in men and women (Salmeron *et al.* 1997a and Salmeron *et al.* 1997b) [12, 13]. While several interventional studies have also reported beneficial effects of consuming low-GI diets. For this reason, there is interest in using these concepts for diet prescription so large interest has recently risen in the development of functional foods or products that can offer health benefit beyond the traditional nutrients. The present study was planned to develop low glycemic index *chapati* for diabetic patients.

Material and Methods

The present study was aimed to develop low Glycemic Index *chapati*. The material and methods used have been discussed here.

Procurement of food ingredients

The basic ingredients, whole wheat flour, and functional food ingredients like oat flour, barley flour, soy flour and chickpea flour were collected at one lot from the local market and stored in bins and used for the entire study.

Designing of blends

Chapaties were prepared from the blends of different flours of cereals and legumes. Oats, barley, soybean and chickpea flour have been reported to have low glycemic index (GI). Ten different blends were prepared by using the above grain flours in different proportions by incorporating in whole wheat flour. The proportions of different ingredients in each blend to be used to prepare *chapati* is given in Table 1

Table 1: Combinations for *chapatti*

	Whole Wheat flour (g/100g)	Oat flour (g/100g)	Soy flour (g/100g)
Control	100	-	-
Blend 1	25	50	25
Blend 2	50	25	25
Blend 3	75	-	25
Barley flour(g/100g)			
Blend 4	25	50	25
Blend 5	50	25	25
		Oat flour (g/100g)	Chickpea flour (g/100g)
Blend 6	25	50	25
Blend 7	50	25	25
Blend 8	75	-	25
Barley flour (g/100g)			
Blend 9	25	50	25
Blend 10	50	25	25

Development of chapati

Chapati was prepared using ten blends. The standardized recipes for control samples were prepared from whole wheat flour is given below. Blends were used to prepare test samples.

Chapati

Ingredients

Whole wheat flour: 100g

Water: Optimal

Method

1. Knead the flour into dough by adding water.
2. The dough was divided into equal portions and each portion of the dough was rounded off between the palms of hands and rolled into a *chapati* with the help of rolling pin.
3. The *chapatis* were baked on thick iron sheet (*tawa*) heated by gas flame at constant temperature.
4. One side of the *chapati* took 45 seconds for getting baked then it was turned and other side was baked for almost the same time.
5. It was turned again and pressed with a clean cloth moving the *chapati* in the circular motion till it become fluffy like a ball.

Organoleptic evaluation of chapati

The developed *chapatis* were evaluated organoleptically by a panel of 15 subjects comprising of students and faculty of department of Food and Nutrition, PAU, Ludhiana. Each *chapati* sample was prepared and tested thrice. The samples were coded to avoid any bias. The panelists were asked to score the samples for color, appearance, flavor, texture, taste and overall acceptability by using a score card of 9 point Hedonic Rating Scale.

The highly acceptable *chapati* along with its corresponding control were weighed, homogenized and oven dried at 60°C. Dried samples were stored in air tight plastic bags for proximate analysis.

Nutritional analysis

Moisture, total ash, crude protein, crude fibre, crude fat were assessed using standard methods.(AOAC 2000) [1] The content of carbohydrates was calculated by subtracting the sum of moisture, protein, ash, fat and crude fibre from 100. Carbohydrates = 100 - (Moisture + Protein + Fat + Ash + Fibre).

The energy content was calculated by factorial method.

Energy (Kcal) = (4×protein) + (9×fat) + (4×carbohydrate)

Glycemic index of the developed products

Glycemic index of *chapati* was estimated, through a scientific approach of determining the glucose response in healthy subjects through meal tolerance test.

The experiment was conducted in the department of Food and Nutrition, College of Home Science PAU Ludhiana. All the subjects were informed beforehand about the experiment and their voluntary consents were taken before conducting the experiment.

Selection of subjects

For each product 10 volunteer healthy non diabetic subjects in the age group of 20 to 40 y were selected. Assessment of glycemic response was done by taking finger prick capillary blood sample.

Glucose tolerance test

The subjects were asked to come for blood glucose test after overnight fast. On first occasion, 50 g carbohydrate in the form of glucose (reference) and on subsequent occasion test food (*chapati*) providing 50 g available carbohydrate was given to the subjects. Fasting blood glucose was checked. The volunteers were asked to consume test *chapati* within 10-12 minutes. The blood samples were drawn and checked after every half an hour interval for two hours for the post prandial

level. The blood glucose response curves were plotted for both oral glucose tolerance test and test product.

