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Evaluation of Composite Millet Breads for Sensory and Nutritional Qualities and Glycemic Response

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ABSTRACT

Introduction: This study was undertaken with the objectives of formulating composite bread by utilising finger millet flour and foxtail millet flour and further to evaluate these breads for sensory, nutritional qualities, and glycemic response. **Methods:** Two genotypes of finger millet VL-146 and PRM-601 and one local cultivar of foxtail millet were studied. The finger millet flour (FMF) and foxtail millet flour (FTF) were individually blended in various proportions (30 to 60%) into refined wheat flour (RWF). These blends were then used in the preparation of composite breads. The refined wheat flour bread (RWF) served as the control. One bread from each millet flour blend was selected finally for further investigation on the basis of sensory scores. **Results**: As the 30% millet flour substitution was most preferred among the three millet samples, it was selected for further evaluation. Nutrient composition of the selected breads showed that composite bread formulated using FTF showed significantly higher crude protein, crude fat, total ash, phosphorus and insoluble dietary fibre. The composite bread formulated using FMF contained significantly higher calcium, soluble dietary fibre, tannin and phytic acid. However, the control (RWF) bread contained significantly higher carbohydrate, physiological energy and starch. The lowest value for glycemic index among the breads was observed for bread containing FMF from genotype VL- 146 (41.43), followed by bread containing FMF from the genotype PRM- 601 (43.10), bread containing FTF (49.53) and control bread (67.82). **Conclusion:** Millet flour incorporated breads had low glycemic indices and were acceptable and nutritious.

Keywords: Composite bread, glycemic index, millet

INTRODUCTION

Millet is the staple food of millions inhabiting the arid and semi-arid tropics of the world and is considered a food security crop (Rao, 1986). In India, large areas in different parts of the country are cultivated with millet. Millet grains are nutritionally comparable and even superior to major cereals with respect to protein, energy, vitamins and minerals. Besides, they are a rich source of dietary fibre, phytochemicals and micronutrients and hence they are rightly termed as 'nutricereals'. Finger millet (*Eleucine coracana*) and foxtail millet (*Setaria italica*) are important food grains grown in

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the foot hills of Himalayas. Finger millet grain is highly nutritious and is richer in protein, fat, minerals and dietary fibre than rice. It is non-acid forming, minimally allergic and an easy-to-digest grain (Railey, 2000). Foxtail millet is twice richer in protein compared to rice which ranges from 10 to 15%. It also contains good amounts of crude fibre and phosphorus (Malleshi & Desikachar, 1985). Millets contain water soluble gum and β-glucan that is useful in improving glucose metabolism (Vijayalakshmi & Radha, 2006). Studies show that individuals on a millet -based diet suffer less from degenerative diseases such as heart disease, diabetes, hypertension etc. Low glycemic index nutritious food products prepared from millet can be used as an effective support therapy in the treatment of diabetes mellitus (Arora & Srivastava, 2002).

The incidence of diabetes is rapidly rising throughout the world (Huizinga & Rothman, 2006). Therefore, there is a need for healthy food products which would cater to the needs of millions suffering from degenerative diseases like diabetes mellitus. Millet based ready-to- eat food products can be utilised as dietary supplements for diabetics. In the present scenario, ready-to-eat food products of millets are not available in the market. The use of millet for a varied range of food products is constrained by grittiness of flour and lack of gluten. This setback can be remedied by blending millet flour with other cereal flours. One possibility is blending millet flour with wheat flour for the preparation of baked products. Finger millet flour can be blended with wheat flour up to 30% for preparation of bread (Beswa, Kock & Siwela, 2010). Bakery products can be developed and targeted to fulfill specific therapeutic needs of consumers. Several studies indicate the possibility of incorporating millet flour in bread making. However, scientific information on composite bread formulation with the incorporation of finger and foxtail millet is limited. Studies are not available on higher levels of millet substitution with the addition of gluten. Therefore, in view of these considerations the present study was undertaken with the objectives of (i) formulating finger millet flour and foxtail millet flour incorporated composite breads, (ii) evaluating these breads for sensory, nutritional qualities, and (iii) studying the glycemic response elicited.

