AKADÉMIAI KIADÓ

Suitability of pearl millet (*Pennisetum glaucum* (L.) R. Br.) and sorghum (*Sorghum bicolor* (L.) Moench) based food products for diabetics

A. Sewak[1]* , N. Singla[1], M. Javed[2] and G.S. Gill[3]

[1] Department of Food and Nutrition, Punjab Agricultural University, Ludhiana, India

[2] Department of Mathematics, Statistics & Physics, Punjab Agricultural University, Ludhiana, India

[3] Krishi Vigyan Kendra, Patiala, India

ORIGINAL RESEARCH PAPER

© 2023 The Author(s)

ABSTRACT

In the study, suitability of porridge, bun, and salad prepared from processed pearl millet FBC16 and sorghum PSC4 had been evaluated organoleptically by a panel of semi-trained judges and 25 non-insulin dependent diabetes mellitus subjects. Organoleptically, germinated pearl millet was found to be more suitable for porridge (50%) and salad (100%), while puffed sorghum was best suitable for bun (15%) preparation. Prepared porridge had significantly ($P \leq 0.05$) higher protein (16.9%) and total phenols (178.8 mg GAE/100 g) contents and antioxidant capacity (1,036 mg TE/100 g) than control. The dietary fibre and *in vitro* starch digestibility of composite porridge and bun increased significantly ($P \leq 0.05$). Most acceptable composition of porridge, bun, and salad had low glycaemic index (17.64–26.79) and medium to low glycaemic load (8.82–13.40). Suitability of pearl millet and sorghum using appropriate processing techniques (germination and puffing) is recommended for preparation of indigenous food products especially for diabetics.

---

* Corresponding author. E-mail: aditi-fn@pau.edu

AKJournals

1. INTRODUCTION

India is ranked second after China for carrying 49 percent of global diabetes (an autoimmune destruction of β-cells in islets of Langerhans causing resistance to insulin) burden (Pradeepa and Mohan, 2021). Presently, 25.2 million Indian adults suffer from impaired glucose tolerance with predicted rise to 35.7 million by 2045. A robust approach to tackle diabetes ranging from biomedical to public health action is called for, owing to its association with diet and lifestyle. Indian diet predominantly contains cereals; therefore, intervention in diet can improve the diabetic scenario. Millets and sorghum have developed strong clinical impression of reducing post-prandial blood glucose rise and glycosylated haemoglobin levels than glucogenic staples (Palanisamy and Sree, 2020).

Pearl millet has slowly digestible and resistant starch, which reduces its glycaemic index (GI) and sorghum is loaded with cellulosic and non-cellulosic polysaccharides (mainly glucuronoar-abinoxylans [GAX]), thus, having high gelatinisation temperature leading to low starch digestibility. Recipes prepared from these grains are not readily accepted, owing to characteristic flavour, thus, conventional processing techniques should be applied to improve these traits and nutrition value. Therefore, suitability of pearl millet and sorghum grains for the development of low GI foods for diabetics was assessed.

2. MATERIALS AND METHODS

Pearl millet FBC16 (PM) and sorghum PSC4 (SOR) grain samples procured from PAU, Ludhiana were cleaned, rinsed with deionised water. Wheat, split mung, and functional ingredients were procured from the local market. Samples were subjected to germination and puffing using standardised methods:

Germination: Grains were soaked (30 °C) in water (1:2). Damp grains were treated in formaldehyde solution (0.2%), rinsed in distilled water to remove its remnants, and kept in moist muslin at 30 °C in an incubator for 48 h. Germinated grains were dried at 50 °C to a constant weight in a hot air oven.

Puffing: Conditioned grains (19% moisture) were puffed in an iron pan using fine sand as heat exchange medium.

2.1. Flour preparation

Control and processed grains were dried in hot air oven (5% moisture) and finely ground to flour after passing through mesh size 240 in a laboratory hammer mill using zero number stainless steel sieve (particle size: 53 μm).

