AJHS
Asian Journal of Home Science
Volume 8 | Issue 2 | December, 2013 | 383-387

Research Paper

Hypoglycaemic and hypolipidemic efficacy of barnyard millet (*Echinochloa frumentacea* Link) based health food

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Received: 09.04.2013; **Revised:** 08.08.2013; **Accepted:** 05.09.2013

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ABSTRACT : An investigation was planned to exploit the beneficial aspects of barnyard millet by fabricating a health food and to evaluate its clinical efficacy in terms of glycaemic and lipemic response in seven normal adult volunteers. Barnyard millet constituted the main ingredient (77%) and other ingredients such as black gram *Dhal* (4.6 %), dehydrated carrot (9.2%) were added either as a source of lysine, antioxidants, dietary fibre, hypoglycaemic and hypocholesterimic constituents, apart from enhancing sensory qualities. The developed health food had high protein (12%), dietary fibre (37%) and β-carotene (36,703μg/100g) content. Fat and calorific contents of health food were low having 4.63 per cent and 282 Kcal/100g, respectively. The glycaemic index of health food was 59 with values ranging from 41-71 among the volunteers.The feeding intervention of 28 days revealed a reduction in body weight (2 %) besides changing blood lipids. Significant reduction in blood sugar (7%) was observed. Reduction in triglycerides (10 %), total cholesterol (8%), Low Density Lipoprotein-cholesterol (9%) and Very Low Density Lipoprotein-cholesterol (9 %) and increase in High Density Lipoprotein-cholesterol (5%) were observed in experimental group. Reduction in the ratio of TC: HDL and LDL: HDL observed was 12 and 13 per cent, respectively. Thus, the formulated barnyard millet health food possessed hypoglycaemic and hypolipemic properties.

KEY WORDS : Barnyard millet, Dietary fibre, Glycaemic index, Total cholesterol

HOW TO CITE THIS PAPER : Surekha, N., Chimmad, B.V. and Naik, Ravikumar S. (2013). Hypoglycaemic and hypolipidemic efficacy of barnyard millet (*Echinochloa frumentacea* Link) based health food. *Asian J. Home Sci.,* **8** (2): 383-387.

Millets have been food commodities since ancient times. Because of their important nutritional qualities, there is a need to revive their usage in daily diet. Millets can substitute major cereals for better health benefits. Barnyard millet (*Echinochloa frumentacea* Link synonyms are Japanese barnyard millet, *Ooda, Oadalu, Sanwa and Sanwank*) is an important minor millet because of its fair amounts of protein (12%) that is highly digestible (81.13%) coupled with low carbohydrate content (58.56%) of slow digestibility (25.88%). The dietary fibre is an important phytochemical component of barnyard millet (13% total dietary fibre with 4.66 and 8.18 % of soluble and insoluble fractions, respectively) that could be considered in the management of disorders like diabetes mellitus, obesity, hyperlipidemia etc.

Apart from this, the grain has high utilization potential owing to its excellent capacity to blend with other food grains without imparting any off flavour or after taste. Thus, the millet can be incorporated in traditional foods and valuarized to novel food uses (Veena, 2003). A health mix based on barnyard millet with excellent organoleptic and storage quality attributes was fabricated for health benefits (Surekha *et al.*, 2004). Hence, an investigation was planned to evaluate the clinical efficiency of barnyard millet based health food in normal adult volunteers.

RESEARCH METHODS

Food formulation:

Barnyard millet constituted main ingredient and other ingredients such as grated carrot and black gram dhal grits were added either as a source of lysine, antioxidants, β-carotene, dietary fibre, anti-carcinogeneic, hypoglycemic, hypocholesterimic and diuretic constituents (Table A).Seeds of fenugreek, cumin, coriander, pepper, corn and dry ginger were selected for the health food formulation. The spices were added at varying levels, *viz.*, cumin at 1-3 per cent, coriander 2-4 per cent, pepper 1-3 per cent and dry ginger 1-3 per cent. Each spice was tested organoleptically keeping the level of one spice constant at one time. Thus, there were 27 spice combinations used in the standardization. Fenugreek seeds were added at a constant level of 4 per cent. The health food was organoleptically tested by the expert panel for quality attributes such as appearance, colour, flavour and texture using four point descriptive scales. The nutrient composition of the health food were analyzed by standard procedures (AOAC, 1990).

