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Formulation and evaluation of foods from composite flour blends of sorghum, pearl millet and whole wheat for suitability in diabetic diet

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Abstract
Diabetes mellitus is one of the most common syndrome from the cluster of Syndrome X affecting masses. However, diet remains the cornerstone for diabetic patients, especially non-insulin dependent diabetics. Whole grains coupled with millet based foods possess low glycemic index, which plays a major role in the management of hyperglycemia in diabetes. The present study has been undertaken with a view to develop three composite flour blends namely CFB1 (WSP) with wheat, sorghum and pearl millet in the ratio of 40:30:30, CFB 2 (SWP) with sorghum, whole wheat and pearl millet in the ratio 40:30:30, and CFB 3 (PSW) with pearl millet, sorghum and whole wheat in the ratio 40:30:30, and their products namely biscuits and chapattis were standardized. Thereafter these were evaluated for their nutritional quality, sensory characteristics and glycemic response in a sample of hundred normal subjects. The biscuits were also evaluated for storage stability. The CFB 3 (PSW) showed higher total ash (2.86%), crude fiber was highest for CFB 2 (12.43%), crude protein for CFB2 (25.34%), crude fat in CFB 2 (9.77%) and energy (378.5 kcal/100g) over other composite flour blends. The results recorded in case of flour products i.e. biscuits, chapattis and instant upma. Moreover the CFB 2 (SWP) and its products were reported to have higher crude protein and total ash content. CFB 3 (PSW) showed slightly higher soluble dietary fiber content. Sensory characteristics' evaluation of products was subjected to by Score Card method and Nine Point Hedonic scale that revealed acceptability of all products with maximum liking and scores for CFB 1 (WSP) chapatti and CFB 3 (PSW) biscuits. All the products were found to be acceptable for 45 days, being stored in polythene bags for a span of 45 days. The glycemic index of products selected according to sensory attributes indicated lower GI values of chapatti composed of flour CFB1 (WSP) (25.4) and biscuits of flour CFB3(PSW) (27.5) in comparison to controls i.e. wheat based chapatti (40.4) and biscuits (44.28).

Keywords: Glycemic index (GI), composite flour blends, non insulin dependent diabetics

Introduction
Researchers are searching for strategies and processing technologies to enhance the content and bioavailability of nutrients and bioactive compounds of cereal foods. The bioavailability of compounds depends on bioaccessibility, absorption, transformation, disposition and excretion, where the main issue is bioaccessibility, which is affected by how food processing influences nutrients available for digestion and absorption in the gastro- intestinal tract.

The subsequent and dramatic changes in diet and lifestyle of people in developing countries have lead to a magnificent incidence of chronic diseases, diabetes mellitus being one of the major problems.

Shocking statistics on diabetes revealed that twenty per cent of the world's diabetics are Indians. Also thirty per cent of diabetics in urban India are below the age of forty and WHO has estimated that by 2025, India would have the highest number of diabetics followed by China and can be called as 'diabetic capital' of world. Globally there are about 177.7 million diabetics (WHO, 2003) [13].

The term diabetes mellitus was derived from the Greek words meaning passing through and sweet as honey (diabetes = flow through meh = Honey). It is a chronic metabolic disorder with a strong hereditary basis, associated with blood glucose. Basically it is caused by the deficiency in the secretion of insulin of pancreatic cells.

The two main types of diabetes classified by WHO are insulin dependent or Type 1 and non-insulin dependent diabetes or Type 2. About ninety per cent of diabetics belong to Type – 2 (Reddy, 1999) [11].

According to diabetic principles of diet, sufficient calories are to be provided for maintaining ideal body weight from complex carbohydrates, diet rich in protein supplying amino acids for tissue repair and fat cannot be oxidized as readily as carbohydrates. Thereafter greater flexibility should be offered to the patient in choice of foods (Jenkins, 1999) [5]. Persons with diabetes mellitus also follow a regulation of diet, as it is a sheet anchor of treatment and a useful supplement for insulin therapy in younger subjects. Several well designed studies have shown that lifestyle modification with proper diet coupled with physical exercise is essential to prevent type 2 diabetes mellitus (Yasumitsu *et al.*, 2002) [15]. In the present study the flour blends incorporating sorghum (*Glycine max* L.), pearl millet (*Pennisetum glaucum* L.) and wheat (*Triticum aestivum*) have been formulated. The glycemic index of wheat is 70, sorghum 30 and pearl millet is 55 (Jenkins *et al.*, 1981). Hence these flavours were incorporated in different ratios to meticulously design food products for diabetic patients. Hence the study was undertaken with the objectives of formulation and evaluation of flour blends using pearl millet, sorghum and wheat and their products i.e. chapatti and biscuits for nutritional qualities and for sensory characteristics for their hypoglycemic effect.

Materials and Methods

Material sources

Pearl millet, sorghum millet, whole wheat grains and other ingredients used for the purpose of study were purchased from local market of Churu, Rajasthan. All the reagents used in the present investigation were of analytical grade.

Preparation of composite flour blends

The composite flour blends were prepared from pearl millet, sorghum and wheat as discussed below.

Washing and cleaning

Soil and dust were removed from pearl millet, sorghum and wheat by washing them separately under tap water in plastic tubs with gentle force.

Soaking

Sorghum was soaked for 5 to 6 hours to remove its outer covering so as to retard the development of off flavour in the products. However, for wheat and pearl millet soaking was not required.

