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Nutritional composition and glycemic response of *Mathi* developed from cereal pulse blends

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Abstract
The study was conducted to develop culturally accepted low glycemic *mathi* for the patients of diabetes mellitus. The acceptability, nutritional composition and glycemic index (GI) of the developed *mathi* were assessed. Oat, barley, soybean and chickpea flour were incorporated into the refined wheat flour to prepare *mathi* by using ten flour combinations. Blend of refined wheat flour with soy flour or chickpea flour (75 and 25%) and another blend of refined flour with barley and soy flour (50, 25 and 25%) had the highest acceptability for *mathi*. 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 products prepared from selected blends. The *mathi* prepared from refined flour in combination with barley and soy flour (50, 25 and 25%), had moderate Glycemic Index (60.6). Hence it can be an alternative snack for diabetic patients.

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

Introduction
IDF (International Diabetes Federation) Diabetes atlas Ninth edition 2019 has shown that globally the prevalence of the diabetes in 2019 was 463 million (adults of age 20-79 years) is estimated to rise to 700 million in 2045. (IDF Diabetes Atlas Ninth edition 2019). India is the member country of the seven countries of the IDF SEA (South East Asia) region. Globally 463 million people have diabetes and 88 million people in the SEA region have the disease; it could increase to 153 million by 2045. India is at number two position after China with 77 million cases of Type 2 diabetes (T2DM). Shah and Mohan 2015 observed that the clinical profile of type 2 diabetics in Asian Indians is different from Caucasians as Asian Indians have higher central obesity, greater insulin resistance, beta cell function at an early age.
The use of whole-grain or traditionally processed cereals and legumes has been associated with improved glycemic control in both diabetic and insulin-resistant individuals. Long-term cohort studies have indicated that whole-grain consumption reduces the risk of both type 2 diabetes and cardiovascular disease. Pulses are a very good source of protein and good source of dietary fiber contain slow release carbohydrates which makes them foods of low glycemic values. A meal consisting of combination of cereal pulse mixes are found to be more effective than the only cereal diet (Bijlani 1993) [2]. Paharia and Ray (2017) [9] have also found that moisture and fiber content also exert impact on the postprandial blood glucose levels and insulin levels. Both the amount and type of carbohydrate can play an important role in weight management and risk of chronic diseases (Turner-McGrievy *et al* 2011) [13]. Classifying carbohydrates according to their postprandial glycemic effect (i.e. the glycemic index of foods) has yielded more useful insights than the historical distinctions of simple vs. complex chemical structure. Diets based on carbohydrates that are more slowly digested and absorbed (i.e. low glycemic index diets) have been independently linked to reduced risk of type 2 diabetes, CVD and some type of cancer (Marsh and Brand Miller, 2008) [7]. For this reason, there has been a growing interest in using these concepts for nutritional assessment and diet prescription so large interest has recently risen in the development of functional foods, products that may provide a health benefit beyond the traditional nutrients.
Though the GI of different food ingredients is extensively studied, a need for development of “Ready to eat” foods for diabetics hold significance in the present scenario when people have busy life styles with lesser time available for elaborative food preparations. The study is planned to develop the functional food which take care of blood glucose levels of the diabetics along with being acceptable and convenient. Sufficient work has been carried out abroad on the development of low GI foods however not much review is available on the development of

low GI foods which could be accepted by the diabetic patients from Indian origin. The present study was designed to develop low GI or moderate GI food for diabetic patients.

Material and Methods

Procurement of food ingredients

The basic ingredients, refined 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

Mathis 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 refined wheat flour. The proportions of different ingredients in each blend to be used to prepare *mathi* is given in Table 1

Table 1: Combinations for *mathi*

	Refined 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 *mathi*

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

Mathi

Ingredients

Refined wheat flour	100 g
Fat	40 g
Salt	5 g
Ajwain	2g
Water	optimum

Method

1. Add *ajwain* and salt to the flour.
2. Rub *ghee* and flour with palms to make a uniform texture.
3. Knead a hard dough using small amount of water.
4. Make small balls of kneaded dough and flatten on pan or with the help of rolling pin.
5. Prick them with fork.
6. Deep fry in oil on medium flame.