The glycemic index was calculated using the formula given by Wolever and Jenkins (1986) [17].

$$\text{Glycemic index} = \frac{\text{Area under glucose curve after test meal}}{\text{Area under glucose curve after reference meal}} \times 100$$

The Glycemic load (GL) was determined by the method of Salmeron *et al.* (1997). The GL was calculated based on the quantity of the recipe per serving and the respective available carbohydrate content. The following formula was used:

$$\text{Glycemic load} = \frac{\text{Available carbohydrates (g)} \times \text{GI}}{100}$$

Statistical analysis

The results of organoleptic scores, proximate analysis and glycemic index were statistically analyzed using analysis of variance technique and student's *t* test with the aid of Microsoft statistical analysis tool pack. The limit of probability fixed for the test of significance was $P=0.05$. Wherever the significant results were obtained, the critical difference was calculated.

Ethical issues

Informed consent was obtained before conducting the experiment before feeding food items and checking the blood glucose of human subjects. The privacy rights of human

subjects will always be observed.

Results and Discussion

The present study was conducted to evaluate the acceptability, nutritional composition and glycemic index of developed *chapati* s using different blends of whole wheat flour and legume flours.

Organoleptic evaluation of developed *chapati*

Chapaties were prepared using different blends (Table 1) and were evaluated organoleptically. The mean scores of colour, (Table 2) appearance, flavor, texture, taste and overall acceptability of 10 blends ranged from 7.33 to 8.06, 7.00 to 8.06, 6.73 to 7.87, 6.81 to 7.70, 7.85 to 6.67, 6.54 to 7.82 and maximum scores for colour and appearance (8.06) were observed with the blend of whole wheat flour, barley flour and soy flour in the proportion of 50, 25 and 25% followed by blend of whole wheat flour, barley flour and soy flour in the proportion of 25, 50 and 25 while for flavor, texture and taste maximum scores were observed in blend 3 containing whole wheat flour and soy flour (75 and 25%). The minimum scores (7.33) for colour were observed in blend containing whole wheat flour, oat flour and soy flour (25, 50 and 25%) and in blend 6 containing whole wheat flour, barley flour, chickpea flour in the proportion of 25, 50 and 25%.

The scores of overall acceptability were highest in control (8.03) followed by the blend containing whole wheat flour and soy flour in the proportion of 75 and 25% (7.82) and minimum in blend 6 (6.54). No significant difference was found in blend 3, 4 and 5 when compared with the control (Fig 1).

Table 2: Organoleptic scores of *chapati* using different blends

	Flour combinations	Amount (g/100g)	Colour	Appearance	Flavor	Texture feel	Taste	Overall acceptability
Blend 1	Whole wheat flour+Oat+Soybean	25+50+25	7.33±0.83	7.17±0.91	6.73±1.18	7.17±1.03	6.89±0.95	7.04±0.80
Blend 2	Whole wheat flour+Oat+Soybean	50+25+25	7.75±0.81	7.58±1.08	7.25±1.11	7.44±1.00	7.50±0.85	7.53±0.77
Blend 3	Whole wheat flour+Soybean	75+25	7.89±0.62	7.80±0.76	7.87±0.63	7.70±0.73	7.85±0.64	7.82±0.53
Blend 4	Whole wheat flour+Barley+Soybean	25+50+25	8.00±0.53	7.97±0.45	7.69±0.95	7.67±0.79	7.81±0.89	7.80±0.65
Blend 5	Whole wheat flour+Barley+Soybean	50+25+25	8.06±0.53	8.06±0.33	7.69±0.89	7.69±0.67	7.75±0.77	7.81±0.61
Blend 6	Whole wheat flour+Oat+Chickpea	25+50+25	7.33±1.12	7.00±0.99	6.81±0.12	6.81±0.14	6.67±1.07	6.54±0.90
Blend 7	Whole wheat flour+Oat+Chickpea	50+25+25	7.44±0.88	7.22±0.90	7.28±0.88	7.28±0.78	7.03±0.81	7.26±0.71
Blend 8	Whole wheat flour+Chickpea	75+25	7.56±0.88	7.28±1.00	7.32±0.86	7.46±0.44	7.32±0.96	7.38±0.84
Blend 9	Whole wheat flour+Barley+Chickpea	25+50+25	7.36±1.10	7.17±1.06	7.11±1.26	7.14±0.20	7.11±1.06	7.29±0.96
Blend 10	Whole wheat flour+Barley+Chickpea	50+25+25	7.61±0.84	7.58±0.65	7.22±0.93	7.47±0.81	7.28±1.30	7.56±0.82
Control	Whole wheat flour	100	7.97±0.36	7.97±0.43	8.03±0.33	8.01±0.32	8.05±0.35	8.03±0.25
CD at 5%			0.24	0.25	0.27	0.26	0.26	0.22