Removal of outer covering or hull of sorghum

Removal of outer covering of sorghum by hands, scrubbing them continuously to obtain a product with better quality characteristics.

Drying time and temperature

Sorghum, wheat and pearl millet were spread uniformly on trays lined with newspaper.

Sorghum was dried in hot air oven at 50º C for 24 hours. Wheat was dried at 60º C for 5 to 6 hours and pearl millet was dried at 50º C for 4 hours.

Grinding and packaging of pearl millet, sorghum and whole wheat

Dried pearl millet, sorghum and wheat were ground to powder in miller separately and packed in air tight plastic containers until used. The flour blends were prepared in following ratios:

CFB 1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB 2 (SPW): 40% sorghum, 30% pearl millet and 30% wheat
CFB 3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat

Preparation of Composite flour blends based products

Three food products biscuits, chapatti and instant upma mix with these flour blends were prepared.

Biscuits

Standardization of product

The biscuits of CFB1 (WSP). CFB2 (SBW) and CFB3(PSW) were prepared as well as control biscuits were prepared from 100 per cent wheat flour incorporation for the purpose of comparison of glycemic index. The composition of these is given in Table 1.

Method

1. Wheat flour, sorghum flour and pearl millet flour were mixed thoroughly, baking powder (sodium bicarbonate) was added to it and the flour was sieved two to three times.
2. Hydrogenated fat and powdered sugar were creamed separately.
3. Prepared mixture of flour was added into creamed mixture.
4. Tight dough was prepared by addition of water.
5. Balls were prepared from the dough.
6. The balls were then put in the mould and pressed to prepare 1 cm thick biscuits.
7. The biscuits were then placed on a greased tray and baked at 200º C for 25 minutes in a preheated oven.

Cooked weight of biscuits = 150g
Number of Biscuits = 18

Table 1: Recipe for CFB 1 (WSP), CFB 2 (SPW), CFB 3 (PSW) and control wheat based biscuits

Ingredients	CFB1* (WSP) Biscuits	CFB 2* (SPW) Biscuits	CFB 3* (PSW) Biscuits	Control Biscuits
Wheat flour (g)	40	30	30	100
Sorghum flour (g)	30	40	30	-
Pearl millet flour (g)	30	30	40	-
Sugar (g)	10	10	10	10
Hydrogenated fat (g)	30	30	30	30
Sodium bicarbonate (g)	A pinch	A pinch	A pinch	A pinch
Baking powder (g)	¼ teaspoon	¼ teaspoon	¼ teaspoon	¼ teaspoon
Water (ml)	50	50	50	50
Cinnamon powder (g)	1	1	1	1

*CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
*CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
*CFB3 (WSP): 40% pearl millet, 30% sorghum and 30% wheat

Chapatti

The product chapatti was standardized according to ISI standards (1980). The chapattis of CFB1 (WSP), CFB2 (SBW) and CFB3(PSW) were prepared as well as control chapattis were prepared from 100 per cent wheat flour for the purpose of comparison of glycemic index of flour mix products.

The composition of CFB 1, 2, 3 and control chapattis is given in Table 2.

Method

1. Wheat, sorghum and pearl millet flours were mixed thoroughly.
2. The water was added to make soft dough.
3. Balls were prepared and pressed to form a chapatti.
4. Chapattis were cooked on sac.
   Cooked weight of chapatti – 150g
   Number of chapattis – 4

Table 2: Recipe for CFB1 (WSP), CFB2 (SWP), CFB3 (PSW) and control wheat based chapattis

Ingredients	CFB1 *(WSP) chapatti	CFB2*(SPW) chapatti	CFB3* (PSW) chapatti	Wheat flour chapatti
Wheat flour (g)	40	30	30	100
Sorghum flour (g)	30	40	30	-
Pearl millet flour	30	30	40	-
Water	125	125	125	125
Salt	A pinch	A pinch	A pinch	A pinch

*CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
*CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
*CFB3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat

Nutritional composition of food products

The blends and food products namely chapatti and biscuits were analysed for proximate composition (AOAC, 1995) [2].

The carbohydrate content was determined by subtracting the sum of the values (per 100 g) for moisture, total ash, crude fat, crude fibre and crude protein from hundred. The calorific value (Kcal per 100g) of sample was calculated by summing up the product of multiplication of per cent crude protein, crude fat and carbohydrate present in the sample by 4, 9, and 4, respectively. The total dietary fiber was estimated as per the method of Asp and Johanson (1981).

Sensory Evaluation of Food Products

The food products prepared were evaluated for sensory quality by Nine Point Hedonic Scale and by Score Card Method to test various attributes as colour, flavour, texture, appearance and overall acceptability which contribute to the acceptability of the products (Amerine *et al.*, 1965) [1].

Evaluation of food products for storage stability

Biscuits

Hundred gram sample of all three types of biscuits of flour CFB 1,2 and 3 were kept in thermally sealed polyethylene bags for exactly forty five days at room temperature ranging from 19 to 35 ºC and relative humidity 50 to 60 per cent. The sensory quality of biscuits was evaluated at intervals of fifteen days by Score Card Method and Nine Point Hedonic Scale (Amerine *et al*., 1965) [1]. The free fatty acids were estimated by method of Pearson (1973) [9].

Suitability of food products for diabetic diet

All the developed food products *viz*. biscuits and chapatti were evaluated for suitability for diabetics. The evaluation of food products for their hypoglycemic effect was done. The hundred normal subjects were selected randomly from Hostel, OPJS, Churu, Rajasthan for determination of glycemic index of food products for five consecutive days by glucose tolerance test.