METHODS

Two genotypes of finger millet (VL-146 and PRM-601) and one local cultivar of foxtail millet were used for the present study. Finger millet genotype VL-146 was purchased from Krishi Vigyan Kendra, Majhera, district Almora. Genotype PRM-601 was procured from College of Forestry and Hill Agriculture, Ranichauri. One locally grown cultivar of foxtail millet was procured from farmers in the village of Chauna, district Almora, Uttarakhand. Yeast was purchased from Jadish bakers, Nainital. Gluten was procured from Modern Bakeries, Bareilly. Refined wheat flour and other ingredients were purchased from the local market at Pantnagar. All the grains were cleaned to remove dirt, dust, stones and other foreign materials. Each millet sample was then ground in a small capacity flour mill, separately. The ground flour was further sieved through a **100??** mesh sieve.

Sensory evaluation of millet flour incorporated breads

Flours from the two genotypes of finger millet and one sample of foxtail millet were blended separately with refined wheat flour in the following ratios: (i)70: 30, (ii) 60: 40, (iii) 50: 50, and (iv) 40: 60. These flour blends were then utilised in the formulation of composite millet breads. Control consisted of refined wheat flour bread. Straight dough method (Philip, 2003) was used for bread preparation. Breads formulated in this manner were subjected to sensory evaluation by a semi-trained panel of ten members. Several preliminary trials for sensory evaluation were conducted using the Hedonic scale and the two highest scoring breads were chosen from each separate flour blend. These two breads were further evaluated for acceptability using the score card method. Finally a sample of composite bread each was selected from the finger millet genotype VL-146, genotype PRM-601 and foxtail millet flour blend on the basis of scores obtained. The selected breads were further evaluated for nutritional quality and glycemic response.

Analysis of bread for nutrient composition

Moisture in bread was estimated by the AACC (1969) method. Crude protein, crude fat, crude fibre and total ash were evaluated by standardised AOAC (1975) procedures. Calculations were also done for carbohydrate by difference and physiological energy of bread.

Calcium was estimated titerimetrically (AOAC,1975). Phosphorus was estimated by Fiske and Subba Row method as described in Ranganna (1995). Atomic absorption spectrophotometer was used for the determination of iron, copper and zinc contents of samples (Raghuramulu, 2003). Total dietary fibre content was estimated by the method of Asp & Johanson (1981). Starch was estimated colorimetrically using a combination of methods given by Clegg (1956) and Cerning & Guilbot (1973) . Tannins was estimated by Folin Denis method(Sadasivam & Manikam, 2005) and phytic acid by the Wheeler & Ferrel (1971) method.

Evaluation of food products for glycemic index (GI)

Ten healthy human volunteers were randomly selected from Kasturba Bhavan Hostel, GB Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. All the subjects were female adults, aged 24-27 years. The BMI of the subjects ranged from 18.28 to 22.80. Consent of the subjects to participate in the study and to draw blood sample was obtained. All the subjects had normal blood pressure and none of them suffered from any disease. The subjects were given general instructions to avoid any physical exertion, medication, fasts and feasts during the experimental period. As all the subjects resided in the same hostel, their dietary pattern was almost similar. They were instructed to take habitual diets.

On the first day of the study, glucose tolerance test (GTT) was conducted on overnight fasted subjects. A 50g glucose dissolved in 200ml water was given to the subjects. The subjects were instructed to finish the glucose solution within 15 min and to avoid physical exertion during the experimental period. The blood glucose level was measured at 0, 30, 60, 90,120 and 150 min with the help of a glucometer. On every alternate day, 10 overnight fasted subjects were served with one type of bread containing 50g carbohydrate. For 50g equicarbohydrate portion, 107g of bread containing finger millet flour from genotype VL-146, 110g of bread containing finger millet flour from genotype PRM-601, 113g of bread containing foxtail millet flour and 91g of control refined wheat flour bread was served. The food product was served with 200ml of water. The subjects were asked to follow the same instructions as for the glucose tolerance test. The blood glucose was measured initially and at 30, 60, 90,120 and 150 min of finishing the food product.

Evaluation of glycemic response and GI of food products

For estimating the glycemic response of each food product, the area under the blood glucose response curve and GI was calculated according to the formula given by Wolever (1990).

The GI value of each individual was calculated and the average GI of 10 replicates was computed.

$$GI = \frac{\text{Incremental area under blood glucose response curve for food product}}{\text{Corresponding area after equicarbohydrate portion of glucose}} \times 100$$

Statistical tests

Mean and standard deviations were computed. Paired *t*-test was used for evaluation of sensory qualities. Nutrient composition of four different types of breads was analysed with the help of ANOVA. The area under the blood glucose response curve of (five food products) composite millet bread, control bread and glucose were also analysed using ANOVA.