Values are presented as Mean± SD

Key to scores: 9= Like extremely, 8= Like very much, 7= Like moderately, 6= Like slightly, 5= Neither like or nor

dislike, 4= Dislike slightly, 3= Dislike moderately, 2= Dislike very much, 1= Dislike extremely

Fig 1: Overall acceptability scores of *chapatis* prepared from different blends

Proximate composition of most acceptable chapati sample

The proximate composition of most accepted *chapatti* has been given in Table 3.

Chapati

The *chapatties* prepared from blend 3 comprising of whole wheat flour and soy flour (75 and 25%) and blend 5 comprising of whole wheat flour, barley flour and soy flour (50, 25 and 25%) had higher overall acceptability, so were selected for proximate analysis. The comparison of the proximate principles of blends with the control (whole wheat flour) was made.

The results revealed that the moisture content of blend 3 and 5 had significantly ($p < 0.05$) lower moisture content i.e. 1.71 and 1.63 g /100 g, respectively as compared to the control

(2.58g/100g) but no significant difference in moisture content was found between two blends (Table 3). The ash content was found to be significantly more in blend 3 (2.40g/100g) and blend 5 (2.55g/100g) when compared with the control (1.4g/100g) but no significant difference in ash content was observed between the two blends. The high ash content of *chapatties* prepared from two blends was attributed to the supplementation of soy flour.

Similarly, the crude fibre content of the blend 3 and blend 5 was found to be significantly more i.e. 1.47 and 1.16g/100g, respectively when compared to the control (0.79g/100g) but the difference between the two blends was found to be non-significant. Sharma (2009) ^[14] observed that the test *missi roti* supplemented with 30% oats had 3% moisture, 0.9% ash, 16.9% crude protein, 3% fat and 5.4% crude fibre.

Fig 2: Proximate composition of selected blends of *chapati* (g/100g on fresh weight basis)

Blend 3: whole wheat flour, soy flour (75+25), Blend 5: whole wheat flour, barley flour and soy flour (50+25+25), Control: whole wheat flour

Table 3: Proximate composition of selected blends of *chapati* (g/100g on dry weight basis)

Blends	Flour combinations	Amount (g/100g)	Moisture	Total Ash	Crude Fibre	Crude Fat	Crude Protein	Carbohydrate	Energy (kcal)
Blend 3	Whole wheat flour+Soybean	75+25	1.71±0.05	2.4±0.06	1.47±0.08	6.08±0.25	16.09±0.06	72±0.12	408
Blend 5	Whole wheat flour + Barley + Soybean	50+25+25	1.63±0.13	2.55±0.06	1.16±0.20	7.65±0.15	16.88±0.16	70±0.03	417
Control	Whole wheat flour	100	2.58±0.46	1.45±0.09	0.79±0.25	1.66±0.00	11.18±0.59	82±0.29	389
CD at 5%			0.82	0.21	0.57	0.50	1.05	0.55	4.25

The fat content of blend 3 and blend 5 was found to be significantly more when compared to the control. The crude protein content of blend 3 and blend 5 was significantly ($p<0.05$) more i.e. 16.09 and 16.88g/100g as compared to the control. (11.18g/100g) but no significant difference was found between two blends. The increase in fat and protein content was due to the incorporation of soy flour.

The available carbohydrates were 72.25 and 70.13g/100g in blend 3 and 5 which were significantly lower than control (82.43g/100g). The purpose to develop the products from these blends was to lower the carbohydrate content and ultimately the lower GI. The energy content of *chapaties* from blend 3 and blend 5 was 408 and 417 Kcal/100g.

On fresh weight basis, *chapaties* from blend 3 and 5 had 1.7% ash and 11.5% protein which were higher than the control. Besides this crude fibre, fat and energy was higher than the control recipe (Fig 2).

The findings concluded that supplementation of whole wheat flour with barley and soy flour significantly reduced carbohydrates and increased ash, fibre, fat and protein contents. Moreover these blends had higher acceptability, hence *chapaties* prepared from the blends of these flours will be suitable for the diabetics.