All the subjects were female adults of the age 22 to 26 years and had given consent to participate in the study and to draw their blood sample.

The blood glucose level was measured at 0, 30, 60, 90 and 120 minutes with the help of glucometer (One Touch Life Scan, Johnson and Johnson Company). For estimating the glycemic response of each food product the area under the blood glucose response curve was calculated as given by (Jenkins *et al*., 1981).

Results and Discussion

In the present investigation pearl millet, sorghum and wheat were selected for the preparation of three flour blends – Flour CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW). The nutritional, sensory quality and storage stability of flour blends and their products i.e. biscuits and chapatti were studied. The suitability of products in a diabetic diet was judged through GTT curve and glycemic index of products.

Nutritional composition of flour blends

Proximate composition

Moisture content

The average moisture content of CFB1 (WSP), CFB2 (SWP) and CFB3(PSW) was 11.03±0.05, 10.6± 0.02 and 11.05± 0.09 per cent, respectively. These values were reportedly i.e. 13 per cent moisture on dry basis. Gopalan *et al.* (2010) reported 12.2 per cent moisture, which were comparable to obtained values Table 3.

Table 3: Proximate analysis of flour blends (per 100g)

Parameters	CFB1 (WSP)	CFB2 (SWP)	CFB3(PSW)
Moisture (%)	11.03± 0.05	10.61±0.02	11.05±0.09
Crude protein (%)	21.16±0.07	24.34±0.03	21.22±0.05
Crude fat (%)	8.03±0.14	9.77±0.10	8.30±0.01
Total ash (%)	2.68±0.06	2.95±0.22	2.78±0.25
Crude fiber (%)	2.22±0.01	2.41±0.02	2.16±0.02
Carbohydrates (%)	54.23±0.01	49.41±0.01	53.98±0.01
Energy (kcal/100g)	343.3±0.25	376.4±0.46	333.20 ±0.36

Mean ±S.D.
CFB1 * (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB2* (SWP): 40% sorghum, 30% wheat and 30% pearl millet
CFB3* (WSP): 40% pearl millet, 30% sorghum and 30% wheat

Crude protein
The protein content of all the flour blends is higher than that of ISI (1980) i.e. 17 per cent. Gopalan *et al.* (2010) reported the total crude protein 12.1 per cent in wheat flour which is much lower than obtained values.

Crude fat
The crude fat content of CFB2 (SWP) was highest of all the three (9.97). These values are much higher than reported values of wheat flour by Gopalan *et al.* (2010) i.e. 1.7 per cent.

Total ash
CFB2 (SWP) exhibited highest ash content among all the three. These values were slightly higher than the values given by ISI (1980) i.e. 2.5 per cent. Gopalan *et al.* (2010) reported the total ash for wheat flour as 2.7 per cent which is similar to obtained values.

Crude fiber
Gopalan *et al.* (1999) reported crude fiber 1.0 per cent in wheat flour, which was lower than obtained values of blends. ISI (1980) has reported 2.5 per cent crude fiber in wheat flour which was comparable to values obtained for flour blends.
Carbohydrate by difference:
Gopalan *et al*. (2010) reported the carbohydrate content of wheat flour as 69.4 per cent which was higher than the values of the blends.

Energy value
The energy values for CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) were 343.30± 0.25, 383.4±0.46 and 376±0.36 kcal/100g, respectively.

Dietary fiber
The results are obtained are presented in Table 4.

Table 4: Dietary fiber content of flour blends and their products (Biscuits and Chapattis)

Parameters	Flour			Biscuits			Chapatti		
	CFB1 (WSP)	CFB2 (SWP)	CFB3 (PSW)	CFB1 (WSP)	Mix2 (SWP)	Mix3 (PSW)	CFB1 (WSP)	CFB2 (SWP)	Mix3 (PSW)
Total dietary fiber (%)	5.22	5.57	5.00	3.72	4.04	3.19	3.97	4.93	4.39
Soluble dietary fiber (%)	1.67	1.71	1.90	1.57	1.61	1.79	1.64	1.70	1.88
Insoluble dietary fiber (%)	3.55	3.36	3.10	2.15	2.43	3.19	2.33	3.23	2.51

*CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
*CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
*CFB3 (WSP): 40% pearl millet, 30% sorghum and 30% wheat

Total dietary fiber (TDF)
The TDF content of CFB1 (WSP), CFB2 (SWP) and CFB3(PSW) flour blends was 5.22, 5.57 and 5.00 per cent respectively. The total dietary fiber content of Mix (SWP) was highest among the three. The total dietary fiber content of wheat flour has not been reported in any earlier studies.

Soluble Dietary Fiber
The soluble dietary fiber of CFB1 (WSP), CFB2 (SWP) and CFB3(PSW) was 1.67, 1.71 and 1.90 per cent, respectively of which that of CFB3(PSW) was highest among the three.

Insoluble dietary fiber
The insoluble dietary fiber content of CFB1 (WSP) was found to be 3.55 which was highest among the three.