RESULTS

Sensory evaluation of millet flour incorporated bread samples

On the basis of preliminary sensory trials, two breads were selected from each flour blend. The breads selected from finger millet flour (genotype-VL-146) and refined wheat flour blends were designated as product code D1 and D2. The proportion of ingredients in product code D1 (70% refined wheat flour : 30% finger millet flour) was 175g refined wheat flour, 75g finger millet flour, 8.75g sugar, 8.75g yeast, 3g salt, 4g gluten and 8.75g fat; product code D2 (60% refined wheat flour: 40% finger millet flour) contained 150g refined wheat flour, 100g finger millet flour 8.75g sugar, 8.75g yeast, 3g salt, 8g gluten and 8.75g fat. Preliminary trials also revealed that breads containing 50 and 60% millet flour scored lower for all the composite millet flour blends. Product code D1, D2 and control refined wheat flour breads were liked moderately. Thereafter the score card method was used to select one bread from product code D1 and D2 (Table 1). Rating of product code D1and D2 from finger millet flour blend (genotype VL-146) by score card method showed that product code D1 scored significantly higher for the parameters - colour of crumb, texture of crumb and appearance. Therefore on the basis of sensory quality, bread containing 30% finger millet flour (genotype VL 146) and product code D1 were selected for further investigation.

Similarly the breads selected through preliminary trial from finger millet flour (genotype-PRM-601) and refined wheat flour blend were designated as product code D11 and D12. The proportion of ingredients in product code D11 (70% refined wheat flour: 30% finger millet flour) was 175g refined wheat flour, 75g finger millet flour, 8.75g sugar, 8.75g yeast, 3g salt, 4g gluten and 8.75g fat, and for product code D12 (60% refined wheat flour: 40% finger millet flour) it was 150g refined wheat flour, 100g finger millet flour, 8.75g sugar, 8.75g yeast, 3g salt, 8g gluten and 8.75g fat. Further evaluation of product code D11and D12 from finger millet flour blend (genotype PRM-601) by the score card method showed that product code D11 scored significantly higher for these parameters: colour of crumb, colour of crust and overall acceptability. Therefore on the basis of sensory quality, bread containing 30% finger millet flour (genotype PRM-601) product code D11 was selected for further investigation (Table 1).

Preliminary tests for sensory evaluation of foxtail millet flour incorporated breads by a nine-point Hedonic scale showed that product code D22 and D23 were preferred in comparison to other breads of the same millet flour blend. Product code D22 (70% refined wheat flour: 30 % foxtail millet flour) containing 175g refined wheat flour, 75g foxtail millet flour, 8.75g sugar, 8.75g yeast, 3g salt, 3g gluten and 8.75g fat scored higher and was liked moderately. Similar scores were observed for bread containing 60% refined wheat flour : 40% foxtail millet flour, that is, breads prepared with 150g refined

Table 1. Rating of finger millet flour (genotypeVL-146 and PRM-601) and foxtail millet flour incorporated bread for acceptability by score card method

Parameter	*Product code - D1*	*Product code - D2*	*t-value*
Colour of crumb	7.60±0.84	7.00±0.49	2.34
Colour of crust	7.40±0.96	7.15±0.57	0.72
Texture of crumb	7.75±0.81	6.80±0.81	3.42
Texture of crust	7.15±1.37	7.00±0.87	0.85
Appearance	7.80±0.82	7.00±0.79	2.48
Flavour	7.35±0.66	7.15±0.88	1.00
Taste	7.45±0.68	7.20±1.03	1.24
Overall acceptability	7.45±0.83	7.20±0.78	0.69
	Product code - D 11	*Product code - D 12*	
Colour of crumb	7.75±0.54	7.10±0.48	2.37
Colour of crust	7.80±0.42	7.05±0.83	3.73
Texture of crumb	7.60±0.51	7.40±0.52	1.00
Texture of crust	7.40±0.69	7.00±0.76	1.71
Appearance	7.55±0.76	7.05±0.68	1.62
Flavour	7.70±0.82	7.20±0.63	1.86
Taste	7.80±0.42	7.10±0.47	2.80
Overall acceptability	7.70±0.42	7.00±0.40	4.23
	Product code - D22	*Product code - D23*	
Colour of crumb	7.90±0.31	7.20±0.52	2.67
Colour of crust	7.75±0.79	7.40±0.69	1.65
Texture of crumb	7.75±0.79	7.25±0.63	1.43
Texture of crust	7.70±0.66	7.00±0.45	2.37
Appearance	7.90±0.59	7.15±0.47	2.90
Flavour	7.80±0.96	7.40±0.65	1.87
Taste	7.75±0.95	7.25±0.58	1.70
Overall acceptability	7.80±0.69	7.20±0.49	2.45

