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Nutritional analysis and glycemic response of *Idli* developed from cereal pulse blends

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Abstract
The study was conducted to develop culturally accepted low glycemic food for the patients of diabetes mellitus. The acceptability, nutritional composition and glycemic index (GI) of the developed *idli* were assessed. Oat, barley, soybean and chickpea flour were incorporated into the semolina to prepare *idli* by using ten flour combinations. The developed *Idli* was compared with control *idli* prepared from semolina. *Idli* prepared from semolina and blended with either soybean or chickpea (75 and 25%) had the highest acceptability score. 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 *idli* from selected blends. The GI of *Idli* prepared from semolina and soy flour (75 and 25%) had significantly lower GI(74.17) as compared to GI of control *idli*(100). Increased protein and crude fiber content and decreased carbohydrates resulted in a significant ($p \leq 0.05$) reduction in the GI of all the developed *idli*.

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

Introduction
Prevalence of chronic degenerative diseases has been increased over the last few years, especially type 2 diabetes mellitus (Shah and Mohan 2015) [13]. It is due to the increased intake of refined foods and simple sugars (WHO, FAO, 1998) [15]. Cereals are the staple diet of South Indians and carbohydrate comprise around 55–65% of their daily intake of calories. There has been a change in the quality of cereal grains consumed from whole cereal grains to highly polished ones. Consumption of whole cereals or grains is always encouraged unlike refined grains, which consist mainly of endosperm that have found to stimulate undesirable effect on the cardio-metabolic risk factors including diabetes (Radhika *et al.* 2009) [10].
The concept of glycemic index (GI) was developed by Jenkins *et al.* (2008) [6] as a physiologic approach for classifying carbohydrates. Glycemic index (GI) describes the blood glucose response after consuming carbohydrate containing test food relative to reference food containing carbohydrate which could be glucose or white bread. GI was originally calculated for people with diabetes as a guide to food selection, advice was given to choose foods with a low GI. The quantity 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 into the bloodstream after having a meal, as well as the subsequent demand from the pancreas to secrete insulin to normalize the 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].
Pavithran *et al.* (2020a) [9] investigated that Low GI local south Indian recipes showed significant reduction ($p < 0.05$) of truncal obesity and glycated hemoglobin. A positive association has been found between increased dietary GI and risk for coronary heart disease (Liu *et al.* 2000), 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) [9, 8]. Pavithran *et al.* (2020b) [8] found that long-term implementation of Low Glycemic Index diet of Kerala cuisine promote weight loss, enhance insulin sensitivity and reduce the cardiovascular risk. There is need to increase the intake of complex carbohydrates with low glycemic index. (Korrapati *et al.* 2018) [7] The present study was designed to develop low GI *idli*, and to assess its nutritional composition.

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

Procurement of food ingredients
The basic ingredients, semolina 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
Idli was 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 semolina. The proportions of different ingredients in each blend to be used to prepare *idli* is given in Table 1.

Table 1: Combinations for *Idli*

	Semolina (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

IDLI
Ingredients

Semolina	100 g
Curd	100 g
Onion	50 g
Tomato	50 g
French beans	50 g
Capsicum	50 g
Eno salt	1 sachet
Salt	5 g
Oil	10 g

Method
1. Wash and finely chop onion, tomato, french beans and capsicum.
2. Add salt and eno salt to the semolina.
3. Add curd to make a batter of thick semi-solid consistency. Mix well.
4. Greece *idli* stands with oil and put small portion of the batter on them.
5. Pour water in the pressure cooker for steam. Place the stand into it and cover the lid and remove the whistle of lid.
6. Cook it for 15 minutes on low flame. Then remove the *idlies* from the stand after they get cool.
7. Cut into pieces of required size and toss them in sautéd vegetables.

Organoleptic evaluation of developed products
The developed *idli*es were evaluated organoleptically by a panel of 15 subjects comprising of students and faculty of department of Food and Nutrition, PAU, Ludhiana. 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 *idli* sample along with control sample 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 *idli*
Glycemic index of *idli* 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 (*idli*) providing 50 g available carbohydrate was given to the subjects. Fasting blood glucose was checked. The volunteers were asked to consume test *idli* 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 (*idli*).
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:

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

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 *idli* using different blends of semolina and legume flours.

