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ORIGINAL ARTICLE

Glycemic index and significance of barnyard millet (*Echinochloa frumentacae*) in type II diabetics

Roopashree Ugare · Bharati Chimmad · Rama Naik · Pushpa Bharati · Sunanda Itagi

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Abstract The study was undertaken to assess nutrient composition, glycemic index and health benefits of barnyard millet in type II diabetics. The millet had 10.5% protein 3.6% fat, 68.8% carbohydrate and 398 kcal/100 g energy. The total dietary fibre content was high (12.6%) including soluble (4.2%) and insoluble (8.4%) fractions. Low glycemic index of the grains both dehulled (50.0) and dehulled and heat treated (41.7) was recorded. The feeding intervention of 28 days revealed a significant reduction in glucose (139.2 to 131.1 mg/dl), LDL-C (from 167.7 to 162.9 mg/dl), VLDL-C (from 24.0 to 23.2 mg/dl), ratio of TC: HDL (from 4.7 to 4.6) and LDL: HDL (from 3.2 to 3.1) in the experimental diabetic groups. Similar, but marginal changes were observed in experimental non diabetics. Marginal decrease of triglycerides and increase of HDL were registered in diabetic groups due to barnyard millet intervention. The study indicated that the dehulled and heat treated barnyard millet is beneficial for type-II diabetics.

Keywords Barnyard millet · *Echinochloa frumentacae* · Glycemic index

Introduction

Barnyard millet *(Echinochloa frumentacaea)* is one of the hardiest millets, which is called by several names viz., Japanese barnyard millet, *ooda, oadalu, sawan, sanwa, and sanwank.* Nutritionally, Barnyard millet is an important crop. It is a fair source of protein, which is highly digestible and is an excellent source of dietary fibre with good amounts of soluble and insoluble fractions (Hadimani and Malleshi 1993; Veena et al. 2005). The carbohydrate content is low and slowly digestible (Veena et al. 2005), which makes the Barnyard millet a natural designer food. In the present days of increased diabetes mellitus, barnyard millet could become an ideal food.

Although barnyard millet like any other minor millet is nutritionally superior to cereals, yet its utilization is limited. Besides, barnyard is a fastest multi purpose crop, which yields food and forage in a short duration and at low inputs even under adverse climatic conditions. Further, Krishna Kumari and Thayumanavan (1997) have indicated that rats fed with diets prepared from native and treated starch of barnyard millet recorded lowest blood glucose, serum cholesterol and triglycerides compared to foxtail, Proso, Kodo, and Little millets. There is a need to assess the effect of barnyard millet for its nutritional qualities and potential health benefits among normal and diabetic volunteers. Hence, a study was undertaken to evaluate nutrient composition, glycemic index and health benefits of barnyard millet in type II diabetics.

Materials and methods

The proximate composition of barnyard millet was assessed by standard AOAC (1990) procedures. Calorific value was determined through digital bomb calorimeter with differential temperature/firing unit of Toshniwal make. Dietary fibre was estimated by the methods of Asp et al. (1983). All analyses were made in triplicates.

Glycemic index (GI) The glycemic index (GI) of both dehulled and heat treated grains (dehulled grains heated at 60 °C, in four cycles with intermittent cooling for 1 h) was assessed through post prandial GTT of test carbohydrate

R. Ugare · B. Chimmad (✉) · R. Naik · P. Bharati · S. Itagi
Department of Food Science and Nutrition,
University of Agricultural Sciences,
Dharwad 580005, India
e-mail: bvchimmad@gmail.com

(barnyard millet) and comparing with reference carbohydrate (glucose) in six non diabetic healthy volunteers by following the methods of Wolever et al. (1991). Reference carbohydrate and test meal equivalent to 50 g carbohydrate were administered separately to the volunteers on three separate days with an interval of 1 week. The normal and healthy volunteers aged between 37 and 40 years (3 males), of sedentary life style without any medication were included for GI test.

Feeding intervention The long term feeding study with dehulled and heat treated barnyard millet was conducted on nine diabetic and six non-diabetic volunteers. The feeding intervention was conducted on separate groups of volunteers maintaining a matched control in terms of age, gender, dietary habits, life style and anthropometry. The test meal consisted of heat treated grains of 73 g (equivalent of 50 g carbohydrate content) was packed in unit packages and distributed to the volunteers. The volunteers were instructed to consume the test food for breakfast, lunch and/or dinner in the form of *upma* like product (prepared by cooking dehulled and roasted barnyard millet in water 1:4, w:v with 2 g of green chillies) or cooked like rice. Compliance report was obtained from the volunteers during and after the study. The venous blood samples were collected from the volunteers before and after intervention to assess the impact on blood glucose, triglycerides, total cholesterol, HDL-C, LDL-C and VLDL-C, which were analyzed using Swemed diagnostic kits in Swemed semi-auto analyzer. Paired't' test was applied to evaluate the impact of feeding intervention.