2.2. Formulation of food products

Three food products viz., porridge, bun, and salad were standardised, using germinated pearl millet (GPM) and sorghum (GSOR); and puffed pearl millet (PPM) and sorghum (PSOR). Recipes prepared from unprocessed grains were taken as their respective control (CPM and CSOR). Different compositions of control and processed PM and SOR with varying amounts of

water and other ingredients were tried, to prepare porridge, bun, and salad and were tested by a semi-trained panel to standardise the final recipe as presented in Table 1.

Table 1. Standardised recipes of porridge, bun, and salad

Porridge

Ingredients	T1	T2	T3	Method
CPM/CSOR	50	–	–	PM and SOR grains were milled to grits
GPM/GSOR	–	50	–	(1.41–2 mm) after passing through
PPM/PSOR	–	–	50	ASTM sieve no. 10 and 14. To reduce
Wheat porridge	30	30	30	cooking time smaller grit size (0.954–
Split mung	20	20	20	1.41 mm; ASTM14 and 20) was used.
Oil	7	7	7	Oil was heated, cumin seeds and onion
Cumin seeds	2	2	2	were sautéed. Vegetables and PM/SOR
Chopped onion	10	10	10	grains with salt & spices were added
French beans	10	10	10	with water. Lid was removed after steam
Carrots	10	10	10	escaped.
Peas	10	10	10	
Salt	1.25	1.25	1.25	
Water (mL)	600	600	600	

Bun

Ingredients	B1	B2	B3	Method
CPM/CSOR	15	–	–	Sugar and fresh yeast were dissolved in
GPM/GSOR	–	15	–	lukewarm water. Dry ingredients were
PPM/PSOR	–	–	15	sieved, dough was prepared and left for
Refined flour	85	85	85	proofing (2 h). Dough was rolled, balls
Yeast	3	3	3	were made and kept for second
Sugar	3	3	3	proofing. Baked at 200 °C for 20 min.
Salt	1	1	1	
Oil	5	5	5	
Water (mL)	65	65	65	

Salad

Ingredients	S1	S2	Method
GPM/GSOR		–	Processed grains were steamed and
PPM/PSOR	–	100	mixed with cucumber, tomato, and
Cucumber	25	25	onion with salt, spices, and lemon juice.
Tomato	25	25	
Onion	20	20	
Lemon juice	3	3	
Salt	1	1	
Pepper	0.5	0.5	

CPM: Control pearl millet (T1: 50%; B1: 15%); CSOR: Control sorghum (T1: 50%; B1: 15%); GPM: Germinated pearl millet (T2: 50%; B2: 15%; S1: 100%); GSOR: Germinated sorghum (T2: 50%; B2: 15%; S1: 100%); PPM: Puffed pearl millet (T3: 50%; B3: 15%; S2: 100%); PSOR: Puffed sorghum (T3: 50%; B3: 15%; S2: 100%)

2.3. Organoleptic evaluation

Prepared products were evaluated using 9-point hedonic scale by a panel of 30 semi-expert judges and Likert scale by a consumer panel of 25 diabetics.

2.4. Nutritional evaluation

Prepared products were weighed, homogenised, oven dried at 60 °C, and evaluated for proximate composition including moisture, total ash, crude protein (N × 6.25), crude fibre and crude fat contents according to AOAC official methods 925.09, 923.03, 979.09, 962.09, and 4.5.01, respectively, and total dietary fibre by Method 985.29 AOAC (2000). Total carbohydrates contents excluding crude fibre were calculated by difference. The energy values of the grains were estimated in kcal by multiplying percent protein, fat, and carbohydrates by their energy values per gram. In vitro starch digestibility (Singh et al., 1982) with bioactive compounds including total phenols (Singleton et al., 1999) were determined using Folin–Ciocalteu (FC) reagent and expressed as mg of gallic acid equivalents (GAE)/g, tannins (Singh and Jambunathan, 1981) as mg tannic acid equivalents (TAE)/g total flavonoid content (Zhishen et al., 1999) as mg rutin equivalent (RE)/100 g, and antioxidant activity (AOA) by DPPH was determined using free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) in methanolic solution and calculated as percent discoloration:

$$\text{AOA (\%)} = \text{Percent inhibition} = \frac{Ac - Ae}{Ac} \times 100$$

where, Ac = Absorbance of control; Ae = Absorbance of extract, and by Ferric Reducing Antioxidant Power (FRAP) and expressed as mg Trolox Equivalent (TE)/100 g (Tadhani et al., 2007).