Table A : Barnyard millet health mix formulation

Ingredients	Quantity (g)
Barnyard	100
Dehydrated carrot	12
Black gram dhal	06
Spice mixture	12

Glucose tolerance test (GTT) :

GTT was evaluated following the methods of Wolever and Jenkins (1986) in seven normal healthy volunteers. The volunteers were administered glucose and test carbohydrate (50 g carbohydrate equivalent or 88g of the health mix) separately 12 h post prandially. The capillary blood samples were drawn by finger prick method at 0,1 and 2 h intervals for estimation of glucose using active glucose strips in a Glucometer (Accu-Check model).

Dietary intervention :

A total of 11 randomly selected healthy staff; age ranging between 25-45 years from the staff University of Agricultural Sciences, Dharwad comprised the volunteers for the study. Seven members formed the experimental group (female 4) and four in the control group (female 2). The volunteers in the experimental group consumed the health food (50 g carbohydrate equivalent or 88 g of the health mix) in their homes in one or two meals daily for 28 days. Compliance report was obtained after the intervention.

Biochemical parameters :

The venous blood samples were collected from the volunteers to assess the impact of health mix on blood glucose, triglycerides, total cholesterol and HDL, LDL and VLDL cholesterol using Span diagnostic kits. These biochemical parameters were assessed at the beginning and at the end of intervention period. The glyceamic and lipemic responses were analyzed using't' test.

■ RESEARCH FINDINGS AND DISCUSSION

In an Indian traditional meal consisting of whole grains, cereals, pulses, fruits and vegetables make a good combination to supply protein, dietary fibre and other nutrients along with complex and slow digestible carbohydrates. In the present investigation, a single meal comprising of the barnyard millet based health mix formulation provided fair amounts of vital nutrients both macro and micro (Table 1). An adult serving of the health food could provide substantial amount of dietary fibre (22%) coupled with low carbohydrate content (30%) that is slowly digestible (25 % digestibility). This is noteworthy in the management of metabolic disorders. Further, the β-carotene content (22, 021 µg / serving) is also an important phytochemical contributing to the nutraceutical effects. One adult serving of the health food could contribute only 169 K cal of energy that was much less than a similar serving of traditional foods like *Chapathi* (300 K cal/serving), *Roti (280 K cal/serving)* or a bowl of rice (210 K cal). Further, it is important to note that one serving of health food recorded high satiety value in comparison with the traditional foods. A majority of subjects in the experimental group reported that the given quantity of health food (88 g of the food or 50 g carbohydrate equivalent) could be consumed as a sole meal in breakfast and lunch without any additions of other foods. Thus, the health food contributed low calories to the diet at high satiety value.

Table 1 : Nutrient composition of barnyard millet health food

Nutrient	Per 100g	Per serving
Moisture (g)	4.63	2.78
Protein (g)	11.99	7.19
Fat (g)	4.93	2.96
Total minerals (g)	2.98	1.79
Dietary fiber (g)	37.00	22.20
Total carbohydrate (g)*	49.60	29.76
Calcium (mg)*	87.00	52.20
Iron (mg)*	2.21	1.33
Energy (K cal)*	282.00	169.00
β-carotene (µg)	36703.00	22021.00

* Computed values

Glycaemic index of health food :

The glycaemic response of health mix is presented in Table 2. The Area Under Curve (AUC) for health food ranged between 61.50 to 9.50 mg min per 100 ml. The mean AUC for health food was 37.70 mg min per 100 ml. AUC for glucose ranged between 104.5 mg min per 100 ml to 23.00 mg min per 100 ml with a mean score of 62 mg min per 100 ml. The mean Glycaemic index (GI) of health food was found to be 59.10 with highest index of 71.71 and the leas was

41.00 mg min per 100 ml. The individual variations might be because of physiological differences among the volunteers. Generally, those foods having GI of more than 65 are considered as high GI foods and those with less than 40 GI are considered as low GI foods (Raghuram *et al.*, 1995). The present health food can be clubbed under moderate GI.

Table 2 : Glycaemic response of barnyard millet health food in normal volunteers

Subjects	Age (years)	Gender	Area under curve (mg min/100 ml) Health food	Glucose	Glycaemic index
A	29	F	61.5	104.5	58.85
B	43	F	35.5	49.5	71.71
C	43	M	55.0	85.0	64.0
D	25	M	9.5	23.0	41.0
E	43	F	33.0	54.5	60.5
F	43	F	29.0	51.5	56.3
G	42	F	40.5	66.0	61.36
Mean	38.2		37.7	62.0	59.1

Effect of feeding health food on body weight and blood profile :

The barnyard millet based health food when administered to normal healthy volunteers, revealed an impact on body weight (Table 3). The consumption of health food reduced body weight of the experimental subjects from an initial mean of 71.00 kg to 70.00 kg over a period of 28 days. However, in contrast, among the volunteers of control group, there was an increase in body weights from an initial mean of 66.00 kg to 67.00 kg which might be due to the prevailing festive season during the feeding period.