Nutritional quality of composite flour blend biscuits
Proximate Composition: The results of proximate composition of CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) biscuits are presented in Table 5:

Table 5: Proximate analysis of flour blend biscuits (per 100 g)

Parameters	CFP1 WSP	CFP2 SWP	CFP3 PSW
Moisture (%)	3.50± 0.0	3.03±0.15	3.00 ±0.15
Crude protein (%)	18.28±0.01	22.38 ±0.03	19.04 ±0.01
Crude fat (%)	11.03±0.39	12.75 ±0.35	11.05 ±0.34
Total ash (%)	2.16±0.23	2.72 ±0.27	2.61 ±0.21
Crude fiber (%)	1.93±0.02	2.08± 0.01	2.15 ±0.01
Carbohydrates (%)	63.27±0.06	57.08 ±0.05	62.16 ±0.07
Energy (kcal/100g)	425.46±0.02	430.56± 0.04	424.28 ± 0.01

Mean ±S.D.
*CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
*CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
*CFB3 (WSP): 40% pearl millet, 30% sorghum and 30% wheat

Moisture content
Semwal *et al.* (1996) [12] reported 4.84 per cent moisture content in glucose biscuits which was slightly higher than obtained values.

Crude Protein
Semwal *et al.* (1996) [12] reported crude fat of 24.66 per cent in glucose biscuits which was much higher a value than the obtained values.

Total Ash
CFB2 (SWP) was recorded to have the highest value of 2.72±0.27. The results obtained for all the blends were however higher than the value (1.20 per cent) glucose biscuits as that reported by Semwal *et al.* (1996) [12].

Crude Fiber
The value for crude fiber was reported by Semwal *et al.* (1996) [12] of 1.05 per cent in glucose biscuits was slightly lower than the obtained values for flour mix biscuits.

Carbohydrate by Difference
Semwal *et al.* (1996) [12] reported the carbohydrate content of glucose biscuits in the range of 50.48 to 60.68 per cent. The values obtained in the study are comparable to reported values.

Energy Value
Semwal *et al.* (1996) [12] reported the energy value of glucose biscuits in the range of 420.25 to 435.26 kcal/100g. The values obtained in the study are comparable to reported value.

Dietary Fiber: The results obtained are recorded in Table 4.

Total dietary fiber
The total dietary fiber content of CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) biscuits was 1.57, 1.61 and 1.79 per cent respectively.

The soluble dietary fiber of CFB3 (PSW) biscuits was found to be highest (1.79 per cent) among the three. The values for soluble dietary fiber content of glucose biscuits are not reported in literature.

Insoluble dietary fiber
The insoluble dietary fiber of CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) biscuits was 2.15, 2.43 and 1.40 per cent, respectively. The insoluble dietary fiber of CFB2 (SWP) biscuits was found to be highest among the three. The soluble dietary fiber content of biscuits is not available in literature.

Nutritional quality of flour mix chapatti
Proximate composition
The result of proximate composition of flour mix chapattis are presented in Table 6.

Table 6: Proximate Analysis of Flour Blend Chapattis (per 100 g)

Parameters	CFB1 (WSP)	CFB2 (SWP)	CFB3(PSW)
Moisture (%)	20.05 ±0.20	25.13±0.06	26.02±0.05
Crude Protein (%)	19.25±0.04	23.07±0.02	20.05±0.01
Crude Fat (%)	7.03±0.02	8.75±0.04	8.02±0.05
Total Ash (%)	2.15±0.015	2.71±0.03	2.33±0.01*
Crude Fiber (%)	2.05±0.01	2.41±0.02	2.16±0.01
Carbohydrates (%)	49.53±0.03	38.05±0.04	41.08±0.03
Energy (kcal/100g)	338.35±0.13	323.27±0.14	316.55±0.12

Mean ± S.D.
*CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
*CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
*CFB3 (WSP): 40% pearl millet, 30% sorghum and 30% wheat

Moisture content
The moisture content of CFB3 (PSW) chapattis was highest among all the three. Raghuvanshi and Verma (2002) [10] reported 38.98 per cent moisture content in wheat flour chapatti which was much higher a value over obtained values.

Crude protein
The values for crude protein content of CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) chapattis was 19.25±0.04, 23.07±0.02 and 20.05±0.01 per cent respectively. The protein content of CFB2 (SWP) chapatti was highest among all the three, which may be due to incorporation of 40 per cent sorghum flour. These values are much higher than the values reported by Raghuvanshi and Verma (2002) [10] 8.52 in wheat chapatti.

Crude fat
The results indicate that CFB2 (SWP) chapatti had highest content of crude fat among all the three. Raghuvanshi and Verma (2002) [10] reported crude fat of 1.26 per cent in wheat flour chapatti which was much lower than the obtained values.

Total ash
CFB2 (SWP) exhibited ash content of 2.6 per cent which is highest among all the three. The results obtained are higher than the value (1.86 per cent) reported by Raghuvanshi and Verma (2002) [10].

Crude fiber: The values for crude fiber for CFB2 (SWP) chapatti was highest among all the three. The value of crude fiber reported by Raghuvanshi and Verma (2002) [10] in wheat was slightly lower than the obtained value for flour mix chapattis (1.26 per cent).

Carbohydrates by difference
The values of CFB1 (WSP), CFB2 (SWP) and CFB3(PSW) chapattis were 49.08±0.03, 38.05±0.04 and 41.08±0.03 per cent carbohydrate content, respectively. CFB1 (WSP) chapatti exhibited highest carbohydrate content (49.53±0.03 per cent) among all the three. Raghuvanshi and Verma (2002) [10] reported the carbohydrate content of wheat flour chapatti (48.08 per cent). The values obtained in the study are comparable to the reported value.

Energy values
Raghuvanshi and Verma (2002) [10] reported the energy value of wheat flour chapatti (237.79 kcal/100g). The values obtained in this study are slightly higher to reported values.