wheat flour, 100g foxtail millet flour 8.75g sugar, 8.75g yeast, 3g salt, 7.5g gluten and 8.75g fat. Further evaluation of product codes D22 and D23 by the score card method showed that product code D22 obtained significantly higher scores for the parameters of colour of crumb, texture of crust, appearance and overall acceptability. On the basis of all the parameters for sensory quality bread containing 30% foxtail millet flour, that is, product code D22 was chosen for further evaluation (Table 1). On the basis of results obtained for sensory evaluation using the score card method, the breads selected for further study were product codes D1, D 11 and D22.

Nutrient composition of bread samples

Results of proximate composition of bread are presented in Table 2**.** The moisture content of bread incorporating finger millet flour from genotype VL-146 was 38.70 % and of bread incorporating finger millet flour from genotype PRM-601 was 38.38 %. Foxtail millet flour incorporated bread showed a moisture content of 37.01 % while control refined wheat flour bread had a moisture content of 34.69%. The moisture content of

Table 2. Proximate composition of millet flour incorporated breads and control refined wheat flour bread (on fresh weight and dry weight basis)

Treatment		*Moisture (%)*	*Crude protein (%)*		*Crude fat (%)*		*Crude fiber (%)*		*Total ash (%)*		*Carbohydrate (by difference)*		*Energy (Kcal)*
			FWB	*DWB*	*FWB*	*DWB*	*FWB*	*DWB*	*FWB*	*DWB*	*FWB*	*DWB*	
Finger millet flour incorporated bread	Genotypes VL 146	38.70 ±0.69	8.74 ±0.43	14.26 ±0.55	3.73 ±0.03	6.18 ±0.01	0.98 ±0.07	1.60 ±0.14	1.03 ±0.10	1.68 ±0.19	46.79 ±0.42	76.34 ±0.29	255 ±3.33
	Genotypes PRM 601	38.38 ±0.68	9.91 ±0.25	16.08 ±0.33	3.86 ±0.07	6.27 ±0.07	1.18 ±0.02	1.91 ±0.06	1.26 ±0.05	2.05 ±0.08	45.38 ±0.50	73.65 ±0.35	254 ±2.68
Foxtail millet flour incorporated bread		37.01 ±0.70	11.22 ±0.25	17.28 ±0.56	4.13 ±0.07	6.56 ±0.19	1.70 ±0.10	2.69 ±0.19	1.53 ±0.07	2.43 ±0.15	44.39 ±1.17	70.47 ±1.08	257 ±2.32
Control refined wheat flour bread		34.69 ±1.43	7.58 ±0.40	11.61 ±0.85	1.71 ±0.15	2.62 ±0.18	0.35 ±0.08	0.53 ±0.12	0.53 ±0.12	0.81 ±0.18	55.12 ±1.51	84.39 ±5.76	266
S.Em.±		0.54	0.19	–	0.05	–	0.04	–	0.05	–	0.58	–	–
CD at 5%		1.76	0.65	–	0.17	–	0.14	–	0.17	–	1.90	–	–

FWB = Fresh weight basis
DWB = Dry weight basis

the control bread differed significantly from millet flour incorporated breads.

The protein content values of bread incorporating finger millet flour from genotypes VL-146 and PRM -601 were 8.74% and 9.91%, respectively on a fresh weight basis and 14.26 and 16.08%, respectively on a dry weight basis. A significant difference was observed between the two finger millet breads. Foxtail millet bread contained 11.2% protein on a fresh weight basis and 17.28 % protein on a dry weight basis. Kamaraddi & Santhakumar (2003) reported 7.2% protein in 30% finger millet flour incorporated bread and a protein content of 8.6% in foxtail millet incorporated bread (on a fresh weight basis) without the addition of gluten as an ingredient. Control bread showed a protein content of 7.58% on a fresh weight basis and 11.61% on a dry weight basis. Foxtail millet flour incorporated bread contained significantly higher amounts of protein compared to all other breads.