Organoleptic evaluation of *mathi*

The developed *mathis* were evaluated organoleptically by a panel of 15 subjects comprising of students and faculty of department of Food and Nutrition, PAU, Ludhiana. Each *mathi* 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 *mathi* along with its corresponding control were weighed, homogenized and oven dried at 60ºC. 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 *mathi*

Glycemic index of *mathi* 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(*mathi*) providing 50 g available carbohydrate was given to the subjects. Fasting blood glucose was checked. The volunteers were asked to consume test *mathi* 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) [15].

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

The Glycemic load (GL) was determined by the method of Salmeron *et al*. (1997) [10]. 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 *mathi*s using different blends of refined wheat flour and legume flours.

Organoleptic evaluation

The mean scores for sensory characters in *mathi* are presented in the Table 2. The average scores of colour, appearance, flavor, texture, taste and overall acceptability in *mathi* prepared by using different blends ranged from 6.68 to 7.88, 6.85 to 7.80, 6.79 to 7.74, 6.79 to 7.85, 6.85 to 7.85 and 6.81 to 7.79, respectively. Maximum scores for colour, texture, taste and overall acceptability were observed in blend 5 but for appearance and flavor in blend 8.

The minimum scores in the overall acceptability were in blend 1 containing refined wheat flour, oat flour and soy flour (25, 50 and 25%). Blend 3 containing refined wheat flour and soy flour (75 and 25%), blend 5 containing refined wheat flour, barley flour and soy flour (50,25 and 25%) and 8 containing refined wheat flour and chickpea flour (75 and 25%) had higher scores when compared to the control but the difference was non-significant (Fig 1).

In *mathi*, the blend 3 containing refined wheat flour and soy flour (75 and 25%), blend 5 containing refined wheat flour, barley and soy flour (50, 25 and 25%) and blend 8 containing refined wheat flour and chickpea flour (75 and 25%) were found to have more scores for overall acceptability in sensory evaluation when compared with the control. Shah (2005) [12] developed *mathi* using 20, 30 and 40% defatted soy flour where 20% was most acceptable with a score of 7.73. Mittal (2011) [8] observed highest mean score (7.18) in *mathi* containing 35% oats, 25% rice flour, 10% *urad dal* and 30% *besan.*

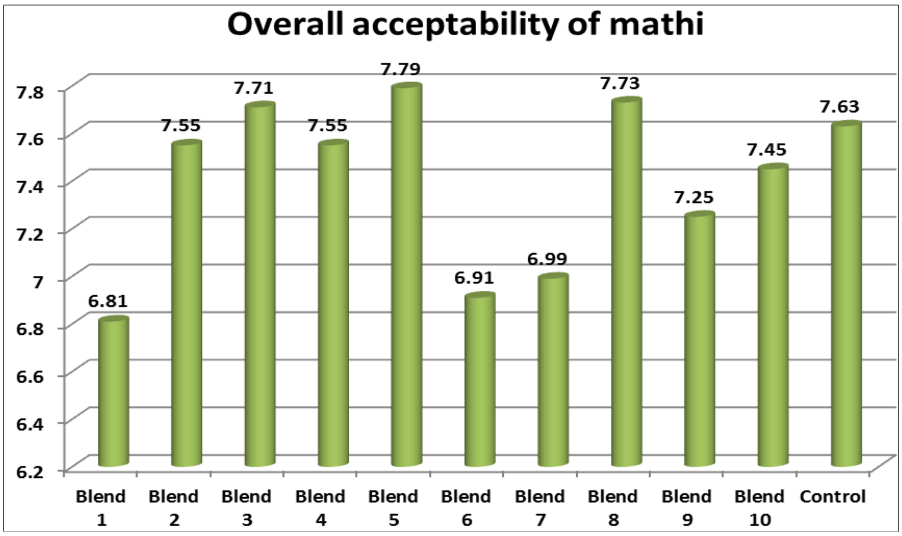


Fig 1: Overall acceptability of 10 blends of *mathi* Proximate composition of *mathi*

