

Development and Quality Evaluation of Pearl Millet Based Anti-diabetic Flour

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Abstract: Pearl millet is produced and consumed in arid and semi-arid regions of Rajasthan as staple food grain, missi roti composite flour Indian bread is consumed by diabetics to manage the blood glucose level, however, a beneficial combination for diabetics is not known. Hence the pearl millet (PM) based anti-diabetic flour were developed. After several trails of different proportions of PM, barley (BY) and Bengal gram (BG); a proportion of 3:2 of PM and BG and 3:1:1 of PM, BG and BY were found most suitable in the preparation of roti and were acceptable by panel of judges. Recipe for roti was standardized for its carbohydrate content (40 g/serve), serving size, cooking time, cooked weight, water required for preparing the dough and acceptability on nine point hedonic scale (scores >6). Moisture, protein, fat, ash, fiber, carbohydrate and energy contents per 100 g for PM+BG, PM+BG+BY composite flour ranged from 10.79-12.10, 6.43-15.53, 2.51-3.14, 0.97-1.07, 1-2.14, 2.51-3.14, 0.97-1.07, 1-2.14, 66.20-77.12 g and 354-363 kcal, respectively. Composite flour were providing 75-85% energy from carbohydrate and were a good sources of fiber. Quality of the protein was better for composite flour (9-10.4 NDPCal%) than plain flour (1.7 NDAPcal%). Developed flour stored in 1 kg capacity flour bags at room temp for a period of three months showed an increase in free fatty acid and peroxides with storage, but did not exceed the safe limit. However, acceptability of roti from PM flour decreased significantly ($P>0.05$) at one month of storage, whereas roti of its blends (PM+BG and PM+BG+BY) remained acceptable up to two months of storage. Glucose tolerance test from 40 g and test recipes, i.e. plain and missi roti and kachari chutney on diabetic ($n=10$) and non diabetic subjects ($n=10$) of 30-55 years age range at 0, $\frac{1}{2}$, 1, $1\frac{1}{2}$ and 2 hour after feeding showed lower glycaemic index (GI) values for PM+BG (54) and PM+BG+BY (74) flour than the plain PM flour (78). On the basis of the findings it can be concluded that composite flour are better for diabetics and blend of pearl millet with Bengal gram is the best.

Key words: Pearl millet, Bengal gram, barley, diabetic, glycaemic index, glucose.

Pearl millet landraces provide nutritional quality and security under the harsh environmental condition of Rajasthan, India. Pearl millet is the staple food and fodder crop of arid and semi-arid regions of Rajasthan. In north west India, where it is grown in 4-6 M ha area annually (Brockee *et al.*, 2003), is the major source of dietary nutrients for a large section of the population. Various preparations such as roti, khichada, dhokla, ghughari, rabri, etc. are prepared from pearl millet. Mani *et al.* (1993) have reported that pearl millet lowers blood glucose, hence the present study was undertaken to develop pearl millet-based anti-diabetic flour.

Materials and Methods

Anti-diabetic flour was developed for pearl millet (PM) with barley and/or Bengal

gram mixed in various proportions to prepare roti. Roti was standardized for carbohydrate content (40 g/serve), serving size, cooked weight, cooking time, water required for the dough making and acceptability (score >6). The quality of the developed flour was tested for its nutrient composition and shelf life. The nutrient composition (Raghuramulu *et al.*, 2003) including protein quality (Platt *et al.*, 1961) of the fresh flour was evaluated. Shelf life of the flour was tested by physical examination and estimation of moisture and rancidity at monthly interval for a period of three months. The quality of flour was also tested at monthly intervals for its acceptability using nine point hedonic scale in the preparation of roti.