Dietary Fiber: The results arrived at are presented in Table 4.

Total Dietary Fiber
The total dietary fiber content of CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) chapattis was 3.97, 4.93 and 4.39 per cent, respectively. The total dietary fiber content of CFB2 (SWP) chapattis was found out to be 4.93 per cent which was highest among the three. The dietary fiber content of wheat flour chapatti has not been reported in any earlier studies.

Soluble Dietary Fiber
The soluble dietary fiber content of CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) chapattis was 1.64, 1.70 and 1.88 per cent, respectively. The soluble dietary fiber content of CFB3 (PSW) chapatti was found to be 1.88 per cent which was highest among the three. The values for soluble dietary fiber content of wheat flour chapattis are not reported in literature.

Insoluble dietary fiber

The insoluble dietary fiber content of CFB2 (SWP) chapatti was found to be 3.23 which was highest among the three. The insoluble dietary fiber content of wheat flour chapattis is not available in literature.

Sensory quality evaluation of flour blend products

Three types of flour mix biscuits were prepared using standardized method mentioned above and were subjected to sensory analysis through Score Card and Nine Point Hedonic Scale method of fifteen members.

Sensory quality evaluation by score card method

The mean scores for sensory quality characteristic of biscuits through Score Card Method are presented in Table 7. The biscuits were judged on the basis of colour, taste, flavour, texture, appearance and overall acceptability. CFB3 (PSW) biscuits had the highest scores for colour, taste and flavour (7.8). Texture (7.7), appearance (8.0) and overall acceptability (7.6) and the differences were significant compared to CFB1 (WSP) biscuits. The non- significant difference was observed between CFB2 (SWP) biscuits with CFB1 (WSP) biscuits. The non significant difference was observed between CFB2 (SWP) biscuits with CFB1 (WSP) and CFB3 (PSW) biscuits.

Table 7: Sensory Quality of Biscuits (Score Card Method)

Biscuits	Colour	Taste	Flavour	Texture	Appearance	Overall acceptability
CFB1 (WSP)	7.2*	6.8*	6.8*	7.0*	7.4*	7.1*
CFB2 (SWP)	7.6	7.5	7.8	7.6	7.7	7.6
CFB3(PSW)	7.8*	7.8*	7.8*	7.7*	8.0*	8.0*
SEM ± CD at 5%	0.184±0.540	0.160±0.480	0.320±0.893	0.278±0.778	0.144±0.404	0.289±0.800

CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
CFB3 (PSW): 40% pearl millet, 30% soybean and 30% wheat
*Significant difference at 5 per cent level of significance

Sensory Quality Evaluation by Nine Point Hedonic Scale

The results of ratings of biscuits by Hedonic Scale are presented in Table 8. It was observed that CFB3(PSW) biscuits had the highest score (7.7) which falls in the range of like moderately to like very much. The significant difference was observed between CFB1 (WSP) biscuits and CFB3(PSW) biscuits. However non- significant difference was observed for CFB2 (SWP) biscuits compared to CFB1 (WSP) and CFB3(PSW) biscuits. Therefore, the CFB3(PSW) biscuit was selected for further determination of glycemic index and glucose tolerance curve.

Table 8: Ranking of Sensory Quality of Biscuits by Nine Point Hedonic Scale

Biscuits	Score	Preference
CFB1 (WSP)	6.6*	Like slightly- like moderately
CFB2(SWP)	7.4	Like moderately
CFB3(PSW)	7.7*	Like moderately- like very much
SEM± CD at 5%	0.135±0.379	

*CFB1 (WSP): 40% wheat, 30% soybean and 30% pearl millet
*CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
*CFB3(PSW): 40% pearl millet, 30% sorghum and 30% wheat

Sensory quality evaluation of chapatti

sensory quality evaluation by score card method

Three types of flour mix chapattis were prepared using standardized method mentioned above and were subjected to sensory analysis through Score Card and Nine Point Hedonic Scale method by a panel of fifteen members.

The mean scores for sensory quality characteristics of chapatti through Score Card method are presented in Table 9.

The chapattis were judged on the basis of colour, taste, texture, flavour, appearance and overall acceptability. CFB1 (WSP) chapattis had highest scores of colour (7.4), taste (7.3), flavour (7.4), texture (7.6), appearance (7.2) and overall acceptability (7.2).

The non significant difference was observed among three types of chapattis. Therefore, CFB1 (WSP) chapattis were selected for determination of glycemic response and glycemic index.

Sensory quality evaluation by nine point hedonic scale

The results of ratings of chapattis by Hedonic Scale are presented in Table 10. It was observed that CFB1 (WSP) chapatti had the highest score (7.06) however, all the chapattis fall in preference category of like moderately. Non-significant differences were observed among the chapattis. Prepared from three types of flour blends, CFB1 (WSP) chapatti was selected for determination of glycemic response and glycemic index.