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

Blends	Flour combinations	Amount (g/100g)	Colour	Appearance	Flavor	Texture feel	Taste	Overall acceptability
Blend 1	Refined flour+Oat+Soybean	25+50+25	6.68±1.22	6.85±1.21	6.79±1.51	6.88±1.25	6.85±1.21	6.81±1.03
Blend 2	Refined flour+Oat+Soybean	50+25+25	7.47±0.93	7.29±1.03	7.47±0.90	7.68±0.84	7.74±0.93	7.55±0.60
Blend 3	Refined flour+Soybean	75+25	7.80±0.63	7.75±0.61	7.65±0.88	7.68±0.93	7.69±0.80	7.71±0.63
Blend 4	Refined flour+Barley+Soybean	25+50+25	7.41±0.56	7.29±0.52	7.56±0.79	7.76±0.82	7.71±0.80	7.55±0.45
Blend 5	Refined flour+Barley+Soybean	50+25+25	7.88±0.33	7.71±0.46	7.71±0.91	7.85±0.56	7.85±0.86	7.79±0.49
Blend 6	Refined flour+Oat+Chickpea	25+50+25	6.79±0.59	7.09±0.71	6.94±1.04	6.79±1.07	6.94±0.95	6.91±0.66
Blend 7	Refined flour+Oat+Chickpea	50+25+25	6.82±0.63	7.09±0.67	7.09±0.93	6.97±0.97	7.03±0.94	6.99±0.65
Blend 8	Refined flour+Chickpea	75+25	7.78±0.55	7.80±0.67	7.74±0.60	7.59±0.62	7.77±0.57	7.73±0.42
Blend 9	Refined flour+Barley+Chickpea	25+50+25	7.12±0.64	7.12±0.69	7.26±0.86	7.35±1.01	7.41±1.02	7.25±0.66
Blend 10	Refined flour+Barley+Chickpea	50+25+25	7.47±0.86	7.26±0.83	7.41±0.89	7.53±0.79	7.59±0.70	7.45±0.61
Control	Refined flour	100	7.79±0.34	7.76±0.34	7.61±0.46	7.47±0.56	7.61±0.56	7.63±0.33
CD at 5 %			0.21	0.22	0.27	0.26	0.26	0.18

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 *mathi* prepared from blend 3 comprising of refined wheat flour and soy flour (75 and 25%), blend 5 comprising of refined wheat flour, barley flour and soy flour (50, 25 and 25%) and blend 8 containing refined wheat flour and soy flour (75 and 25%) had higher overall acceptability when compared with control, so these blends were selected for proximate analysis. The moisture content in these samples ranged from 1.28 to 1.64g/100g. The moisture content of *mathi* made from blend 5 and 8 was significantly less when compared with the control (1.75g/100g).

The ash content of test samples ranged from 3.18 to 3.71g/100g but no significant difference was observed with the control (2.92g/100g) and among themselves (Table 3). The crude protein content ranged from 7.84 to 12.35g/100g with maximum content in blend 3 containing soy flour and minimum in blend 8 containing chickpea flour. Blend 3 and blend 5 had significantly higher protein content when compared with the control. But no significant difference was found with blend 8. Among test samples blend 3 had significantly more protein content than blend 5 and 8. Soy flour significantly increased the protein content of the *mathi.*

The crude fiber content of the test samples ranged from 0.50 to 1.19g/100g, it was significantly ($p<0.05$) higher in blend 5 and 8 but with blend 3, no significant difference was found. Among test samples blend 3 had significantly lower fibre content when compared with blend 5 and 8. The crude fat content ranged from 30.16 to 39.80g/100g in test samples and significantly more than the control (27.83g/100g). Among samples significant differences were there and blend 2 had maximum fat content followed by blend 3 and blend 5.