The crude fat content values of bread containing finger millet flour from genotypes VL-146 and PRM-601 were 3.73 and 3.86 %, respectively on a fresh weight basis and 6.18 and 6.27 %, respectively on a dry weight basis. Finger millet flour incorporated breads from the two genotypes did not differ significantly in percentage on a fresh weight basis but was 6.56 % on a dry weight basis. Control bread had a crude fat content of 1.71 % on a fresh weight basis and 2.62 % on a dry weight basis. Foxtail millet flour incorporated bread contained a significantly higher amount of crude fat than other breads.

Crude fibre content values of bread containing finger millet flour from genotypes VL-146 and PRM-601 were 0.98 and 1.18 %, respectively on a fresh weight basis and were 1.60% and 1.91 %, respectively on a dry weight basis. A significant difference was found in the crude fibre content of the two finger millet flour incorporated breads. Bread containing foxtail millet flour had a crude fibre content of 1.70 % on a fresh weight basis and 2.69 % on a dry weight basis. Crude fibre content of foxtail millet flour incorporated bread was significantly higher than finger millet flour incorporated breads and the control bread. Crude fibre content of control bread was 0.35% on a fresh weight basis and 0.53% on a dry weight basis. Crude fibre content of control bread was significantly lower than millet flour incorporated breads.

The total ash content values of bread containing finger millet flour from genotypes VL-146 and PRM-601 were 1.03 and 1.26 %, respectively on a fresh weight basis and 1.68% and 2.05 %, respectively on a dry weight basis. A significant difference was observed between the two finger millet breads. Foxtail millet flour incorporated bread had an ash content of 1.53% on a fresh weight basis and 2.43 % on a dry weight basis. Refined wheat flour bread had an ash content of 0.53 % on a fresh weight basis and 0.81 % on a dry weight basis. Foxtail millet flour incorporated bread contained a significantly higher amount of total ash than other breads.

Finger millet (VL-146 and PRM-601) flour incorporated bread had carbohydrate content values of 46.79% and 45.38%, respectively on a fresh weight basis and 76.34% and 73.65% carbohydrate, respectively on a dry weight basis. No significant difference was found in the carbohydrate content of the two breads. Foxtail millet flour incorporated bread had a carbohydrate content of 44.39% on a fresh weight basis and 70.47% on a dry weight basis. Control bread contained 55.12% carbohydrate on a fresh weight basis and 84.39% on a dry weight basis. Control bread contained a significantly higher amount of carbohydrate than millet flour incorporated breads.

Bread containing finger millet flour from genotypes VL-146 and PRM-601 had 255 and 254 kcal of energy / 100 g, respectively. No significant difference was found in the energy content of the two breads. Foxtail millet flour incorporated bread had an energy content of 257 kcal / 100 g while the control bread had an energy content of 266 kcal / 100 g. Control bread had a significantly higher energy content.

Mineral content

Results on mineral composition (on a dry weight basis) of breads containing finger millet flour from genotypes VL-146 and PRM-601, foxtail millet flour incorporated bread and control bread are presented in Table 3. The calcium content values of bread containing finger millet flour, genotypes VL-146 and PRM-601 were 83.33 and 90.66 mg / 100 g, respectively. Significant differences were found in the calcium content of finger millet flour incorporated breads from the two genotypes. Foxtail millet flour incorporated bread had a calcium content of 25 mg / 100 g and control bread had calcium content of 21.66 mg / 100 g. The calcium content of finger millet flour incorporated bread was significantly higher than foxtail millet flour incorporated bread and control bread.

The phosphorus content values of bread containing finger millet flour from genotypes VL-146 and PRM-601 were 106.6 and 110 mg / 100g, respectively while foxtail millet flour incorporated bread contained 125.3 mg / 100g phosphorus. Control bread had a phosphorus content of 89.33 mg / 100 g. No significant difference was found in phosphorus content of breads containing finger millet flour from genotypes VL-146 and PRM-601. However, foxtail millet flour incorporated bread had a significantly higher amount of phosphorus than finger millet flour incorporated breads and control bread. The iron content values of bread containing finger millet flour from genotypes VL-146 and PRM-601 were 2.15 and 2.21 mg / 100g, respectively while foxtail millet flour incorporated bread had an iron content of 2.08 mg / 100g. Control bread had an iron content of 1.87 mg / 100 g, significantly lower iron content than millet flour incorporated breads.