2.5. Determination of glycaemic index (GI) and glycaemic load (GL)

Most accepted porridge, bun, and salad were evaluated for GI and GL, whereby reference (55 g glucose; GI 103) and test meals containing 50 g available carbohydrate were pre-tested and the experiment started between 06.00 and 07.00 h. A group of 17 volunteers (18–25 years) with no reported history of gastrointestinal disorders, suffering or suffered diabetes, or not on medication for any chronic disease, or not intolerant/allergic to any foods were selected.

The experiment was conducted as described by Wolever et al. (1991). Each test food was cooked freshly, portioned by weight and fed to healthy subjects on empty stomach with overnight fasting of 10 h. Blood glucose was measured using a pre-calibrated automatic lancet device (Accu-Chek Sensor, Roche Diagnostics GmbH, Mannheim, Germany) twice before consumption of food and then postprandially at 15, 30, 45, 60, 90, and 120 min. Mean blood glucose response curve was graphically plotted for standard and test foods, followed by geometrical calculation of the incremental area under curve using trapezoid method:

$$GI = \frac{\text{Area under the curve for 50 g carbohydrate from test food}}{\text{Area under the curve for 50 g carbohydrate from glucose standard}} \times 100$$

$$GL = \frac{\text{Available carbohydrate content of test food} \times \text{GI of the test food}}{100}$$

GI is classified into low (GI ≤ 55), intermediate (GI 56–69), and high (GI ≥ 70) by ISO (2010), while GL as low (≤10), medium (11–19), and high (≥20) according to Venn and Green (2007).

2.6. Statistical analysis

Experimental data was subjected to Kruskal–Wallis test to assess the significance between organoleptic scores and analysis of variance, followed by Tukey's post hoc test using SPSS statistical software (version 16.0, SPSS Inc., Chicago, Illinois, USA).

3. RESULTS AND DISCUSSION

3.1. Organoleptic evaluation

Organoleptic evaluation of porridge, bun, and salad based on received mean scores by semi-trained panel is presented in Table 2. Likewise, consumer acceptability is displayed in Fig. 1. Appraisal of porridge by semi-trained panel revealed significantly ($P \leq 0.01$) higher overall acceptability score (6.55) for the product prepared from 50% GPM, while the majority of consumers, as well, extremely (32%) and moderately (36%) liked the above composition. However, bun prepared with 15% PSOR flour was evaluated as significantly ($P \leq 0.01$) most desirable