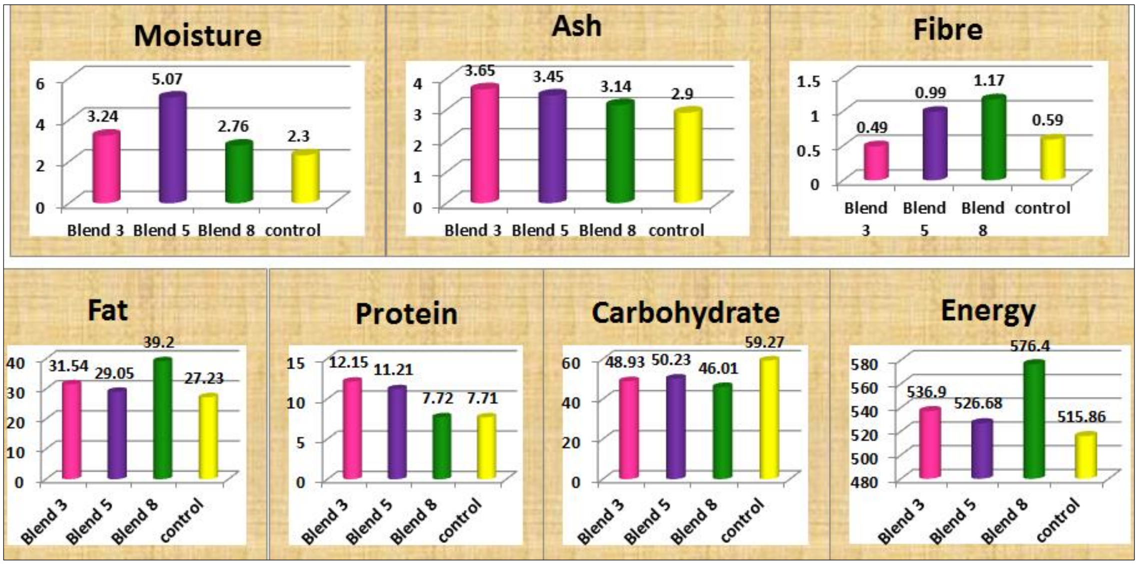
The available carbohydrate content ranged from 46.71 to 52.17g/100g with maximum contents in blend 5 and minimum in blend 8. All the test samples had significantly lower carbohydrate content when compared with the control. The energy content in the test samples ranged from 527 to 576 Kcal /100g while in the control it was 516 Kcal/100g.

On fresh weight basis, the protein content was higher in blend 3 and 5 but ash content was higher in all the three samples i.e. blend 3, 5 and 8 (Fig 2). Shah (2005) [12] reported 7.51% moisture, 12.86% protein, 27.8% fat, 0.60% crude fibre, 1.14% ash, 50.88% carbohydrates and 535 Kcal/100g of energy in *mathi* prepared by supplementing wheat flour with 20% defatted soy flour. Mittal (2011) [8] observed that the moisture, ash, protein, fibre and fat content in the gluten free *mathi* prepared from 35% oats, 25% rice flour, 10% *urad dal* and 30% *besan* was 8, 3.8, 18.4, 3.7 and 31%, respectively.

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

Table 3: Proximate composition of selected blends of *mathi* (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	Refined flour+Soybean	75+25	1.64±0.05	3.71±0.37	0.5±0.05	32.06±0.07	12.35±0.11	50±0.662	537
Blend 5	Refined flour+Barley+Soybean	50+25+25	1.42±0.09	3.58±0.31	1.03±0.22	30.16±0.05	11.64±0.03	52±0.54	527
Blend 8	Refined flour+Chickpea	75+25	1.28±0.05	3.18±0.39	1.19±0.28	39.80±0.20	7.84±0.05	47±0.086	576
Control	Refined flour	100	1.75±0.06	2.92±0.27	0.59±0.07	27.38±0.02	7.76±0.17	60±0.476	516
CD at 5 %			0.16	0.80	0.43	0.26	0.25	1.15	4.34



Blend 3: refined wheat flour, soy flour(75+25), Blend 5 : refined wheat flour, barley flour, soy flour (50+25+25), Blend 8: refined wheat flour, chickpea flour (75+25), Control: refined wheat flour

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

Glycemic index of *mathi*

The glycemic index of control and test blend is presented in Table 4. Further, in case of test *mathi* (Plate 1) from blend 5 comprising of refined wheat flour, barley flour and soy flour (50, 25 and 25%), the blood glucose levels ranged from 81 to 112, 89 to 127, 83 to 109, 91 to 102 mg/dl respectively whereas for the control *mathi* the levels ranged from 95 to 114, 86 to 126, 93 to 119, 102 to 116 mg/dl (Fig 3) and the glycemic index was 60.55 for test *mathi* while for control it was 77.08.