Organoleptic evaluation of developed *idli*

In *Idli*, the mean scores of colour, appearance, flavor, texture, taste and overall acceptability ranged from 6.29 to 7.87, 6.29 to 7.83, 6.38 to 7.93, 6.15 to 7.75, 6.29 to 7.86 and 6.81 to 7.79 respectively. Maximum scores in colour, appearance, flavor, texture, taste and overall acceptability were in blend 3 containing semolina and soy flour (75 and 25%) (Table 2 and Fig 2).

No significant difference in blend 3 containing soy flour and semolina (75 and 25%) and control sample of *idli* was found but other blends had significantly ($p< 0.05$) lower scores.

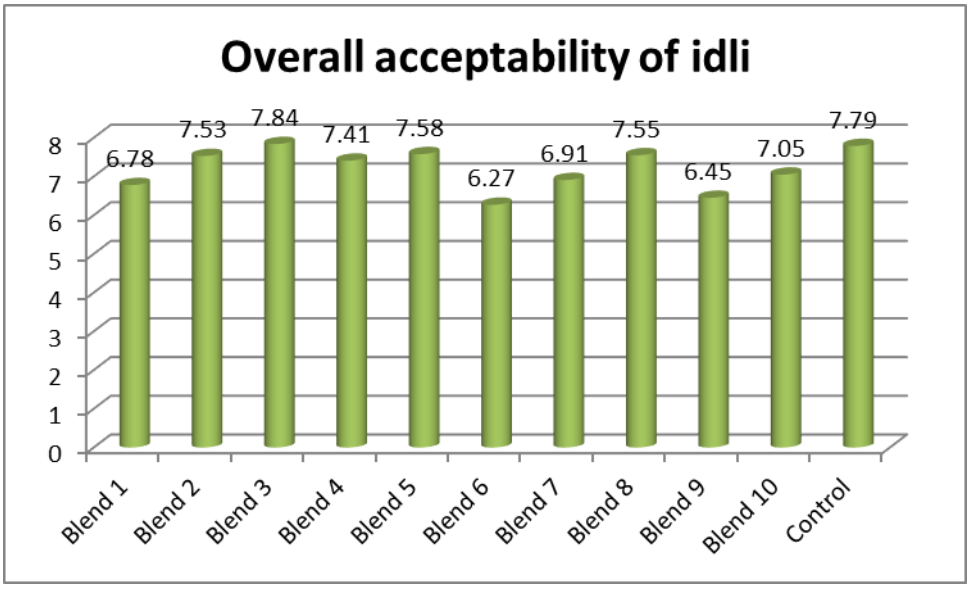

Fig 1: Overall acceptability of 10 blends of *idli*

Proximate composition of most acceptable *idli*

The *idli* prepared from blend 3 comprising of semolina and soy flour (75 and 25%) and blend 8 comprising of semolina and chickpea flour (75 and 25%) had higher overall acceptability scores so were selected for proximate analysis.

The samples of *idli* from blend 3 and 8 had higher moisture content (3.74 and 4.9g/100g) than control (3.62g/100g) but significant difference was only with blend 8 (Table 3).