Table 2. Organoleptic scores of porridge, bun, and salad

	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
			Porridge (50%)			
CPM	6.73 ± 0.70	6.80 ± 0.68	6.33 ± 0.90	6.13 ± 0.74	6.07 ± 0.70	6.41 ± 0.62
GPM	6.67 ± 0.82	6.73 ± 0.80	6.53 ± 0.83	6.40 ± 0.83	6.40 ± 0.74	6.55 ± 0.65
PPM	6.73 ± 0.80	6.73 ± 0.59	6.40 ± 0.83	6.13 ± 0.99	6.13 ± 0.99	6.43 ± 0.68
CSOR	6.73 ± 0.70	6.73 ± 0.70	6.20 ± 0.77	6.47 ± 0.64	6.40 ± 0.74	6.51 ± 0.61
GSOR	6.73 ± 0.70	6.80 ± 0.68	6.40 ± 0.83	6.27 ± 0.70	6.13 ± 0.83	6.47 ± 0.68
PSOR	6.67 ± 0.62	6.53 ± 0.64	6.40 ± 0.83	6.60 ± 1.12	6.60 ± 1.12	6.54 ± 0.74
χ^2 Value	30.475**	43.300**	43.554**	65.786**	56.781**	61.478**
			Bun (15%)			
CPM	7.27 ± 0.46	7.20 ± 0.46	7.13 ± 0.52	6.80 ± 0.86	6.80 ± 0.86	7.04 ± 0.50
GPM	5.60 ± 1.18	5.47 ± 0.99	5.07 ± 0.96	5.07 ± 0.98	5.07 ± 0.96	5.25 ± 0.91
PPM	6.67 ± 1.35	6.47 ± 1.36	6.73 ± 1.16	6.33 ± 1.18	6.27 ± 1.16	6.49 ± 1.15
CSOR	7.13 ± 0.92	7.00 ± 0.85	7.00 ± 0.85	6.80 ± 0.86	6.73 ± 0.88	6.93 ± 0.75
GSOR	5.87 ± 1.06	6.13 ± 0.83	5.47 ± 1.13	5.67 ± 1.35	5.73 ± 1.39	5.77 ± 1.00
PSOR	7.33 ± 1.18	7.20 ± 1.15	7.40 ± 1.18	7.07 ± 1.10	7.00 ± 1.13	7.20 ± 1.10
χ^2 Value	29.689**	32.600**	41.822**	27.929**	25.575**	36.908**
			Salad (100%)			
GPM	7.67 ± 0.49	7.83 ± 0.71	7.89 ± 0.83	7.83 ± 0.62	8.06 ± 0.54	7.86 ± 0.33
GSOR	6.56 ± 0.78	6.78 ± 0.73	5.11 ± 0.68	6.17 ± 0.71	6.11 ± 0.61	6.14 ± 0.33
χ^2 Value	35.615**	39.477**	34.326**	38.715**	41.216**	46.003**

**: Significant at 1% level ($P \leq 0.01$). Values are expressed as mean ± SD; CPM: Control pearl millet; GPM: Germinated pearl millet; PPM: Puffed pearl millet; CSOR: Control sorghum; GSOR: Germinated sorghum; PSOR: Puffed sorghum
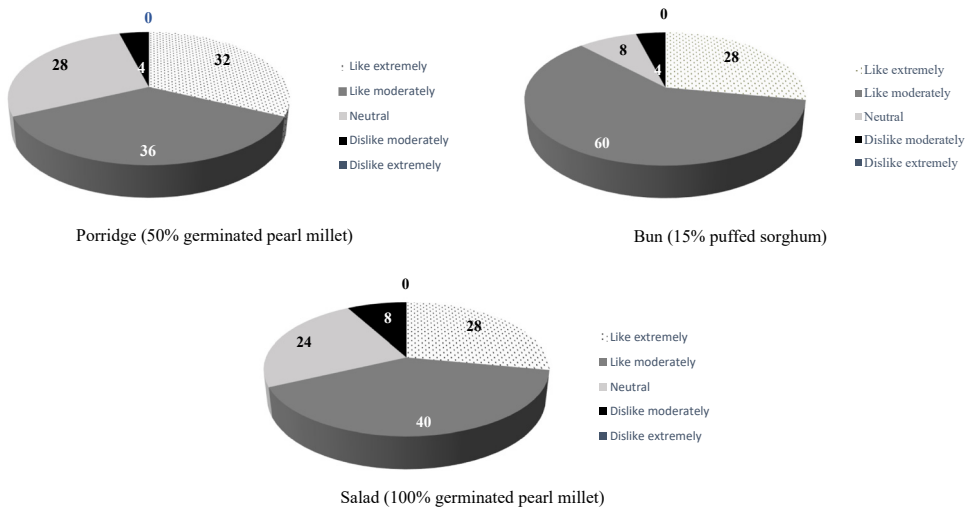
Porridge (50% germinated pearl millet)

Bun (15% puffed sorghum)

Salad (100% germinated pearl millet)

Fig. 1. Percent consumer acceptability of porridge, bun, and salad

by semi-trained panel (7.20). Likewise, majority of consumer panel (60%) moderately and extremely (28%) liked the bun. Correspondingly, salad prepared from 100% GPM received significantly ($P \leq 0.01$) higher overall acceptability score (7.86) by semi-trained panel, while this observation matched the data of consumer panel, whereby, 28% of diabetics extremely, while 40% moderately liked this recipe.