Fasting and postprandial blood glucose level after feeding 40 g glucose was estimated at 0, 0.5, 1.0, 1.5 and 2.0 hours prior to feeding the test recipe. One serving of roti of PM

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Table 1. Nutrient Composition of the flour (g/100 g)

Flour	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate	Energy (Kcal)	NDPcal%
PM	11.33	6.43	3.14	0.98	1.00	77.12	363	1.7
PM + BG	12.10	15.53	2.96	1.07	2.14	66.20	354	10.4
PM+BG+BY	10.79	12.65	2.51	0.97	2.10	70.98	357	9.0

PM = Pearl millet; BG = Bengal gram; BY = Barley.

and its blends with kachari chutney (15 g) containing 40 g carbohydrate was served to diabetics and non-diabetics to find out the glucose response. Glycemic index of the test recipes was calculated. The data were analyzed and test of significance were carried out by applying appropriate statistical tests.

Results and Discussion

After several trials of different proportions of PM+BG and PM+BJ+BY flour in the preparation of roti and acceptability, PM+BG and PM+BG+BY in the proportion of 3:2 and 3:1:1, respectively, were found most suitable. Acceptability scores of roti for different sensory attributes, i.e. appearance, taste, flavor, texture and overall acceptability ranged from 7.10 to 8.50 revealing that roti of plain as well as composite flour were liked moderately to very much.

Acceptability scores of 7 or more on 9 point hedonic scale, 4 or more than 4 on point scale have been reported for different recipes such a vegetable wadi (Sharma *et al.*, 1996), Kabuli chana mix (Sharma *at al.*, 2000), kadi mix (Bikash and Kulkarni, 1991) and rab mix (Mogra and Choudhry, 2003).

Proximate composition of the developed flour ranged for protein from 6.4 to 15.53 g, fat from 2.51 to 3.14 g, fiber from 1.0 to 2.14 g, ash from 0.97 to 1.0 g, carbohydrate from 66.2 to 77.12 g and energy from 354 to 363 kcal per 100 g (Table 1). The contribution of carbohydrate towards total calories was maximum. Recent dietary guidelines also suggest high carbohydrate diet for diabetics (Raghuram, 2000). Protein quality of the flour assessed by calculating NDPcal% revealed that composite flour i.e., diabetic flour with Bengal gram (10.4) and with Bengal gram and barley (9.00) was of better quality than plain flour (1.7). Developed flour stored in 1 kg capacity commercially used flour bags at room temperature and analyzed at 0, 1, 2 and 3 months of storage showed no insect-infestation. Moisture content at 0 month of storage was

less than the safe limit of 14% (ISI, 1988). During storage the moisture either increased or decreased by 1 to 3%, but did not exceed beyond the safe limit (Table 2). Change in the moisture content may be due to the packaging and storage period, i.e. January to April. The temperatures during these months vary as January is the coldest month, whereas from March summer season starts. In present study commercial flour bags were used to store the flour and were not air tight. Monthly observations of rancidity parameters, i.e. acid value, peroxide value and alcoholic acidity increased with storage period, but these were found to be in the safe limit except alcoholic-acidity (Table 2). The reason may be that the maximum limit prescribed by ISI (1988) for alcoholic acidity is 0.18%, which may be comparatively quite lower than the limit for acid value (0.3 to 1.8) and peroxide value

Table 2. Keeping quality of the flour

Particular	Storage period (Months)			
	0	1	2	3
Overall acceptability (n=10)				
PM	7.67 ± 0.09	7.33 ± 0.10	4.80 ± 0.23	-
PM+BG	7.37 ± 0.09	7.53 ± 0.10	5.73 ± 0.20	-
PM+BG+BY	7.77 ± 0.08	7.20 ± 0.09	5.83 ± 0.24	-
Moisture (g %)				
PM	11.33	8.50	8.04	8.10
PM+BG	12.10	9.21	9.50	8.90
PM+BG+BY	10.79	9.00	9.00	7.00
Peroxide value				
PM	*	1.00	1.60	2.30
PM+BG	*	1.40	1.40	1.80
PM+BG+BY	*	1.40	1.40	3.10
Acid value				
PM	*	0.68	0.79	0.81
PM+BG	*	0.99	1.00	1.00
PM+BG+BY	*	0.92	0.99	1.00
Alcoholic acidity				
PM	*	1.30	1.50	1.90
PM+BG	*	1.70	1.80	2.00
PM+BG+BY	*	1.40	1.70	2.00

* Not detectable.

