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Development of millet based therapeutic food products for diabetes mellitus

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Abstract
Two products namely *Shev* and *Kharapara* were developed by using different locally available low glycaemic foods such as pearl millet flour, barnyard millet flour, Bengal gram dhal flour, whole wheat flour, omum, fenugreek seeds powder, drumstick leaves powder, curry leaves powder cooking oil and salt etc. The acceptability was carried out by twenty semi trained panel members using nine-point hedonic scale. Developed therapeutic food products were analysed for proximate and mineral composition. Sixty days shelf life study was conducted. Result of acceptability evaluation indicated that Shev (8.5) and *Kharapara* (7.9) secured scores for overall acceptability. The findings of the nutrient evaluation evidenced that developed therapeutic food products *Shev* and *Kharapara* was rich in protein (15.07% and 12.09%) and calcium (133 and 102 mg/100g) respectively. Sixty days of storage period both products were well accepted and microbial level found to be below detectable (BDL) level. Blood glucose response of developed snacks were studied among normal subjects and glycaemic index was calculated. Glycaemic index of *Shev* was 44.33 and *kharapara* was 42.34. Hence both developed therapeutic food products may be beneficial for the consumption by the diabetic people.

Keywords: Therapeutic foods, millets sensory evaluation, nutrient analysis, glycaemic index

Introduction
Millets are important nutritional bio source due to its richness in starch, protein, fiber, niacin, magnesium, phosphorus, manganese, iron potassium, essential amino acids and vitamin E. In addition to being as a good source of nutrients, millets have various therapeutic benefits such as prevention of heart disease, diabetes, migration cancer and gastro intestinal diseases (Das and Rakshit, 2016). Millets contain higher proportion of unavailable carbohydrate and hence release of sugar from millet is slow. Millets contain water soluble gum, β-glucan that is useful in improving glucose metabolism Therefore, millets are suitable for diabetic people. (Anderson *et al.*, 2003). Barnyard millet has potential benefits in the diet therapy of diabetics. The barnyard millet showed improved carbohydrate tolerance among experimental volunteers (both diabetic and non-diabetic) as revealed by significant reduction in fasting plasma glucose levels (Surekha *et al.*, 2016).
Diabetes Mellitus is the most common metabolic disorder affecting humankind and creating health hazards. Diabetes is an increasing problem among urban as well as in rural population (Hwang 2016). India is home to 69.1 million people with diabetes mellitus and is estimated to have the second highest number of cases of diabetes mellitus in the world after China in 2015 (IDF 2016).
Low glycaemic index foods, by virtue of their slow digestion and absorption, produce gradual rises in blood sugar and insulin levels, and have proven benefits for health. Various researches have proved that low glycaemic index foods control blood glucose levels and effectively manage diabetes. Therefore, an attempt was made to develop therapeutic food products for consumption by diabetes mellitus.

Materials and Methods
Selection of ingredients: Therapeutic food products were developed using various ingredients such as wheat flour, pearl millet flour, barnyard millet flour, bengal gram dhal flour, omum, fenugreek seeds, drumstick leaves powder, curry leaves powder, red chilly powder cooking oil and salt etc. All the ingredients were processed hygienically and were stored in air tight container at room temperature. For further use in preparation of therapeutic food products.

Preparation of therapeutic food products: Two traditional food products namely *shev* and *kharapara* were prepared using pearl millet and barnyard millet with basic ingredients. The prepared products were organoleptically evaluated for sensory parameters such as colour, texture, taste, flavour and overall acceptability by semi trained 20 panellist using nine-point hedonic scale (Amerine *et.al.,* 1965) [2].

Nutritional Evaluation of therapeutic food products: The developed therapeutic food products were analysed for nutritional quality assessment. The parameters analysed were moisture, total minerals, total fat, dietary fiber, by AOAC procedures (1990) and protein was estimated by macrokjeldhal method. Calcium were estimated by EDTA method. The trace elements iron, copper, manganese and zinc, were estimated by absorption spectrophotometer (Perkin & Elmer model-3110). The values of carbohydrate and energy were calculated by using the food composition tables (Gopalan *et al.,* 2010) [5].

Glycaemic index evaluation: Both developed therapeutic food products was evaluated individually in twelve normal subjects. Blood glucose response technique was employed to evaluate the glycaemic index of glucose and each test food. Weighted amount of developed test foods providing 50 g of carbohydrate was served to the subject around 7.30 am. Then finger prick samples of blood were collected with lancet at 0, 30, 60, 90 and 120 minutes. Glucose content in the blood was determined by Glucometer (One touch). In the same way glucose response in the blood of the subjects was also determined. Using the blood glucose tolerance curve and food tolerance curve the glycaemic index of the test food was calculated using the formula given by Woleven and Jenkins (1981).