3.2. Nutritional evaluation

Chemical composition of most accepted porridge is delineated in Table 3. The protein content was found to be significantly ($P \leq 0.05$) higher in GPM porridge, owing to utilisation of carbohydrates and fats during respiration and synthesis of amino acids (Jan et al., 2017). The significant ($P \leq 0.05$) reduction of carbohydrates in GPM porridge may be due to increased α-amylase activity, hydrolysing starch to simple sugars in cotyledon providing energy for cell division (Nonogaki et al., 2010).

Significantly ($P \leq 0.05$) higher dietary fibre content was detected in GPM porridge (Table 4), perhaps due to surged activity of xylanases during germination, solubilising arabinoxylans (Maina et al., 2021). Total phenols and flavonoids amounts were significantly ($P \leq 0.05$) higher in GPM porridge that could be due to stimulation of enzyme phenylalanine ammonia-lyase, responsible for biosynthesis of phytochemicals (phenols and flavonoids) (Nkhata et al., 2018). Tannin contents reduced significantly ($P \leq 0.05$) in GPM porridge, owing to leaching of dispersible portion and accelerated by subsequent germination (Hussain et al., 2011). This observation was in line with the results of Sharma et al. (2015), whereby, germination significantly ($P \leq 0.05$) increased (27.10–57.72 mg RU/g) total flavonoids amounts but decreased (2.803–0.983 mg/100 g) tannin content of foxtail millet.

A significant ($P \leq 0.05$) increase in *in vitro* starch digestibility was observed in GPM porridge, attributed to enhanced amylase activity, hydrolysing complex starch to simpler by-product. Total

Table 3. Proximate composition of porridge, bun, and salad

Composition of food product	Moisture (%)	Ash (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Carbohydrates (%)	Energy (KCal)
Porridge (50%)							
CPM	$2.79^b \pm 0.24$	$4.67^a \pm 0.27$	$15.44^b \pm 0.45$	$6.38^a \pm 0.14$	$2.37^a \pm 0.49$	$67.56^a \pm 0.93$	$363.38^a \pm 1.16$
GPM	$6.59^a \pm 0.14$	$4.77^a \pm 0.47$	$16.85^a \pm 0.53$	$7.96^a \pm 3.15$	$2.35^a \pm 0.09$	$61.48^b \pm 3.48$	$384.96^{ab} \pm 16.61$
Bun (15%)							
CSOR	$5.20^a \pm 0.08$	$2.58^a \pm 0.07$	$10.74^a \pm 0.51$	$4.85^a \pm 0.92$	$0.34^b \pm 0.05$	$76.30^a \pm 1.24$	$391.79^a \pm 5.33$
PSOR	$4.90^a \pm 0.19$	$2.50^a \pm 0.09$	$10.48^a \pm 1.05$	$4.32^a \pm 0.35$	$0.44^a \pm 0.02$	$77.21^a \pm 1.41$	$390.25^a \pm 2.09$
Salad (100%)							
GPM	4.13 ± 0.04	5.40 ± 0.11	12.66 ± 0.87	4.57 ± 0.29	2.23 ± 0.11	71.01 ± 1.13	375.82 ± 1.52

Mean values with different superscript are significantly different ($P \leq 0.05$) using Tukey's test, CPM: Control pearl millet; GPM: Germinated pearl millet; PPM: Puffed pearl millet; CSOR: Control sorghum; GSOR: Germinated sorghum; PSOR: Puffed sorghum