Table 2: Organoleptic scores of developed blends of *idli*

Blend	Flour combinations	Amount (g/100g)	Colour	Appearance	Flavor	Texture feel	Taste	Overall acceptability
Blend 1	Semolina+Oat+Soybean	25+50+25	6.88±1.01	6.71±1.29	6.88±1.25	6.74±1.40	6.85±1.37	6.78±0.99
Blend 2	Semolina +Oat+Soybean	50+25+25	7.59±0.92	7.38±0.82	7.65±1.01	7.50±1.05	7.50±1.11	7.53±0.81
Blend 3	Semolina +Soybean	75+25	7.87±0.74	7.83±0.88	7.93±0.69	7.75±1.01	7.86±0.71	7.84±0.60
Blend 4	Semolina +Barley+Soybean	25+50+25	7.47±1.02	7.29±1.06	7.41±1.13	7.35±1.18	7.53±0.99	7.41±0.84
Blend 5	Semolina +Barley+Soybean	50+25+25	7.38±0.92	7.53±0.90	7.65±1.01	7.65±0.88	7.68±1.01	7.58±0.76
Blend 6	Semolina +Oat+Chickpea	25+50+25	6.29±1.36	6.29±1.43	6.44±1.31	6.15±1.33	6.29±1.34	6.27±0.14
Blend 7	Semolina +Oat+Chickpea	50+25+25	6.94±1.13	6.88±1.12	6.94±0.98	6.91±1.19	7.03±1.11	6.91±0.90
Blend 8	Semolina+Chickpea	75+25	7.45±1.09	7.47±1.19	7.49±0.95	7.64±1.09	7.70±1.01	7.55±0.82
Blend 9	Semolina +Barley+Chickpea	25+50+25	6.47±1.48	6.47±1.42	6.38±1.46	6.44±1.37	6.50±1.35	6.45±1.15
Blend 10	Semolina +Barley+Chickpea	50+25+25	7.12±1.01	7.09±1.08	6.88±1.15	7.06±1.04	7.12±1.12	7.05±0.84
Control	Semolina	100	7.91±0.51	7.82±0.54	7.89±0.46	7.90±0.55	7.91±0.50	7.79±0.55
CD at 5%			0.26	0.33	0.32	0.34	0.32	0.26

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

The ash content of *idli* was significantly more in blend 3 and 8 (9.55 and 6.77g/100g) when compared with control. Between samples *idli* from blend 3 had significant more ash content. The crude fibre content of *idli* was 1.18 and 1.45g/100g in blend 3 and 8 respectively. Both test samples contained significantly more fibre than control sample (0.52g/100g). Blend 3 had the maximum fat content 9.31g/100g which was significantly higher than the control (6.34g/100g) but no significant difference was observed with *idli* of blend 8.

The protein content was 15.68 and 13.78g/100g in *idli* from blend 3 and 8 respectively. The protein content of the test blends was significantly ($p< 0.05$) more when compared with the control samples. The available carbohydrate content was 60.51 and 65.96 g/100g in *idli* from blend 3 and 8 which was significantly lower than the control sample (72.43g/100g),

significant ($p< 0.05$) difference was also observed between two test samples. The energy content of blend 3 and 8 was 389 and 383 kcal/100g whereas in control it was 394 Kcal/100g. Sharma (2009) observed that *idli* having 15% oat supplementation had 5% moisture, 0.54% ash, 9.6% crude protein, 1.8% crude fibre and 3.9% fat. On fresh weight basis the total ash, crude fibre, crude protein and crude fat content was higher in the blend 3 and 8 as compared to the control (Fig 2).

The findings concluded that supplementation of semolina with soy flour and chickpea flour significantly reduced carbohydrates and increased ash, fibre, fat and protein contents.

Table 3: Proximate composition of selected blends of *idli* (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	Semolina+Soybean	75+25	3.74±0.06	9.55±0.11	1.18±0.04	9.31±0.32	15.68±0.62	61±0.311	389
Blend 8	Semolina+Chickpea	75+25	4.9±0.03	6.77±0.10	1.45±0.11	7.14±0.09	13.78±0.05	66±0.3195	383
Control	Semolina	100	3.62±0.02	5.39±0.40	0.52±0.02	6.34±0.34	11.70±0.44	72±0.4956	394
CD at 5%			0.13	0.73	0.20	0.81	1.30	1.14	6.26