Results and discussion

The proximate composition of barnyard millet is presented in Table 1. Staple foods such as wheat and rice were reported to contain much lower levels of dietary fibre of around 8.0 to 9.0. The data on proximate composition of barnyard millet in the present study is in agreement with the reports of previous investigators (Hadimani and Malleshi 1993; Veena et al. 2005).

The glycemic indices of both dehulled and heat treated grains were found to be lower than glucose (Fig. 1). The GI of the dehulled grains ranged from 45.2 to 54.8 with a mean of 50.0. While, the mean GI of the dehulled and heat treated grains was 41.7 with a range of 38.4 to 45.3, which was relatively lower than the dehulled grains. This reduction in glycemic index could be attributed to development of resistant starch during heating and cooling cycles given to the dehulled and heat treated millet. Studies have indicated that heat processing renders some amount of starch fractions resistant to mammalian enzymes and thus escape

Table 1 Nutrient composition of barnyard millet (*dwb*)

Moisture, %	8.7
Protein, %	10.5
Fat. %	3.6
Crude fiber, %	6.6
Total minerals, %	2.0
Total carbohydrates, % (by difference)	68.8
Calorific value, kcal/100 g	398.0
Total dietary fiber, %	12.6
Soluble, %	4.2
Insoluble, %	8.4

(*n*=3)

digestion. Retrogradation of amylose is reported to lead to the formation of resistant starch (Jenkins et al. 1982). It has been demonstrated that intermittent heating and cooling cycles significantly increased resistant starch fraction in wheat (Ranhotra et al. 1991). It is pertinent to recall that native wheat starch subjected to five cycles of autoclaving and cooling contained 11.5% resistant starch, as against a meager level of 0.5 in native samples. Meanwhile, both dehulled and dehulled and heat treated grain meals in the present study can be grouped under low GI foods as per the suggested classification (Brand-Miller et al. 2003). The barnyard millet based health mix developed by Surekha et al. (2004) showed a relatively higher GI of 59.80, despite the inclusion of noticeable amounts of hypoglycemic ingredients. The plain grain meal in the present study without any hypoglycemic agents exhibited a significantly low GI of 41.7. This is very important for development of designer foods for 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. A mean reduction of 6.0% in the diabetics was observed after the feeding intervention (Table 2). Similarly, the non-diabetic volunteers also

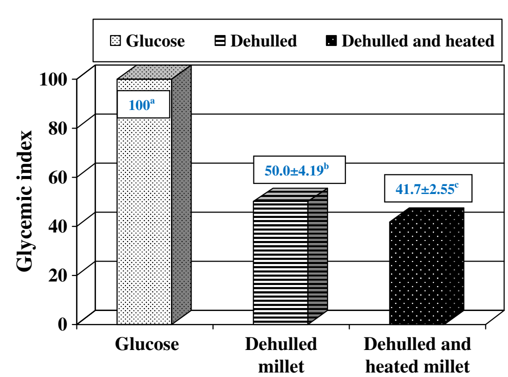

Fig. 1 Glycemic index of dehulled and dehulled and heated barnyard millet (*n*=6)

Table 2 Effect of barnyard millet intervention on blood glucose and lipid levels (mg/dl) of diabetic volunteers

	Experimental			Control		
	Initial	Final	't' value	Initial	Final	't' value
Fasting blood glucose	139.2±12.94	131.1±16.15 (−6.0)	5.00**	138.5±10.30	141.3±10.28 (2.0)	2.32*
Triglycerides	119.9±19.36	116.1±20.77 (−3.3)	1.93^{NS}	125.0±14.99	128.8±14.57 (3.0)	3.86**
Total cholesterol	242.7±33.50	239.5±37.31 (−2.8)	2.30^{NS}	237.9±15.51	242.1±15.59 (1.8)	5.32**
HDL-C	52.2±5.80	53.4±4.58 (2.3)	1.52^{NS}	51.2±4.39	50.26±5.29 (−1.8)	1.41^{NS}
LDL-C	167.7±30.74	162.9±32.59 (−4.5)	2.64*	161.7±15.15	166.06±13.84 (2.7)	3.42**
VLDL-C	24.0±3.87	23.2±4.15 (−3.4)	2.90*	25.0±7.83	25.75±7.62 (3.0)	3.82**
TC : HDL	4.7±0.64	4.6±0.58 (−6.7)	2.56*	4.7±0.53	4.9±0.54 (3.8)	2.45*
LDL : HDL	3.2±0.60	3.1±0.65 (−9.4)	2.59*	3.2±0.47	3.3±0.47 (4.7)	2.33*

(n=9) *p<0.05, **p<0.01; *NS* Not- significant

Figures in parentheses indicate per cent change over initial

showed a reduction in fasting glucose level with a mean reduction of 7.0% (Table 3). A similar decrease of about 7.0% in glucose level of non-diabetics as an effect of barnyard millet based health mix was also reported by Surekha et al. (2004). The high dietary fibre and low carbohydrate content (53–66%) of low digestibility (20–28%, over 2 h assay), may support the reduction in glucose levels (Veena et al. 2005). On the other hand, there was an increase in blood glucose level in respective diabetic and non-diabetic control groups by 2.0 and 1.5%, respectively.