Glycemic index of control and test *chapati*

The glycemic index of control and test *chapati* is presented in Table 4.

The fasting blood glucose ranged from 67 to 112, 83 to 88 and 75 to 83, respectively, in case of reference (glucose), control *chapati* (whole wheat flour) and test *chapati* (blend 5 comprising of wheat flour, barley flour and soy flour 50, 25 and 25%)(Plate 1). The peak rise in blood glucose after half an hour, 1 hour, 1 hour 30 minutes and 2 hours ranged from 90 to 162, 96 to 142, 96 to 127 and 83 to 119 in case of reference glucose (Fig 3). It ranged from 86 to 101, 109 to 115, 90 to 119 and 85 to 103 in case of control *chapati*. Further in case of test *chapati* it ranged from 70 to 116, 85 to 99, 92 to

103 and 85 to 94 mg/dl respectively. It is evident from Table 4 and Fig. 3 that the blood glucose curve declined sharply in case of glucose (reference) where as a slow decline was observed in case of developed *chapati*. This could be due to the slow release of glucose. It could be due to the fact that the developed *chapati* (test *chapati*) is rich in complex carbohydrates and total dietary fiber which takes time for digestion and digests at a much slower rate than the free sugars. This would be beneficial for diabetics as satiety value for this *chapati* would be high. The glycemic index was found lower in test *chapati* (51.95) compared to glycemic index of control *chapati* (61.24) (Table 4).

Table 4: Glycemic index of control and test products

Product	Quantity administered (grams)	GI	GI Category
<i>Chapati</i> (control)	92	61.24	Moderate
<i>Chapati</i> (test)	104	51.95	Low

Control *chapati*: Whole wheat flour (100) Test *chapati*: Whole wheat flour, barley flour, Soy flour (50+25+25)

Plate 1: *Chapati*

The lowering of glycemic index in *chapati* can be attributed to the addition of legumes which contains 5-10% more amylose compared to cereal grains and this amylose is more resistant to digestion. With the incorporation of legumes, the protein content had increased and higher amount of proteins may

physically encapsulate starch, preventing the enzyme access (Holm *et al.* 1989)^[6]. Apart from this the crude fibre had also increased in test chapati. Dietary fibre inhibits starch digestibility by increasing the viscosity of intestinal contents and slow down the absorption of carbohydrates from the food (Wolever 1990)^[16].

Fig 3: Mean blood glucose curves after consumption of glucose, control chapati and test chapati containing 50g carbohydrates

Table 5: Glycemic load of developed products

Product	GI	Normal serving size (g)	Available carbohydrate (g)	Glycemic load (GL)
Chapati (control)	61.24	40	22	13.47
Chapati (test)	51.95	40	19	9.87

Table 5 displays that the mean GI and GL of the supplemented chapati was significantly lower as compared to the control chapati. Anything with GI value of 70 or more is a high GI food, moderate GI foods ranged from 56 to 69 and low GI foods have scores from 0 to 55 (Foster Powell *et al.* 2002)^[4]. Whole wheat based chapati comprising of wheat flour, barley flour and soy flour (50,25 and 25%) with 51.95 glycemic index had 9.29% lower GI units when compared with control. It would have importance in north India where wheat is the staple food. Increase in protein and crude fiber and decrease in carbohydrates were responsible for lowering the glycemic value of the developed chapati. The developed chapati can be included in the regular diets of diabetics for the management of diabetes and to avoid any further complications.

Conclusion

The present study was conducted to develop the low GI chapati (Indian flat bread) and to evaluate the acceptability, nutritional composition and glycemic index of it. Oat, barley, soybean and chickpea flour were incorporated in the whole wheat flour to make chapati, by making 10 combinations of these flours. Ten samples of each product were prepared including a control. Maximum scores for colour and appearance (8.06) were observed in blend of wheat flour, barley flour and soy flour in the proportion of 50, 25 and 25%. The results of proximate analysis revealed a significantly ($p \leq 0.05$) higher fibre, protein and a significantly ($p \leq 0.05$) lower carbohydrate content in the developed chapati. The Glycemic Index of chapati prepared from whole wheat flour, barley and soy flour (50, 25 and 25%), had significantly ($p \leq 0.05$) lower GI (52) with 9.29% lower GI units. Thus it could be a healthy alternative for diabetic patients to manage the disease and to prevent further complications.

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