Table 4. Nutritional parameters of most accepted food products

Composition of food product	Total dietary fibre (%)	Total phenols (mg GAE/ 100 g)	Tannins (mg/100 g)	Total flavonoids (mg RE/100 g)	*In vitro* starch digestibility (mg maltose released/g)	DPPH TAC (mg TE/100 g)	FRAP TAC (mg TE/100 g)
			Porridge (50%)				
CPM	$13.56^b \pm 0.58$	$120.72^b \pm 2.16$	$266.33^a \pm 7.44$	$184.79^b \pm 3.83$	$50.33^b \pm 2.28$	$913.90^b \pm 3.82$	$142.36^b \pm 1.42$
GPM	$15.98^a \pm 0.22$	$178.75^a \pm 2.81$	$209.18^b \pm 5.34$	$253.48^a \pm 2.30$	$70.40^a \pm 2.64$	$1{,}035.92^a \pm 8.48$	$189.23^a \pm 19.50$
			Bun (15%)				
CSOR	$3.63^b \pm 0.57$	$68.86^a \pm 1.39$	$66.01^a \pm 3.38$	$148.04^a \pm 3.03$	$57.58^b \pm 0.83$	$1709.57^a \pm 13.27$	$106.90^a \pm 2.69$
PSOR	$4.92^a \pm 0.25$	$64.68^b \pm 1.71$	$68.71^a \pm 4.29$	$115.49^b \pm 3.01$	$62.97^a \pm 2.98$	$1{,}541.01^b \pm 71.12$	$84.01^b \pm 1.86$
			Salad (100%)				
GPM	14.88 ± 0.76	140.06 ± 4.14	55.81 ± 6.46	281.13 ± 2.09	25.16 ± 2.10	616.40 ± 9.43	227.89 ± 22.70

Mean values with different superscript are significantly different ($P < 0.05$) using Tukey's test, CPM: Control pearl millet; GPM: Germinated pearl millet; CSOR: Control sorghum; PSOR: Puffed sorghum

antioxidant (DPPH and FRAP) value was observed to be significantly ($P \leq 0.05$) higher in GPM porridge attributed to raised levels of antioxidative enzymes, superoxide-dismutases, glutathione-S-transferase, peroxidises, and catalases due to germination.

Analysis of crude fibre (Table 3) displayed a significant ($P \leq 0.05$) increase of 29.4% in PSOR bun. Similar results were reported by Kumari et al. (2018) demonstrating a notable increase in crude fibre of PM varieties post popping owing to loss of moisture. Significantly ($P \leq 0.05$) higher dietary fibre was observed in PSOR bun (Table 4), owing to increase in β-glucan availability post sand roasting, due to release of bound β-glucan by the thermal effect of puffing (Kora, 2019). Total phenolic and flavonoid contents of PSOR bun reduced significantly ($P \leq 0.05$) by 6.07% and 22%, respectively. Likewise, Devi et al. (2020) reported a reduction of about 50% in phenols and 35% in flavonoids associated to thermal degradation of heat-labile phenols and flavonoids along with dissociation of bran post popping makhana (foxnut) kernel.

Significantly ($P \leq 0.05$) higher *in vitro* starch digestibility was observed in PSOR bun due to puffing, which enhanced gelatinisation of starch (Huang et al., 2018). Total antioxidant activity reduced significantly ($P \leq 0.05$) in PSOR bun, which might be due to decomposition of phytochemicals along with detachment of bran during puffing.

Prepared salad recipe contained remarkable amount of crude protein (12.7%) (Table 3) with dietary fibre and total phenol contents of 14.88% and 140.1 mg GAE/100 g, respectively, with a low tannin content of 55.81 mg/100 g (Table 4). Total antioxidant capacities by DPPH and FRAP of GPM salad were 616.4 and 227.9 mg TE/100 g, respectively.