Table 9: Sensory Quality of Chapatti by Score Card Method:

Chapatti	Colour	Taste	Flavour	Texture	Appearance	Overall Acceptability
CFB1 (WSP)	7.40	7.33	7.40	7.60	7.40	7.20
CFB2 (SWP)	7.30	7.10	7.30	7.50	7.30	7.10
CFB3(PSW)	7.40	7.10	7.20	7.40	7.10	7.10
SEM±CD at 5%	0.266±0.761	0.294±0.841	0.321±0.918	0.220±0.629	0.206±0.588	0.265±0.757

CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB2(SWP): 40% sorghum,30% wheat and 30% pearl millet
CFB3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat

Table 10: Ranking of Sensory Quality of Chapatti by Nine Point Hedonic Scale

Chapatti	Score	Preference
CFB1 (WSP)	7.06	Like moderately
CFB2 (SWP)	7.00	Like moderately
CFB3(PSW)	7.00	Like moderately
SEM±CD at 5%	0.198±0.567	

CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB2(SWP): 40% sorghum,30% wheat and 30% pearl millet
CFB3(PSW): 40% pearl millet, 30% sorghum and 30% wheat

Sensory Quality Changes during Storage

The sensory quality of developed flour mix biscuits packed in polythene bags during storage for a span of 45 days at room temperature (i.e. 19 to 35ºC) were evaluated by Score Card Method presented in Table 11. The biscuits were judged o the basis of colour, taste, flavour, texture, appearance and overall acceptability for 0, 15, 30, and 45 days. The results indicated that for CFB1 (WSP) and CFB2 (SWP) and CFB3(PSW) biscuits significant difference was observed in mean scores from 0 to 45 days for colour, taste, flavour, appearance and overall acceptability however, non- significant difference was observed in case of texture from 0 to 45 days and 0 to 15 days in all other attributes. Therefore, all the flour mix biscuits can be stored for 15 days without affecting its sensory attributes. However, all the products were acceptable till 45 days.

Table 11: Changes in sensory scores of biscuits during storage by score card method

Biscuits	Package	Days	Colour	Taste	Flavour	Texture	Appearance	OAA
Mix1 (WSP)	Polythene bag	0	7.2*	6.8*	6.8*	7.0	7.4*	7.1*
		15	7.0	6.6	6.2	6.8	6.7	7.3*
		30	7.2	6.5*	7.0	7.3	7.5	6.8
		45	6.5*	6.2*	7.1*	6.5	6.7*	6.4*
SEM ± CD at 5%			0.184	0.160	0.171	0.167	0.167	0.164
			0.516	0.449	0.470	0.468	0.451	0.459
CFB2 (SWP)	Polythene bag	0	7.6*	7.5*	7.8*	7.6	7.7*	6.0*
		15	7.3*	7.2*	6.7*	7.13	7.0*	7.4*
		30	6.8*	7.0	7.0*	7.3	7.0*	7.0*
		45	7.0*	7.1*	7.0*	7.2	7.2*	7.2*
SEM ± CD at 5%			0.160	0.139	0.148	0.145	0.144	0.142
			0.446	0.389	0.414	0.405	0.404	0.397
CFB3(PSW)	Polythene bag	0	7.8*	7.8*	7.8*	7.7	8.0*	7.6*
		15	7.3	7.0*	7.0*	6.93	6.7*	7.2*
		30	6.8*	6.8*	6.5*	7.3	6.8*	7.2*
		45	6.7*	7.2*	6.6*	7.1	7.1*	6.9*
SEM±CD at 5%			0.320	0.278	0.297	0.290	0.289	0.284
			0.873	0.776	0.829	0.811	0.809	0.300

CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
CFB3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat
*Significant difference at 5 per cent level of significance

Sensory quality changes in biscuits by nine point hedonic scale

The results of ratings of biscuits by Nine Point Hedonic Scale while storage are presented in Table 12. In CFB3(PSW) biscuits, significant difference was observed from 0 to 45 days of storage scores ranging from 7.7 to 6.6 and rating from like moderately- like very much- like slightly- like moderately. The results indicated non- significant differences for CFB1 (WSP) and CFB2 (SWP) biscuits in sensory quality from 0 to 45 days. Therefore, CFB3(PSW) biscuits were affected most while storage.

Changes in present moisture content and free fatty acid value of biscuits during storage

Change in percent moisture content of biscuits during storage

All flour mix biscuits exhibited significantly difference in moisture percent from 0 to 30 and 45 days presented in Table 13. However, the reported values were under the acceptable range of moisture (6.0 per cent) according to ISI Standard (1980).

Table 12: Rating of Biscuits during Storage by Nine Point Hedonic Scale Method

Biscuits	Package	Days	Score	Preference
CFB1 (WSP)	Polythene bag	0	6.6	Like slightly-like moderately
		15	6.5	Like slightly-like moderately
		30	6.6	Like slightly-like moderately
		45	6.8	Like slightly-like moderately
SEM ± CD at 5%			0.135	
			0.377	
CFB2 (SWP)	Polythene bag	0	7.4	Like moderately
		15	7.0	Like moderately
		30	7.0	Like moderately
		45	7.4	Like moderately
SEM ± CD at 5%			0.117	

			0.326	
CFB3(PSW)	Polythene bag	0	7.7*	Like moderately- like very much
		15	7.4*	Like moderately- like very much
		30	7.0*	Like moderately
		45	6.6*	Like slightly- Moderately
SEM ± CD at 5%			0.234	
			0.656	

CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
CFB3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat
*Significant difference at 5 per cent level of significance

Table 13: Changes in Moisture Content (%) of Biscuits during Storage

Parameter	Days	CFB1 (WSP)	CFB2 (SWP)	CFB3(PSW)
Moisture (%)	0	3.5±0.07	3.0±0.06	3.0±0.05
	15	4.0± 0.05	3.5±0.05	3.4±0.07
	30	4.3± 0.07	3.7±0.07	3.5±0.06
	45	4.4± 0.02	4.0±0.01	4.0±0.02
SEM±CD at 5%		0.201	0.255	0.160
		0.603	0.675	0.480

Mean ± S.D.
*CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
*CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
*CFB3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat

Changes in free fatty acid value of biscuits during storage: The results are presented in Table 14.