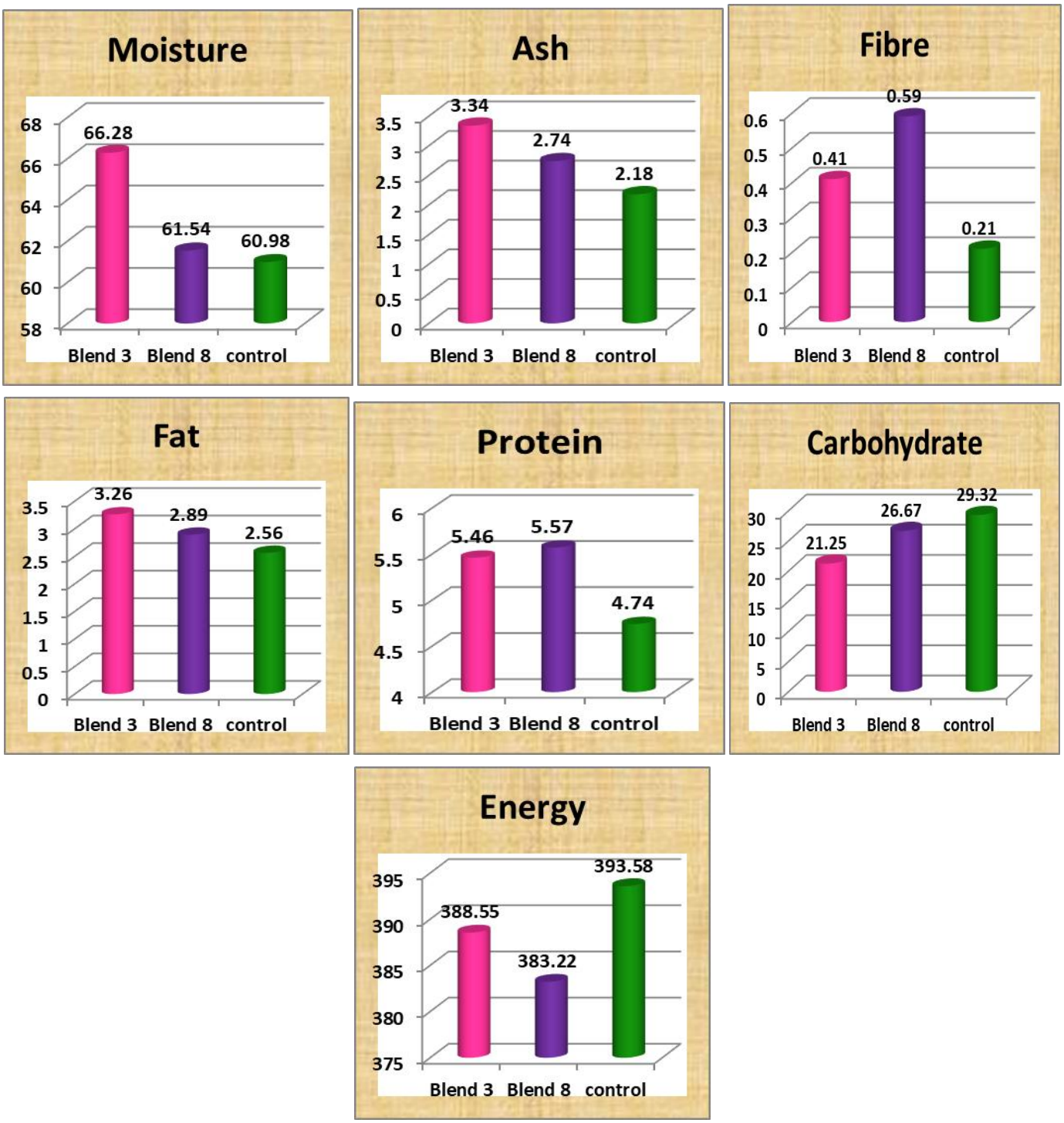

Fig 2: Proximate composition of selected blends of *idli* (g/100g on fresh weight basis) Blend 3: semolina, soy flour (75+25%), Blend 8: semolina, chickpea flour (75+25%), Control: semolina (100%)

Glycemic index of developed *idli*

The glycemic index of control and test blends of *idli* 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), In case of *idli* (Plate 1) the peak rise in blood glucose after half an hour, 1 hour, 1 hour 30 minutes and 2 hour ranged from 93 to 123, 106 to 129, 103 to 115, 86 to 109mg/dl for control and for test *idli* (combination of semolina and soy flour in the proportion of 75 and 25%)(Fig. 3). The range was 98 to 114, 90 to 132, 90 to 112, 95 to 101mg/dl, the GI of test *idli* was 74.17 which was lower than the control *idli* (100).