Improvement in the lipid profile was also noted in the present study (Tables 2 and 3). A non significant decrease in triglyceride level from 119.9 to 116.1 mg/dl in diabetics and 107.7 to 104.3 mg/dl in non-diabetic experimental groups was recorded after the feeding intervention. A significant decrease in total cholesterol from 217.7 to 215.4 mg/dl in non-diabetic and from 242.7 to 239.5 mg/dl in diabetic volunteers was observed. In contrast the total cholesterol levels increased significantly in matched control groups. High density lipoprotein (HDL) signifies the good cholesterol. The beneficial effect of consuming barnyard millet was reflected in terms of elevation in the levels of HDL (Tables 2 and 3). The mean initial of HDL levels among diabetics and non-diabetics increased from 52.2 to 53.4 mg/dl and 62.2 to 63.4 mg/dl, respectively, however the increase was not significant. In contrast, a significant decreasing trend for HDL was observed in the respective control groups.

The computation of low density lipoprotein (LDL) and very low density lipoprotein (VLDL) levels revealed that the Barnyard millet brought about a decreasing trend in these levels (Tables 2 and 3). The LDL and VLDL in the experimental diabetic volunteers reduced significantly to an extent of 2.8 and 3.1%, respectively (p<0.05). A reduction of 1.0 and 3.2% was also noted in the experimental non-diabetic volunteers. It was important to note that, there were improvements in the ratios of TC: HDL and LDL: HDL in the present investigation (Tables 2 and 3). The mean initial TC: HDL ratio in the experimental diabetics reduced from 4.7 to 4.6 and no significant reductions were recorded in

Table 3 Effect of barnyard millet intervention on blood glucose and lipid levels (mg/dl) of non-diabetic volunteers

	Experimental			Control		
	Initial	Final	't' value	Initial	Final	't' value
Fasting blood glucose	103.2±7.66	96.1±7.88 (−7.0)	4.38**	104.2±3.34	105.8±3.34 (1.5)	2.24^{NS}
Triglycerides	107.7±20.20	104.3±19.89 (−3.4)	2.13^{NS}	113.6±7.89	116.5±7.78 (2.5)	2.85*
Total cholesterol	217.7±42.93	215.4±44.25 (−1.6)	2.98*	208.6±10.97	210.8±11.52 (1.1)	2.88*
HDL-C	62.8±9.79	63.4±10.13 (0.95)	0.88^{NS}	49.9±6.09	48.2±5.66 (−3.5)	2.86*
LDL-C	129.9±39.35	128.6±40.91 (−3.1)	1.42^{NS}	136.0±11.61	139.36±12.83 (2.5)	3.02*
VLDL-C	21.5±4.04	20.8±3.98 (−3.55)	2.50^{NS}	22.7±1.82	25.3±1.61 (11.3)	2.85*
TC : HDL	3.6±1.31	3.5±1.35 (−3.8)	1.43^{NS}	4.2±0.55	4.4±0.59 (4.73)	4.04**
LDL : HDL	2.2±1.02	2.2±1.24 (−8.0)	1.29^{NS}	2.8±0.49	2.9±0.53 (6.1)	3.60*

(n=6) *p<0.05, **p<0.01; *NS* Not- significant

Figures in parentheses indicate per cent change over initial non-diabetics (3.6 to 3.5). The values were within the recommended range of less than 5.0 (Anon 2000). Similarly, the LDL: HDL ratio in diabetic and non-diabetic volunteers decreased from an initial of 3.2 and 2.2 to 3.1 and 2.2, respectively. The recommended range for this ratio is less than 3.2 and the values were within the range.

The compliance report by the volunteers enrolled in the feeding intervention revealed that dehulled and heat treated barnyard millet as a food for diabetics was highly acceptable with good sensory qualities like soft texture, palatable and pleasant cooked aroma for inclusion in the daily diet. Further the diabetic volunteers expressed that the barnyard millet food elicited high satiety value, a feeling of fullness and they did not crave for foods in between the meals. Many of the non-diabetic and diabetic volunteers expressed comfortable bowel motility, which solved the problems of constipation. It was encouraging to learn that the volunteers were interested to procure and consume the barnyard millet grains even after the intervention study.

Conclusion

Barnyard millet is one of the hardiest millets, which thrives well under adverse agro-climatic conditions. Nutritionally barnyard millet is a superior grain with good amounts of macronutrients and dietary fiber. It is an important grain, which possesses good cooking and sensory qualities. This study indicated the potential benefits of barnyard millet in the diet therapy of diabetics. The dehulled and heat treated grains exerted positive impact on blood glucose and serum lipid levels in diabetic and non-diabetic volunteers after the dietary intervention study of 28 days. Therefore, it could be worthy addition to one's diet. However, there is scope to explore the potential benefits of barnyard millet in the management of metabolic disorders through long term feeding interventions.

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