Table 14: Changes in Free Fatty Acid Values of Biscuits during Storage

Parameter	Days	CFB1 (WSP)	CFB2 (SWP)	CFB3(PSW)
Free fatty acid (as oleic acid)	0	0.050*	0.050*	0.050*
	15	0.282	0.390	0.291
	30	0.907*	0.982*	0.902*
	45	0.980*	0.902*	0.987*
SEM±CD at 5%		0.160	0.139	0.145
		0.480	0.417	0.435

CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
CFB2 (SWP): 40% sorghum, 30% wheat and 30% pearl millet
CFB3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat
*Significant difference at 5 per cent level of significance

The fatty acid value on day 0 of storage for all four flour mix biscuits was 0.05. The non-significant difference was observed in free fatty acid values of flour mix biscuits upon storage for 15 days. The results exhibited significant difference during storage of 30 to 45 days in CFB1 (WSP), CFB2 (SWP) and CFB3 (PSW) biscuits.
However, the reported values were lower than the acceptable value of free fatty acid (1 per cent) according to ISI Standards (1980).

Glycemic Index and Glycemic Response of Food Products
Diet therapy plays an important role in the treatment of diabetes mellitus. Several studies carried out indicate that the nature of carbohydrate and fiber has a significant influence on the postprandial rise in blood glucose. Therefore, it is necessary to determine the glycemic response of food preparations in order to develop food products which have an efficient role in the management of diabetes (Jenkins *et al.*, 1982) [8].
The food products i.e. biscuits and chapattis having highest sensory scores were evaluated for their glycemic index and glycemic response in ten normal subjects. The glycemic index of products is presented in Table 15.

Table 15: Glycemic Index of Flour Mix Products CFB1 chapatti and CFB3Biscuits compared to Control Wheat Based Products

Product	Glycemic Index
Control chapatti	40.40
CFB1 (WSP) chapatti	25.40
Control Biscuits	44.28
CFB3(PSW) Biscuits	27.50

* CFB1 (WSP): 40% wheat, 30% sorghum and 30% pearl millet
*CFB3 (PSW): 40% pearl millet, 30% sorghum and 30% wheat

The normal experimental subjects were ten adult females in the age group of 23 to 25 years with a BMI range of 19.27 to 28.31 kg/m^2.
The physical examination of subjects showed that they did not suffer from any disease. Glucose tolerance tests were carried out on overnight fasted subjects with glucose load of fifty grams. Fifty gram of food product was served to each subject. The mean blood glucose response of normal subjects to the food products CFB1 (WSP) chapatti and CFB3(PSW) biscuits in comparison to glucose and control wheat based products is depicted in Fig.1 and 2. The mean blood glucose level in normal subjects reached to a peak value of 158.9 mg/dl, after thirty minutes. A sharp decline was observed and thereafter gradual decline was noted till one twenty minutes. Both the

products reduced the postprandial glycemia in comparison to wheat based products. The mean total area under the blood glucose was observed to be 8103 mg min/dl when glucose load of fifty gram was given. The values for an area under blood glucose curve for CFB1 (WSP) chapatti and CFB3 (PSW) biscuits were found to be 2060 and 2230 mg min/dl, respectively. Both the products demonstrated reduction in area under blood glucose curve.

Area under the curve was calculated using the following formula given by Jenkins *et al.* (1981):

Area under curve =

$$\frac{\Delta_0 30t}{2} + \Delta_0 30t + \frac{(\Delta_0 60 - \Delta_0 30)t}{2} + \Delta_0 60t + \frac{(\Delta_0 90 - \Delta_0 60)t}{2} + \Delta_0 90t + \frac{(\Delta_0 90)^2 t}{\Delta_0 150 + \Delta_0 90}$$

Where, Δ_0 is change in blood glucose in mg/100 ml from zero time to 30 min., 60 min., 90 min.

and 120 min. that is the time interval between blood samples.

The values of glycemic index for the CFB1 (WSP) chapatti and CFB3 (PSW) biscuit was quite low in comparison to wheat based products (control). The lowest glycemic index was observed for CFB1 (WSP) chapatti (25.4) followed by CFB3 (PSW) biscuits (27.5), control wheat based chapatti (40.4) and biscuits (44.28).

Glycemic index of various food stuffs has been reported by various authors (Jenkins *et al.*, 1980) [7] from 10 to 100 and 44 to 123 has been reported for different food stuffs, owing, to different methods of calculation (Wolever, 1990) [14].

The food stuffs incorporated in the food products formulated in the present study had shown hypoglycemic effect. Jenkins (1981) reported that wheat has a glycemic index of 70, pearl millet (50) and soybean (30). Hence a combination of above food stuffs with hypoglycemic effect in the form of food products may be the reason for low glycemic index values. Remarkably low glycemic index values for chapatti 24.5 and biscuit 27.5 in normal subjects confirmed the

hypoglycemic effect of these products and thereby their therapeutic value in diabetic diet.