The zinc content values of breads containing finger millet flour from genotypes VL-146 and PRM-601 were 0.87 and 0.89 mg / 100 g, respectively while foxtail millet flour incorporated bread contained 0.85 mg / 100 g zinc. Control bread had a zinc content of 0.82 mg / 100g but generally no significant difference was found in the zinc content of breads. The copper content values of breads containing finger millet flour from genotypes VL-146 and PRM-601 were 0.08 and 0.10 mg / 100g, respectively while foxtail millet flour incorporated bread contained 0.19mg / 100g copper; control bread had a copper content of 0.05 mg / 100g. The copper content of foxtail millet flour containing bread was significantly higher than other breads.

Dietary fibre

The insoluble dietary fibre, soluble dietary fibre and total dietary fibre content of bread on a dry weight basis are presented in Table 3. The insoluble dietary fibre content values of bread containing finger millet flour from genotypes VL-146 and PRM-601 were 4.43 % and 4.75 %, respectively. No significant difference was found in breads containing finger millet flour from the two genotypes. Foxtail millet flour incorporated bread contained 5.68 % insoluble dietary fibre while for control bread, it was 3.87 %. Foxtail millet flour incorporated bread contained a significantly higher amount of insoluble dietary fibre than breads with finger millet flour and control bread.

The soluble dietary fibre content values of bread containing finger millet flour from genotypes VL-146 and PRM-601 were found to be 2.15% and 2.19 %, respectively. Foxtail millet flour incorporated bread contained 1.78 % soluble dietary fibre while control bread had a soluble dietary fibre content of 1.70%. No significant difference was found in the soluble dietary fibre content of breads prepared by blending in finger millet flour from genotypes VL-146 and PRM-601; these breads contained a significantly higher amount of soluble dietary fibre than foxtail millet flour incorporated bread and control bread.

Table 3. Mineral, dietary fibre, starch, tannin and phytic acid content of millet flour incorporated breads and control refined wheat flour bread

Mineral (mg/100 g)	*Finger millet flour incorporated bread*		*Foxtail millet flour incorporated bread*	*Control refined wheat flour bread*	*S.Em.±*	*CD at 5%*
	Genotype VL-146	*Genotype PRM-601*				
Calcium (mg/100 g)	83.33±2.88	90.66±3.21	25.00±3.56	21.66±2.88	2.32	7.16
Phosphorus (mg/100 g)	106.66±2.30	110.66±2.30	125.33±4.61	89.33±2.30	1.76	5.43
Iron (mg/100 g)	2.15±0.07	2.21±0.02	2.08±0.118	1.87±0.07	0.05	0.21
Zinc (mg/100 g)	0.87±0.04	0.89±0.006	0.85±0.01	0.82±0.007	0.01	0.06
Copper (mg/100 g)	0.08±0.004	0.10±0.002	0.19±0.158	0.05±0.003	0.03	0.12
Insoluble dietary fibre, % (IDF) (mg/100 g)	4.43±0.44	4.75±0.35	5.68±0.26	3.87±0.26	0.24	0.94
Soluble dietary fibre, % (SDF) (mg/100 g)	2.15±0.77	2.19±0.84	1.78±0.183	1.70±1.34	0.08	0.35
Total dietary fibre %(TDF) (mg/100 g)	6.59±0.36	6.94±0.26	7.46±0.07	5.30±0.25	0.18	0.72
Starch (%) (mg/100 g)	50.40±.014	48.60±1.44	46.80±0.06	56.25±0.56	1.03	4.03
Tannin (mg/100g)	86.6±11.54	60.0±4.65	53.33±11.54	33.33±5.77	5.77	18.81
Phytic acid (mg/100g)	100.0±8.66	85.0±8.66	70.0±17.32	40.0±3.20	7.50	22.44

Values reported are on a dry weight basis

The total dietary fibre values in breads containing finger millet flour from genotype VL-146 and PRM-601 were 6.59% and 6.94 %, respectively with no significant difference found between them. Bread prepared by incorporating foxtail millet flour contained 7.46 % total dietary fibre while control refined wheat flour bread contained 5.3 % total dietary fibre. Millet flour incorporated breads had a significantly higher total dietary fibre content than control bread.