The lowering of glycemic index in the developed *idli* can be attributed to the addition of soy flour which contains 5-10% more amylose as compared to cereal grains and amylose is more resistant to digestion. With the incorporation of soy flour, the protein content had increased and higher amount of proteins may physically encapsulate starch, preventing the enzyme access (Holm *et al*. 1989) [15]. Besides this, the crude fibre had also increased in *idli*. Dietary fibre inhibits starch digestibility by increasing the viscosity of intestinal contents and slow down the absorption of carbohydrates from the diet (Wolever 1990) [16]. There was decrease of 25.83 GI units in the test *idli*.

Table 4: Glycemic index of control and test *idli*

Product	Quantity administered (grams)	GI	GI Category
Idli (control)	170.5	100	High
Idli (test)	235	74.17	Moderate

Control *idli*: Semolina (100) Test *idli*: Semolina, soy flour (75+25)

Plate 1: *Idli*

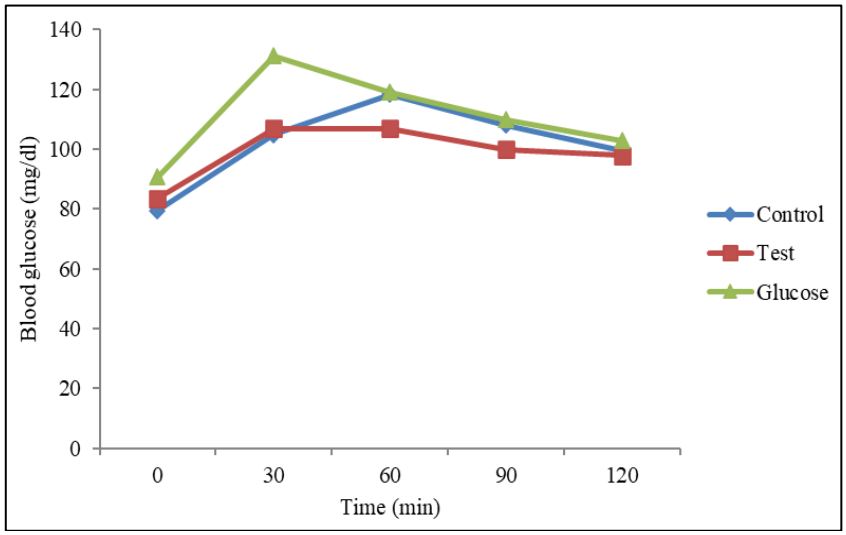

Fig 3: Mean blood glucose curves after consumption of glucose, test *idli* and control *idli* containing 50g carbohydrates

Table 5: Glycemic load of developed *idli*

Product	GI	Normal serving size (g)	Available carbohydrate (g)	Glycemic load (GL)
Idli (control)	108.17	80	23	24.88
Idli (test)	74.17	80	17	12.61

Table 5 displays that the mean GI and GL of the supplemented *idli* was significantly lower as compared to the control samples. 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].

Increase in protein and crude fiber and decrease in carbohydrates were responsible for lowering the glycemic value of the developed *idli*. There was decrease of 25.83 GI units and significant reduction in Glycemic load.

Conclusion

The present study was conducted to develop the low GI *idli* and to evaluate the acceptability, nutritional composition and glycemic index of it. Oat, barley, soybean and chickpea flour were incorporated in the semolina to make *idli*, by making 10 combinations of these flours. Ten samples of *idli* were prepared including a control. The *idli* prepared from blend 3 comprising of semolina and soy flour (75 and 25%) and blend 8 comprising of semolina and chickpea flour (75 and 25%) had higher overall acceptability scores so were selected for

proximate analysis. Results of proximate analysis revealed that supplementation of semolina with soy flour and chickpea flour significantly reduced carbohydrates and increased ash, fibre, fat and protein contents. The rise in blood glucose after half an hour, 1 hour, 1 hour 30 minutes and 2 hour ranged from 93 to 123, 106 to 129, 103 to 115, 86 to 109mg/dl for control and for test *idli* (combination of semolina and soy flour in the proportion of 75 and 25%) the range was 98 to 114, 90 to 132, 90 to 112, 95 to 101mg/dl, the GI of test *idli* was 74.17 which was significantly lower than the control *idli* (100).The mean GI and GL of the supplemented product was significantly lower as compared to the control sample.

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