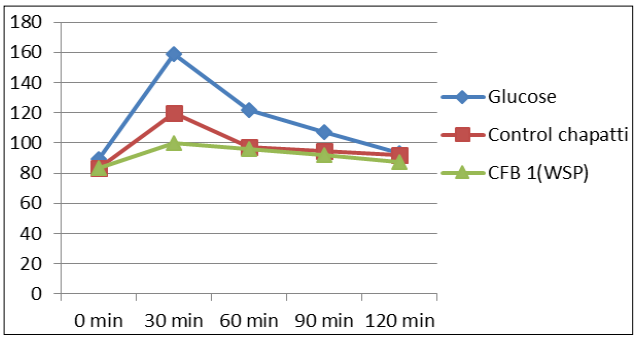

Fig 1: Glucose Tolerance Test (GTT) curve for chapattis

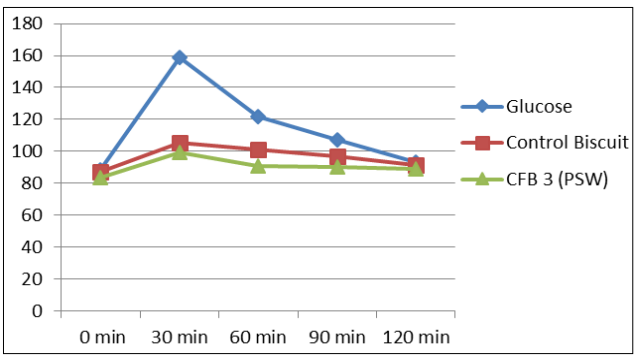

Fig 2: Glucose Tolerance Test (GTT) curve for biscuits

A slightly higher glycemic index value for biscuit compared to chapatti could be attributed to different methods of preparation of products and difference in proportion of ingredients used.

The limitation of the study was that only CFB1 (WSP) chapatti and CFB3 (PSW) biscuits were assessed for glycemic index. The results were interesting and need to be confirmed on a large number of diabetic subjects.

Conclusion

Millet based foods possess low glycemic index which plays major role in the management of hyperglycemia in diabetics. So this study was an effort in the direction of producing low cost, nutritious and low glycemic index food products suitable for home preparation as well as commercial production.

The three flour blends namely CFB1 (WSP) incorporating wheat, sorghum and pearl millet in the ratio of 40:30:30, CFB2 (SWP) with sorghum, wheat and pearl millet in the ratio of 40:30:30 and CFB3 (PSW) with pearl millet, sorghum and wheat in the ratio 40:30:30 were prepared and their products biscuits and chapatti were standardized for examining the suitability in diabetic diet. The nutrient composition of Flour CFB1 (WSP)included moisture 1.03 per cent, crude protein 21.16 per cent, total ash 2.68 per cent, crude fat 8.03 per cent, crude fiber 2.22 per cent, carbohydrate 54.23 per cent and energy 343.3 kcal/100g and total dietary fiber 5.22 per cent.

The nutrient composition of flour CFB2 (SWP) showed 10.61 per cent moisture, 24.34 per cent crude protein, 2.95 per cent total ash, 9.77 per cent crude fat, 2.41 per cent crude fiber, 49.41 per cent carbohydrate, 376.4 kcal/100g energy and 5.57 per cent total dietary fiber. The nutrient composition of flour CFB3(PSW) showed as 11.05 per cent moisture, 21.22 per cent crude protein, 2.78 per cent total ash, 8.3 per cent crude fat, 2.16 per cent crude fiber, 53.98 per cent carbohydrate from 424.28 to 430.56 kcal/100g and total dietary fiber 3.19 to 4.04 per cent.

The nutritional composition of chapatti showed moisture ranging from 20.03 to 26.02 per cent, crude protein from 19.23 to 23.05 per cent, total ash from 2.15 to 2.33 per cent, crude fat from 7.03 to 8.75 per cent, crude fiber from 2.03 to 2.31 per cent, carbohydrate from 38.05 to 49.53 per cent, energy from 316.55 to 338.35 kcal/100g and total dietary fiber 3.97 to 4.93 per cent.

The flour CFB2 (SWP) showed higher nutritional value and similar results were observed in case of flour products like biscuits and chapatti. The flour CFB2 (SWP) and its products reported higher total dietary fiber ranging from 4.04 to 5.59 per cent. CFB3 (PSW) showed higher soluble dietary fiber.

Sensory quality evaluation of products by Score Card Method and Nine Point Hedonic Scale revealed acceptability of all the products with maximum liking and scores for CFB1 (WSP) chapatti and CFB3 (PSW) biscuits.

The storage quality assessment of biscuits stored for forty five days in polythene bags at room temperature revealed significant difference from 0 to 45 days in moisture content, free fatty acid value and sensory qualities. However, all the products were acceptable for 45 days. The glycemic index (GI) of products selected on the basis of sensory quality indicated lower GI values of chapatti (25.4) of flour CFB1 (WSP) and biscuits (27.5) of flour CFB3 (PSW) in comparison to control wheat based chapatti (40.4) and biscuits (44.2).

So it can be concluded that

1. Flour blends had higher nutritive value without affecting

the palatability. The CFB2 (SWP) and its products showed higher protein, energy, fat, fiber and low carbohydrate contents.
2. Results of sensory evaluation of chapatti revealed that CFB1 (WSP) was most acceptable and pearl millet flour, soy flour can be blended with wheat flour up to 30 to 40 per cent to make chapattis. However, the product became stiff, hard and greenish grey in colour.
3. The sensory evaluation of biscuits revealed that CFB3 (PSW) was most acceptable.
4. The storage stability of biscuits showed that there was increase in the moisture per cent and free fatty acid levels during period of 45 days.
5. Both the products i.e. biscuits and chapattis had lower glycemic index than their control and are suitable for diabetic patients.

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