Starch

The starch content values of composite bread containing finger millet flour from genotypes VL-146 and PRM-601 were 50.40 and 48.60 %, respectively while for foxtail millet flour incorporated bread, it was 46.80 %. No significant difference was found in the starch content of millet flour incorporated breads. Control bread contained 56.25% starch, significantly higher than in the other breads. Values have been reported on a dry weight basis (Table 3).

Tannin

The tannin content values of bread containing finger millet flour from genotypes VL-146 and PRM-601, foxtail millet flour incorporated bread and control were 86.66, 60, 53.33 and 33.33 mg / 100 g, respectively. Bread prepared from finger millet flour (genotype VL-146) contained a significantly higher amount of tannin than other breads (Table 3).

Phytic acid

The phytic acid content values of bread containing finger millet flour from genotypes VL-146 and PRM-601, foxtail millet flour incorporated bread and control were 100.0, 85.0 70.0 and 40.0 mg / 100 g, respectively. Phytic acid content of finger millet flour incorporated bread was significantly higher than foxtail millet flour incorporated bread and control bread (Table 3).

Glycemic response

Research into the glysemic index(GI) has clearly proven that equal exchanges of carbohydrate do not elicit similar glycemic responses. It is possible to reduce insulinemic and glycemic effects of food, depending on the raw materials and process used. A GI value $\geq$70 is considered high, a GI value of 56-69 inclusive is medium and a GI value $\leq$55 is low, with glucose = 100 (Brand Miller *et al.*, 2003).

The standardised breads were evaluated for glycemic index in 10 normal female subjects. The BMI of the subjects ranged from 18.28 to 22.80. Normal values for BMI in women ranged from 19 to 24. All the subjects had normal blood pressure and none of them suffered from any disease. The average daily energy, protein, carbohydrate and fat intake of the subjects were 1695 Kcal, 51.56g, 267.1g and 27.38g, respectively.

Glycemic Index

The curves plotted for blood glucose response of composite breads and control refined wheat flour bread in comparison to glucose load of 50 g are shown in Figure 1. The peak rise for glucose and control bread occurred at 30 min and then tapered down. The value obtained for control refined wheat flour bread was lower than that obtained after administration of glucose (50 g).

The peak rise for all the composite breads prepared with millet flours was also observed to be at 30 min. The peak values obtained by composite breads were lower than those obtained for refined wheat flour bread and glucose. The data on area under the blood glucose response curve of breads and glucose in normal subjects is presented in Table 4. The area under the blood glucose response curve was observed to be 4197 mg min / 100 ml for glucose; 2905 mg min / 100 ml for control bread; 2076 mg min / 100 ml for foxtail millet flour incorporated bread; and1800 mg min / 100 ml for bread

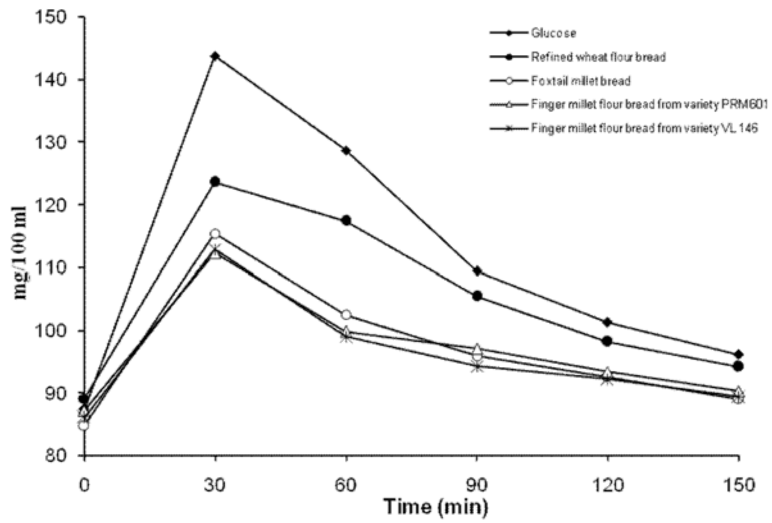

Figure 1: Blood glucose response curve of bread from finger millet (genotype Vl-146 and PRM-601), foxtail millet bread, control refined wheat flour bread and glucose