3.3. Determination of glycaemic index and glycaemic load

The blood glucose response (mg dL^{-1}) of reference and test foods is displayed in Fig. 2. The area under curve (Table 5) for most accepted porridge (50% GPM), bun (15% PSOR), and salad (100% GPM) were considerably lower than glucose. Results indicated that prepared diabetic foods had low GI with medium to low GL (Table 6). In contrast to GI of these recipes, the GI of food contemporaries as reported by Atkinson et al. (2008) were also analysed. GPM porridge had GI 52.5% lower than wheat porridge with reported GI of 55. Likewise, bun made from refined and whole wheat flour had GI of 75 and 74, respectively, while 15% supplementation of
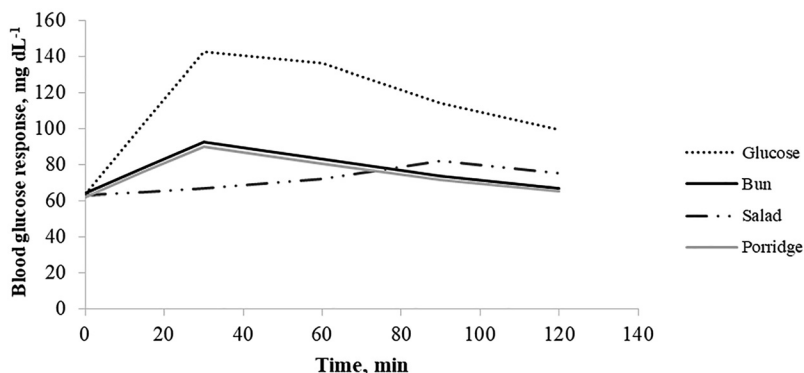

Fig. 2. Graphical representation of blood glucose response of most accepted food products

Table 5. Incremental area under blood glucose response curve (iAUC) of porridge, bun, and salad

Time (min)	Glucose standard		Porridge		Bun		Salad	
	Blood glucose (mg dL^{-1})	Blood glucose increment Δ (mg dL^{-1})	Blood glucose (mg dL^{-1})	Blood glucose increment Δ (mg dL^{-1})	Blood glucose (mg dL^{-1})	Blood glucose increment Δ (mg dL^{-1})	Blood glucose (mg dL^{-1})	Blood glucose increment Δ (mg dL^{-1})
0	63.75	–	62.13	–	63.88	–	62.8	–
15	103.13	39.38	76.01	13.93	78.19	14.31	64.65	1.85
30	142.50	78.75	89.91	27.82	92.50	28.63	66.50	3.70
45	139.25	75.50	85.20	23.22	87.69	23.81	69.30	6.50
60	136.00	72.25	80.58	18.52	82.88	19.00	72.10	9.30
90	114.00	50.25	71.45	9.39	73.50	9.63	82.20	19.40
120	99.38	35.63	64.89	2.81	66.75	2.88	75.30	12.50
Area (mg × min dL^{-1})	6,572		1,715		1,761		1,160	

Mean values for incremental area under curve (iAUC)

Table 6. GIycaemic index and glycaemic load of food products

Food product	GI	GL	Category	
			GI	GL
Glucose standard	100.00	50.00	High	High
Porridge	26.10	13.05	Low	Medium
Bun	26.79	13.40	Low	Medium
Salad	17.64	8.82	Low	Low

PSOR flour reduced GI by about 64.3%. Salad (100% GPM) had GI 44.9% less than gram sprout salad with GI of 32.

4. CONCLUSIONS

Germinated pearl millet was most suitable for porridge and salad, while puffed sorghum for bun. GPM porridge had significantly higher protein, total phenols, and antioxidants. Dietary fibre and *in vitro* starch digestibility of GPM porridge and PSOR bun were significantly better. These compositions had low GI and medium to low GL.

REFERENCES

AOAC (2000). *Official methods of analysis*. Association of Official Analytical Chemists, Washington, DC.

Atkinson, F.S., Foster-Powell, K., and Brand-Miller, J.C. (2008). International tables of glycemic index and glycemic load values. *Diabetes Care*, 31: 2281–2283.

Devi, M., Sharma, K., Jha, S.N., Arora, S., Patel, S., Kumar, Y., and Vishwakarma, R.K. (2020).Effect of popping on physicochemical, technological, antioxidant, and microstructural properties of makhana seed. *Journal of Food Processing and Preservation*, 44(10): e14787.

Huang, R., Pan, X., Lv, J., Zhong, W., Yan, F., Duan, F., and Jia, L. (2018). Effects of explosion puffing on the nutritional composition and digestibility of grains. *International Journal of Food Properties*, 21(1): 2193–2204.