Shelf life study of the formulated snacks: The shelf life of the developed therapeutic food products was studied. It was packed in polythene pouch and stored at room temperature and refrigeration temperature for a period of two months. The samples were drawn fortnightly for organoleptic evaluation.

Microbial evaluation: Total bacterial count and presence of yeast and mould at the initial and final day of storage period were analysed by Direct Method of Counting (DMC) given by Dubey and Maheshwari (2004) [3].

Statistical analysis: The statistical analysis was carried out by following suitable procedures prescribed by Gupta (2014).

Results and Discussion

The composition of developed low glycaemic index snacks is given in Table 1. Wheat flour, pearl millet flour, barnyard millet flour, bengal gram dal flour, drumstick leaves powder, curry leaves powder, red chilly powder, omum, cooking oil, red chilly powder and salt were used in different proportion to prepare *Shev mix* and *kharapara*.

Mean values of organoleptic scores for the acceptability of the developed low glycaemic index snacks are presented in Table 2. Results indicated that *shev* obtained the highest score (8.5±0.51) for overall acceptability followed by *kharapara* (7.9±0.59). On the whole both the products found to have very well accepted for organoleptic characteristics. Similar findings were observed in study conducted by Shinde (2017) [12] they found that all variation scored more than 7.0 for acceptability evaluation of developed functional snack.

The mean value of moisture (g%), protein (g%), fat (g%), fiber (g%), calcium (mg%), iron (mg%), copper (mg%), manganese (mg%) and zinc (mg%) of *shev* were 4.3, 15.07, 26.0, 1.98, 108 2.06, 1.78, 1.66 and 1.18 respectively. The respective values for corresponding nutrients of *kharapara* were 8.9, 12.09, 22.52, 2.42, 133, 4.0, 1.0, 1.70 and 1.98. Calculated value of carbohydrate (g) and energy (kcal) of *Shev* and *kharapara* was 47.54, 49.27 and 311, 296 respectively. (Table 3.) In conclusion the results indicated that both the developed therapeutic food products were rich in protein and calcium content. Development of cereal pulse-based value added nutritious instant mixes studied by Lohekar (2014) [10] also reported all most same amount of nutrient content.

The mean values of blood glucose response in normal subjects at 0, ½, 1, ½ and 2 hours after the intake of the test food was studied (Table 4). From the results it is evident that the blood glucose was at the highest peak at half an hour following the ingestion of the food for both *Shev* (193.25±6.07) and *Kharapara* (113.75±12.17). There after the level of the blood glucose found to be declined gradually. On the whole blood glucose response values for developed snacks were ranging from 101.91±12.63 to 93.83±6.26.

The results indicated that glycaemic index value of *Shev* and *kharapara* was found to be 44.33 and 42.34. Significant difference in the glycaemic index of *shev* and *kharapara* was noticed. In conclusion it can be said that both the products recorded low glycamic index value (Table 5). A study conducted on development and evaluation of *Khakhra* using low glycaemic index ingredients studied by Sugantha and Raajeswari (2013) [13] indicated 56.8 value of glycaemic index which is more than recorded the products developed in present study.

It is clear from the Table 6. that mean scores of overall acceptability of *shev* stored for varying period at room temperature were ranging from 8.5 to 8.0 at and at refrigerator temperature from 8.5 to 7.20. The mean scores of overall acceptability of *Kharapara* stored for varying period at room temperature were ranging from 7.9 to 7.6 room temperature and 7.9 to at refrigerator temperature.

It was found that as the period of storage increased mean score of overall acceptability was significantly decreased in *shev* and *kharapara* but it was significant in *shev* only. Though the score reduced, it was in the category of like moderately (7.0) in both the samples. From the results it can be inferred that *shev* and *khararpara* can be stored up to 60 days in an airtight container at room and refrigerator temperature. Langote (2017) [9] reported similar sensory score for storage (7.7) of developed snacks with incorporation of maize flour.

The Microbial analysis was done for total bacterial count for the developed snacks at initial and on 60th day of storage period at the refrigerator and at room temperature conditions (Table 7). It was observed that there was a increase in bacterial count of stored sample but it did not exceed the safe level for consumption. On the other hand, the yeast and mould count were not noticed. The results are in line of the study conducted by Langote (2017) [9] on formulation of snacks with incorporation of maize flour and its safety aspects.