Table 4. Area under blood glucose response curve for glucose, control refined wheat flour bread and millet flour breads in normal subjects

Food product	*Area mg. min/100 ml*
Glucose	4197± 585
Control refined wheat flour bread	2905± 636
Bread containing finger millet flour from genotype (VL 146)	1733± 269
Bread containing finger millet flour from genotype (PRM 601)	1800± 287
Bread containing foxtail millet flour	2076± 636
SEM.	145.71
CD at 5% level	415.05

containing finger millet flour from genotype PRM 601. Bread containing finger millet flour from genotype VL 146 had the lowest mean area among all breads (1733 mg min / 100 ml). Breads containing millet flour had a significantly lower area under the blood glucose response curve as compared to control bread and glucose. However, the area under the blood glucose response curve for refined wheat flour bread was significantly lower than glucose.

Glycemic index is a physiological classification widely accepted for carbohydrate foods, with implications on health and disease. The lowest GI was observed for bread containing finger millet flour from genotype VL 146 (41.43) followed by bread containing finger millet flour from genotype PRM 601 (43.10). The glycemic index of bread containing foxtail millet flour was observed to be 49.53 and for refined wheat flour bread, it was observed to be 67.82. The GI values obtained by finger millet flour incorporated breads from both the genotypes were significantly lower than the foxtail millet flour incorporated breads and refined wheat flour breads. However, the GI values obtained by foxtail millet flour incorporated breads were significantly lower than refined wheat flour breads.

DISCUSSION

Results on acceptability of millet flour incorporated breads showed a similar trend for all the millet flour blends, that is, breads formulated with 70% refined wheat flour and 30% millet flour were most acceptable. However, breads containing 50 to 60% millet flour had lower acceptability. Since millet flour itself lacks gluten, dry gluten powder was added to all the breads prepared by blending in millet flour. The colour of crumb of breads formulated by incorporating finger millet flour from genotype VL-146 and PRM-601 was light brown and that of bread containing foxtail millet flour was light yellow. All millet flour incorporated breads had a soft crumb. Finger millet flour incorporated breads showed a slightly darker crust colour than control refined wheat flour bread. The reason for this differentiation of colour is that the natural colour of finger millet genotype Vl-146 is dark reddish brown and that of PRM-601 is reddish yellow. The yellow colour of the foxtail millet grains contributed towards the characteristic colour of these millet flour breads.

The overall flavour and taste of all millet flour incorporated breads was liked moderately by the panelists. Nutritionally, millet flour incorporated breads compares well with control refined wheat flour bread. Finger millet flour incorporated breads contained significantly higher amounts of calcium, soluble dietary fibre, tannin and phytic acid as compared to foxtail millet flour incorporated bread and control refined wheat flour bread. Foxtail millet flour incorporated bread contained significantly higher amounts of crude protein, crude fat, total ash, phosphorus, copper, insoluble dietary fibre, and total dietary fibre than finger millet flour incorporated breads and control refined wheat flour bread. All millet flour incorporated breads had significantly higher crude fibre, iron and total dietary fibre content than control refined wheat flour bread. However, the control bread contained significantly higher amounts of carbohydrate, physiological energy and starch.

Results showed that millet flour incorporated breads elicited low glycemic response in normal subjects. Low glycemic index foods produce low blood glucose and insulin response in normal subjects, and improve blood glucose control in type 1 and well controlled patients with Type 2 diabetics (Wolever, 1992). The values for mean area under BGRC were 1733± 269, 1800± 287, 2076±636, 2905±636 and 4197±585 mg min / 100 ml for breads containing finger millet flour from genotypes VL 146 and PRM 601, foxtail millet flour incorporated bread, refined wheat flour bread and glucose, respectively. The lowest GI value (41.43) among breads was observed for bread containing finger millet flour from genotype VL 146 followed by bread containing finger millet flour from genotype PRM 601 (43.10). Foxtail millet flour incorporated bread and refined wheat flour bread showed a GI value of 49.53 and 67.82 respectively.

In conclusion, it can be said that millet flour can be efficiently utilised in the formulation of composite breads. These breads also show a hypoglycaemic effect owing to the high dietary fibre content. It is suggested that they be used as an effective support therapy in the treatment of diabetes mellitus.

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