Hussain, I., Uddin, M.B., and Aziz, M.G. (2011). Optimization of antinutritional factors from germinated wheat and mungbean by response surface methodology. *International Food Research Journal*, 18(3): 957–963.

ISO (2010). *Food products – determination of the glycaemic index (GI) and recommendation for food classification*. ISO 26642: 2010.

Jan, R., Saxena, D.C., and Singh, S. (2017). Physico-chemical, textural, sensory and antioxidant characteristics of gluten free cookies made from raw and germinated Chenopodium (*Chenopodium album*) flour. *LWT – Food Science and Technology*, 71: 281–287.

Kora, A.J. (2019). Applications of sand roasting and baking in the preparation of traditional Indian snacks: nutritional and antioxidant status. *Bulletin of the National Research Centre*, 43: 158.

Kumari, R., Singh, K., Jha, S.K., Singh, R., Sarkar, S.K., and Bhatia, N. (2018). Nutritional composition and popping characteristics of some selected varieties of pearl millet (*Pennisetum glaucum*). *Indian Journal of Agricultural Sciences,* 88(8): 1222–1226.

Maina, N.H., Rieder, A., De Bondt, Y., Mäkelä-Salmi, N., Sahlstrøm, S., Mattila, O., Lamothe, L.M., Nyström, L., Courtin, C.M., Katina, K., and Poutanen, K. (2021). Process-induced changes in the quantity and characteristics of grain dietary fiber. *Foods*, 10: 2566.

Nkhata, S.G., Ayua, E., Kamau, E.H., and Shingiro, J.B. (2018). Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food Science and Nutrition*, 6(8): 2446–2458.

Nonogaki, H., Bassel, G.W., and Bewley, J.W. (2010). Germination - still a mystery. *Plant Science*, 179(6): 574–581.

Palanisamy, T. and Sree, R. (2020). Efficacy of millets (foxtail, kodo, small, barnyard and pearl millet) varieties on postprandial glycaemic response in patients with type 2 diabetes. *European Journal of Pharmaceutical Sciences*, 7(7): 443–449.

Pradeepa, R. and Mohan, V. (2021). Epidemiology of type 2 diabetes in India. *Indian Journal of Ophthalmology*, 69(11): 2932–2938.

Sharma, S., Saxena, D.C., and Riar, C.S. (2015). Antioxidant activity, total phenolics, flavonoids and antinutritional characteristics of germinated foxtail millet (*Setaria italica*). *Cogent Food & Agriculture*, 1(1): 1081728.

Singh, U. and Jambunathan, R. (1981). Studies on *desi* and *kabuli* chickpea cultivars: levels of amylase inhibitors, oligosaccharides and *in vitro* starch digestibility. *Journal of Food Science*, 46: 1364–1367.

Singh, U., Kherdekar, M.S., and Jambunathan, R. (1982). Study on *desi* and *kabuli* chickpea cultivars: levels of amylase inhibitors, oligosaccharides and *in vitro* starch digestibility. *Journal of Food Science*, 47(2): 510–512.

Singleton V.L., Orthofer, R., and Lamuela-Raventos, R.M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin–Ciocalteu reagent. *Methods of Enzymology*, 299: 152–178.

Tadhani, M.B., Patel, V.H., and Subhash, R. (2007). *In vitro* antioxidant activities of *Stevia rebaudiana* leaves and callus. *Journal of Food Composition and Analysis*, 20(3–4): 323–329.

Venn, B.J. and Green, T.J. (2007). Glycemic index and glycemic load: measurement issues and their effect on diet disease relationships. *European Journal of Clinical Nutrition*, 61(Suppl. 1): S122–S131.

Wolever, T.M.S., Jenkins, D.J.A., Jenkins, A.L., and Josse, R.G. (1991). The glycemic index methodology and clinical implications. *The American Journal of Clinical Nutrition*, 54(5): 846–854.

Zhishen, J., Mengcheng, T., and Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry*, 64(4): 555–559.