Table 1: Composition of the developed low glycaemic index snacks

Sr. no.	Ingredients (g)	Shev	Kharapara
1.	Pearl millet flour	-	20
2..	Barnyard millet flour	25	20
3.	Whole wheat flour	-	20
4.	Bengal gram dal flour	70	37
5.	Curry leaves powder	-	2.5
6.	Drumstick leaves powder	05	-
7.	Fenugreek seeds	-	0.5
8.	Cooking oil	25	28
9	Red chilly powder	1/2 tsp	1/2 tsp
10	Omum	1/2 tsp	1/2 tsp
11	Salt	To taste	To taste

Table 2: Mean scores of organoleptic characteristics the acceptability of developed snacks

Products	Mean value of organoleptic scores of developed snacks				
	Colour	Texture	Taste	Flavour	Overall acceptability
Shev	8.9±0.55	8.5±0.41	7.9±0.50	8.1±0	8.5±0.51
Kharapara	7.7±0.72	7.8±0.50	7.8±0.56	7.7±0.41	7.9±0.59

Table 3: Proximate and mineral composition of developed snacks

Nutrients	Shev (Mean±SD)	Kharapara (Mean±SD)
Moisture (g)	4.3±0.02	8.9±0.15
Protein(g)	15.7±0.03	12.09±0.04
Fat (g)	26.0±0.01	22.52±0.62
Fiber (g)	1.98±0.01	2.42±0.02
Carbohydrate (g)*	47.54	49.27
Energy (kcal)*	311	296
Calcium (mg)	108±0.41	133±0.40
Iron (mg)	2.06±0.02	4.0±0.43
Copper (mg)	1.78±0.02	1.0±2.30
Manganese (mg)	1.66±0.03	1.70±0.61
Zinc (mg)	1.18±0.02	1.98±0.02

* Calculated values

Table 4: Mean blood glucose response values of formulated snacks in the selected normal subjects

Particular	Blood glucose response values Mean±SD (mg /100ml)				
	0 hrs.	½ hrs.	1 hrs.	1½ hrs.	2 hrs.
Glucose	94.83±5.11	149±34.7	125.33±15.0	113.33±17.7	100.41±18.87
Shev	193.25±6.07	109.91±12.33	106.33±10.79	97.41±12.48	93.83±6.26
Kharapara	94.5±5.28	113.75±12.17	107.33±9.99	103.83±13	101.91±12.63
CD	-	-	8.94	9.23	9.44
SE ±	-	-	3.03	3.03	3.04
F- value	NS	NS	5.88**	12**	5.60**

NS - Non-Significant ****** - Significant at 1 per cent level

Table 5: Mean glycaemic index values of developed snacks

Name of the snacks	Glycaemic index (%)
Shev	44.33
Kharapara	42.34
CD	11.75
SE±	3.9
F- value	13.90**

****** - Significant at 1 per cent level

Table 6: Mean scores for overall acceptability of Shev and kharapra stored at room temperature and at refrigerator temperature for varying periods

S. No.	Storage period	Mean scores of overall acceptability of Shev		Mean scores of overall acceptability of Kharapara	
		Room temperature Mean	Refrigerator temperature Mean	Room Temperature Mean	Refrigerator temperature Mean
1	Initial	8.50	8.50	7.90	7.90
2	15 days	8.45	8.50	7.90	7.90
3	30 days	8.35	8.35	7.85	7.80
4	45 days	8.15	8.10	7.80	7.75
5	60 days	8.00	7.20	7.60	7.70
	CD	0.42	0.26	0.28	0.34
	SE ±	0.15	0.09	0.10	0.12

	F-value	3.64**	3.73**	1.44 NS	0.51 NS

**- significant at 1 % level

Table 7: Microbial content of developed snacks

Name of product	Bacterial count				Yeast and mould count			
	Room Temperature		Refrigeration Temperature		Room Temperature		Refrigeration Temperature	
	Initial	2 months	Initial	2 months	Initial	2 months	Initial	2 months
Shev	2.9 × 10-4	3.59 × 10-4	2.9 × 10-4	3.28 × 10-4	Nil	Nil	Nil	Nil
Kharapara	2.64 ×10-4	3.80 × 10-4	2.64 × 10-4	3.33 × 10-4	Nil	Nil	Nil	Nil

Conclusion: On the whole, results indicated that developed *Shev* and *Kharapara* had good acceptability and were rich in protein and calcium content and fair in iron content. Even after sixty days of storage both the products were well accepted and microbial level found to be below detectable (BDL) level and fit for consumption. Both the products found to have less than 50 glycaemic index which is considered to be low glycaemic index therefore both products are suitable for consumption by the diabetics.

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