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

Product	Quantity administered (grams)	GI	GI Category
Mathi (control)	84	77.08	High
Mathi (test)	100	60.55	Moderate

The lowering of glycemic index in *mathi* 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) [5]. Apart from proteins and amylose content the crude fibre had also increased in *mathi*. Dietary fibre also inhibits starch digestibility by increasing the viscosity of intestinal contents and there by slowing the absorption of carbohydrates from the food (Wolever 1990) [14]. Casiraghi *et al*. (2006) [3] observed the effect of consumption of crackers and cookies made from barley flour enriched with ß-glucan in comparison with similar products made from wheat flour on fasting and postprandial glucose and found glycemic index values as 78, 81, 49 and 34 for whole wheat crackers, whole wheat cookies, barley crackers and barley cookies, respectively.

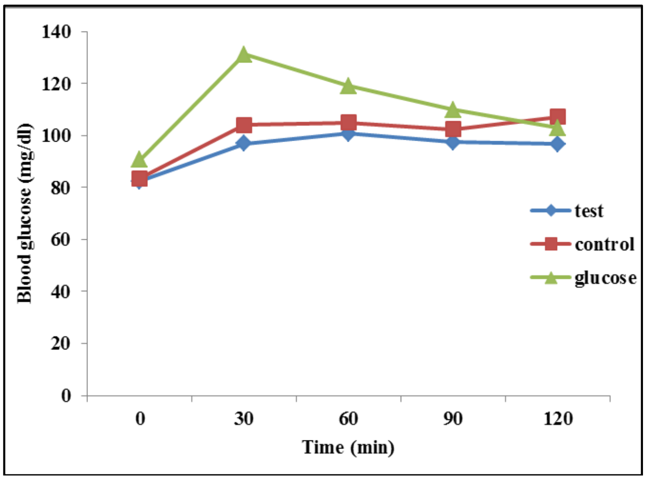


Fig 3: Mean blood glucose curves after consumption of glucose, test *mathi* and and control *mathi* containing 50g carbohydrates

Control *mathi*: Refined wheat flour (100)

Test *mathi*: Refined flour, barley flour, soy flour (50+25+25)

Plate 1: *Mathi*

Table 5: Glycemic load of control and test *mathi*

Product	GI	Normal serving size (g)	Available carbohydrate (g)	Glycemic load (GL)
Mathi (control)	77.08	20	12	9.25
Mathi (test)	60.55	20	10	6.05

Table 5 displays that there was decrease of 16.53 GI units in test *mathi*. Mean GI and GL of the supplemented *mathi* 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]. *Mathi* prepared from refined wheat flour, barley flour and soy flour (2:1:1) had GI units 60.55, which comes under moderate GI foods. Increase in protein and crude fiber and decrease in carbohydrates were responsible for lowering the glycemic value of the developed products. The developed *mathi* can be an alternative snack for diabetic patients.

Conclusion

The concluded that *mathi*, prepared form the blend 3 containing refined wheat flour and soy flour (75 and 25%), blend 5 containing refined wheat flour, barley and soy flour (50, 25 and 25%) and blend 8 containing refined wheat flour and chickpea flour (75 and 25%) were found to have more scores for overall acceptability in sensory evaluation when compared with the control.The findings of proximate analysis showed that supplementation of refined wheat flour with barley, soy flour and chickpea flour significantly reduced carbohydrates and increased ash, fibre, fat and protein contents. Mean GI (60.55) and GL (6.05) of the supplemented *mathi* was significantly lower as compared to the control samples. The developed *mathi* has better nutritional and GI value and it can be used instead of traditional *mathi* which is commonly prepared from refined wheat flour.

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