Effect of feeding health food on blood sugar and lipids :

The assay of blood glucose revealed a significant reduction in blood glucose levels in the experimental group. The health food exhibited improved carbohydrate tolerance among experimental volunteers as shown by significant reduction in fasting plasma glucose levels from a mean initial level of 101.5 mg/dL to 97 mg/dL. On the other hand, there was an increase in glucose level by 5 per cent in control group. A maximum reduction of up to 27 per cent was observed in one volunteer in the experimental group (Table 4).

The triglycerides levels ranged from 122 to 270 mg/dL with a mean of 180 mg/dL in experimental group at the beginning of feeding trial. There was a reduction in triglycerides after the consumption of health food with the mean value of 163 mg/dL and the values ranging between 126 to 206 mg/dL, however, this was not significant. While in control group, the mean initial value was 147 mg/dL, which increased to 154 mg/dL after four weeks period. The reduction in triglycerides level was by 10 per cent in experimental subjects while the increase in control volunteers was by 4 per cent (Table 4).

HDL cholesterol signifies the good cholesterol. The beneficial effects of feeding health food were reflected in terms of elevation in the levels of HDL-cholesterol in a majority of volunteers ranging from 3 to 19 per cent. However, in two volunteers, there was reduction ranging from 6 to 11 per cent. However, the mean increase among the volunteers of experimental group, the mean increase was 5 per cent. In contrast, the levels decreased in the control group by a mean of 10 per cent ranging between 3 to 22 per cent (Table 4). Carrot being an important component of the health food formulation, could have contributed to the nutraceutical effect, which was also reported by Robertson *et al.* (1979) who attributed it for increased fat excretion.

An increase in HDL-cholesterol was seen in experimental group. The mean HDL-C level after intervention was 42 mg/dL with the values ranging from 40 to 46 mg/dL. However, in control group, the HDL-C levels decreased after intervention. There was an increase in HDL-cholesterol level in experimental volunteers by 5 per cent and it reduced in control volunteers by 10 per cent. A report by National Cancer Education Programme

Table 3: Effect of feeding health food on weight of volunteers

Experimental						Control					
Subjects	Age (years)	Gender	Weight (kg) Before	after	% Change	Subjects	Age (years)	Gender	Weight (kg) Before	after	% Change
1	43	M	71	70	-2	1	47	M	69	69.5	0
2	50	M	65	65	0	2	45	M	73	74	1
3	48	M	77	77	0	3	45	F	64	65	1
4	29	F	83	82	-2	4	42	F	72	73	1
5	27	F	81	79	-3	5	40	F	58	58	0
6	43	F	56	55	-1	6	42	F	62	63	1
7	43	F	64	62	-3	7	-	-	-	-	-
Mean	40		71	70	-2	Mean				67	1

Table 4 : Effect of feeding health mix on blood glucose and lipids in experimental and control groups

	FBS (mg/dL)			Triglycerides (mg/dL)			Total cholesterol (mg/dL)			HDL-Cholestrol (mg/dL)			LDL-Cholesterol (mg/dL)			VLDL-Cholesterol (mg/dL)		
	Before	After	Change (%)	Before	After	Change (%)	Before	After	Change (%)	Before	After	Change (%)	Before	After	Change (%)	Before	After	Change (%)
Experimental																		
1	106	101	-5	191	170	-10	230	210	-9	44	45	-11	147	136	-8	38	33	-14
2	97	103	-6	195	206	5	228	203	-11	40	42	3	148	119	-20	39	41	5
3	101	101	0	193	179	-7	184	168	-9	44	46	4	102	85	-17	38	35	-8
4	110	81	-27	122	139	13	193	189	-3	31	37	19	137	124	-10	24	27	12
5	90	81	-10	160	144	-10	186	168	-10	43	44	3	110	98	-11	31	28	-10
6	107	99	-8	270	179	-33	169	165	-3	33	40	19	81	90	11	53	35	-44
7	101	93	-8	132	126	-5	230	212	-8	46	41	-6	156	146	-7	26	25	-4
Mean	101.5	94	-7	180	163	-10	203	188	-8	40	42	5	125	114	-9	35	32	-9
Control																		
1	97	100	3	141	150	6	143	153	6	43	40	-7	71	83	16	27	29	7
2	84	85.5	1	138	141	1	185	185	0	24	23	-5	86	90	4	32	32	0
3	99.5	112	13	169	177	4	132	134	1	39	35	-11	58	63	8	33	35	6
4	69	71	2	161	164	1	165	167	1	46	44	-5	133	133	0	27	28	3
5	81	90	11	71	89	26	158	150	-5	48	37	-22	95	95	0	14	17	21
6	99	100	1	202	204	0	216	216	0	41	40	-3	133	135	1	40	40	0
Mean	88	93	5	147	154	4	166	172	3	40	36	-10	96	99	3	28	30	7