Table 3. Blood glucose response and glycemic index of the flour

Flour	Hours					IAUC mg/dl	GI	Overall GI
	0	0.5	1.0	1.5	2.0			
PM								
Diabetics	219.0±36.62	265.0±38.38	264.2±37.17	264.2±42.17	254.0±45.80	3573.0±479.04	87±36.69	78±26.89
Non-diabetics	99.6±6.03	126.0±9.71	126.2±9.26	122.6±10.13	104.4±5.78	1956.09±569.32	68±17.09	
PM + BG								
Diabetics	221.8±24.76	250.8±29.57	241.6±34.66	233.2±37.27	217.8±34.37	3365.24±746.75	57±8.85	54±10.03
Non-diabetics	96.0±3.81	113.8±5.80	115.0±7.44	104.8±3.18	100.2±4.99	1320.9±338.22	50±11.22	
PM+BG+BY								
Diabetics	80.2±4.23	114.6±7.41	110.0±7.35	103.8±6.22	99.4±2.49	1278.103±628.51	85±33.57	74±34.44
Non-diabetics	101.6±2.15	112.2±2.06	110.2±5.64	111.2±7.03	101.2±4.47	1261.10±383.3	63±35.32	

IAUC=Incremental area under curve; n=10.

(10). Leelavati *et al.* (1983) have also reported higher alcoholic-acidity values for whole wheat flour and resulted atta. Acceptability of roti from plain pearl millet decreased significantly ($P>0.05$) at one month of storage, whereas roti of its blends, i.e. (PM+BG) and (PM+BG+BY) remained acceptable up to two month of storage. Findings of shelf life parameters revealed that although rancidity did not trap due to enzymatic activity of the millets (Pruthi, 1981), but acceptability of the roti determined the shelf life up to one month for diabetic flour i.e. PM+BG and PM+BG+BY.

The nutritional profile of the diabetic (n=10) and non-diabetic subjects (n=10) selected to find out the GI of different types of roti revealed that majority (43%) of the subjects were overweight or obese. Results of waist hip ratio showed abdominal obesity in female subjects. Health and food habits and dietary pattern of the diabetics was same as that of non-diabetics except the hypoglycaemic foods such as green leafy vegetables, fenugreek seeds and whole grain consumed by diabetics. Blood glucose response of diabetic flour i.e. PM+BG, PM+BG+BY roti remained at its peak at 1 hour in comparison to half an hour for glucose (Table 3). The delay in glucose response is due to complex carbohydrate content of roti which delay gastric emptying time and helpful to reduce glucose response of the food. The area under the curve was higher among diabetic as compared to non-diabetics for glucose as well as test recipes. It may be due to increased fasting blood glucose level of diabetics. Batra *et al.* (1994), Sumathi *et al.* (1995) and Wolever (1986) have also reported similar findings.

GI of developed antidiabetic flour i.e. PM+BG (54), PM+BG+BY (74) was less than the plain flour (78). The GI of PM+BG was lowest (54) followed by PM+BG+BY (74). It may be due to addition of Bengal gram in the flour. Pluses contain substantially higher resistant starch and fiber than cereals which delays the gastric emptying time and help to reduce glucose response of the food (Sumathi *et al.*, 1995; Pathak *et al.*, 2000; Arora 2003; Dummer 2011). GI of the flour was not significantly different ($P>0.05$) between diabetic and non-diabetics, suggesting that GI studies can be conducted on any of these subjects.

It can be concluded that composite flour are better than plain flour and pearl millet Bengal gram is the best.

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