Ideal levels : FBS-70-110 mg/dL; PPBS- <120 mg/dL; TGL- <150mg/dL; TC- <200mg/dL; HDL- >40mg/dL; LDL- <100mg/dL; Ref: Anonymous (2000)

(Anonymous, 2000) indicated a change in triglyceride, total cholesterol and LDL and HDL cholesterol level in 60 per cent of volunteers after feeding composite food in long-term feeding intervention. Krishnakumari and Thayumananvan (1997) reported that among the different minor millets such as *Kodo*, Little, Proso, barnyard and rice, barnyard was reported to significantly reduce the blood concentrations of serum cholesterol and serum triglycerides in rats fed for 10 days. There was a decrease in LDL-C and VLDL-C among experimental group. Reduction up to 9 per cent in LDL-C and VLDL-C was observed in experimental group. On the other hand, an increase of 3 per cent and 7 per cent in LDL-C and VLDL-C, respectively, was observed in volunteers from control group. The ratio of LDL: HDL reduced after consumption of health food in experimental group.

The ratios of TC: HDL and LDL:HDL-cholesterol decreased markedly in experimental subjects. The mean TC:HDL- cholesterol at the beginning of feeding trial was 5.0, which decreased to 4.4 after 28 days of intervention period with a mean reduction of 12 per cent. However, in the control group, it increased by a mean 9 per cent. With regard to ratios of lipids, a shift was observed. The mean ratio of LDL:HDL at the beginning of intervention was 3.1, which decreased to 2.7 after intervention (reduction of about 13 %). But, among the volunteers of control group there was increase in LDL:HDL ratio by 12 per cent. The mean LDL: HDL ratio before intervention was 2.4, which increased to 2.7 after intervention (Table 5) .

Table 5: Effect of Health Mix on ratios of blood profile

Subjects	TC:HDL ratio#			LDL:HDL ratio*		
	Before	After	% change	Before	After	% change
Experimental						
1.	5.2	4.6	-12	3.3	3.0	-10
2.	5.2	4.8	-8	3.7	2.8	-25
3.	4.1	3.6	-13	2.3	2.2	-5
4.	6.2	5.1	-18	4.4	3.3	-25
5.	4.3	3.8	-12	2.5	2.2	-12
6.	5.1	4.1	-20	2.4	2.2	-9
7.	5.0	5.1	2	3.3	3.5	6
Mean	5.0	4.4	-12	3.1	2.7	-13
Control						
1.	3.3	3.8	15	1.6	2.0	25
2.	7.7	8.0	3	3.5	3.9	11
3.	3.3	3.8	15	1.4	1.8	28
4.	3.5	3.7	5	2.8	3.0	7
5.	3.2	4.0	25	1.9	2.5	31
6.	5.2	5.4	3	3.2	3.3	3
Mean	4.3	4.7	9	2.4	2.7	12

\# Ideal ratio <5.0 *Ideal ratio <3.2

Compliance report :

The health mix was found to exhibit beneficial effects in the experimental subjects. The volunteers expressed high satiety value of the health food and lack of cravings for other foods and inability for consumption of other foods. This satiety feeling coupled with low calorie intake could have contributed for the reduction in body weight of the volunteers within the short period. More important fact was that none of the volunteers expressed weakness or other complications after the intervention. There were no complications such as diarrhoea, stomach pain or flatulence.

Conclusion :

Nutritional intervention in healthy volunteers revealed a reduction in body weight and changes in blood sugar, triglycerides, total cholesterol, LDL-cholesterol and VLDL-Cholesterol levels were observed. An increase in HDL-cholesterol and reduction in the ratios of TC: HDL and LDL: HDL levels were observed in the experimental group indicating better glycol-lipemic responses.

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