Suitability of barnyard millet (*jeera jhangora*) as compared to rice (*jeera rice*) in control of diabetes

SHWETA JOSHI[1] and SARITA SRIVASTAVA[2]

Department of Foods and Nutrition,College of Home Science ,G.B. Pant University of Agriculture and Technology, Pant Nagar-263145 (U.S. Nagar Uttarakhand)

ABSTRACT : In the present study PRJ-1 variety of barnyard millet was analyzed for various quality parameters as a substitute of rice in diabetes. Proximate composition results indicate that crude protein, crude fat, crude fibre and total ash content of barnyard millet was 9.39, 2.0, 6.3, 2.23 per cent, respectively significantly higher than rice. Minerals *viz;* calcium (24.16 mg%), iron (6.53 mg%), zinc (2.61 mg%), magnesium (78.40 mg%), chromium (0.019 mg%) and phosphorus (228 mg%) content of barnyard millet were significantly higher than rice. The total dietary fibre (11.4%), resistant starch (12.81 %), tannin (67.8%) and total antioxidant activity (59.23%) of barnyard millet was also significantly higher than rice. There was non-significant difference between *jeera jhangora* and *jeera* rice for sensory characteristics. The glycemic index of *jeera jhangora* was 39.5 significantly lower than *jeera* rice (73.9). The study concludes, barnyard millet as a best substitute of rice for people suffering from diabetics.

Key words: Barnyard millet, Diabetes, Glycemic index, *Jeera jhangora, Jeera* rice, Rice

Today there is a significant change in the lifestyle of people due to the rapid industrialization, improvement in socio-economic status, enhancement in health facilities and increased life expectancy. Economic affluence coupled with sedentary lifestyles and changing food patterns are contributing to several chronic degenerative diseases such as diabetes mellitus, cardiovascular diseases, cancer, etc. Diabetes mellitus is a metabolic disorder characterized by the presense of hyperglycemia which occurs either when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. The chronic hyperglycemia of diabetes is associated with long-term micro vascular complications which affect eyes, kidneys and nerves, as well as an increased risk for cardiovascular disease (CVD). The number of people with diabetes is increasing due to population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity (WHO, 2015). In 2000, India topped the world with 31.7 million people with diabetes mellitus followed by China having 20.8 million and United States with 17.7 million diabetic people placing them in second and third place respectively. It is predicted that by 2030 diabetes mellitus may increase up to 79.4 million individuals in India (Kaveeshwar and Cornwell, 2014).

Millets are one of the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes. They are highly nutritious, non-glutinous foods. Barnyard millet (*Echinochloa frumentacaea*) is called by several names *viz*., Japanese barnyard millet, *Ooda, Oodalu, Sawan*, *jhangora* and *madira* (Ugare et al., 2014). Barnyard millet 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. The carbohydrate content is low and slowly digestible, which makes the Barnyard millet a nature's gift for the modern mankind who is engaged in sedentary activities. Rice (*Oryza sativa*) is the staple food of Indians. India is world's largest producers of rice, accounting for twenty per cent of world rice production (Library of Congress, 2009). Intake of rice is not considered safe for diabetic patients due to its high glycemic index which rapidly increase the blood glucose level. But people with diabetes find it difficult to exclude rice from their diet. Barnyard millet is cooked similar to rice in various areas in India. Thus the study was designed to evaluate and compare the nutritional and glycemic index of barnyard millet with that of rice for its suitability in diabetic condition.

MATERIALS AND METHODS

The study was conducted in the Department of Foods and Nutrition, College of Home Science, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. *Jeera jhangora* was prepared using local cultivar of barnyard millet and *jeera* rice was prepared

using *Mahsuri* variety of rice. Proximate analysis of barnyard millet and rice was done using AOAC (1995). Estimation of minerals like calcium, iron zinc, magnesium and chromium was done using atomic absorption spectrophotometer whereas phosphorus was estimated using method given by Fiske and Subbarow (1925).The total dietary fibre content of barnyard millet and rice was estimated using method given by Asp and Johansson (1981). Resistant starch, Antioxidant content and Tannin content of barnyard millet and rice was estimated using method given by McCleary *et al.* (2002), Zhang and Hamauzu (2004) and AOAC (1970), respectively. The sensory evaluation of *jeera jhangora* prepared from barnyard millet and *jeera* rice prepared from Mahsuri variety of rice was done using 9 point Hedonic scale and score card method (Amerine *et al.,* 1965).

For evaluation of glycemic index study 10 normal female adult human volunteers of age group between 24-26 years were selected from Golden Jublee Hostel, G.B.P.U.A&T, Pantnagar, Uttarakhand. Written consent of the subjects was taken to participate in the study. The subjects were given general instructions to avoid any physical exertion, medication, fast and feast during the experimental period. On the first day glucose tolerance test (GTT) for glucose was conducted on overnight fasted subjects. A 50 g glucose dissolved in 200 ml water was given to the subjects. The subjects were instructed to finish glucose solution within 15 minutes. The blood glucose level was measured at 0, 30, 60, 90,120 and 150 min using glucometer. On alternate day the *jeera jhangora* prepared from barnyard millet (raw amount: 71.83g) / *jeera* rice prepared from rice (raw amount: 61.55g) containing 50g of available carbohydrate were served to the same subjects with 200ml of water. The blood glucose was measured initially and at 30, 60, 90, 120 and 150 min of finishing the product.

Glycemic index of *jeera jhangora* and *jeera* rice was calculated using the formula given by (Wolever, 1990)

$$GI = \frac{\text{Incremental area under blood glucose response curve for food product X 100}}{\text{Corresponding area after equicarbohydrate portion of glucose}}$$

The ingredients used in preparation of *jeera jhangora* and *jeera* rice has been presented in Table 1. No spices were used in preparation of *jeera jhangora* and *jeera* rice to avoid effect of spices in their sensory quality and glycemic index.

Table 1: Ingredients used in preparation of *jeera jhangora* and *jeera rice*

Ingredients	Amount	
	Barnyard millet (Local cultivar)	**Rice (*Mahsuri*)**
Barnyard millet	71.83 g	61.55 g
Salt	1.10 g	1.10 g
Jeera	0.50 g	0.50 g
Oil	½ tsp	½ tsp
Water	130 ml	150 ml

tsp= tea spoon

***Jeera jhangora* / *jeera* rice was prepared as follows:**

Barnyard millet/ rice was cleaned to remove extraneous material and washed thoroughly.

↓

Pressure cooker was kept on the gas flame and ½ tsp of refined oil was added.

↓

Cumin seeds were added to oil till golden brown.

↓

Barnyard millet/ rice were added to it.

↓

Thereafter salt was added.

↓

A 130 ml of water for barnyard millet and 150 ml water for rice was added and the lid was closed.

↓

Barnyard millet was cooked for 13 minutes and rice for 17-18 minutes.

↓

STATISTICAL ANALYSIS

The data was analyzed in Excel sheets and values were expressed as mean, standard deviation. T- test for difference between two means was applied to find out the significant difference between nutrional quality of barnyard millet and rice grains and sensory quality and glycemic index values of *jeera jhangora* and *jeera* rice formulated using barnyard millet and rice. One way ANOVA was applied to find out significant difference between area under blood glucose response curve of glucose, *jeera jhangora* and *jeera* rice

RESULTS AND DISCUSSION

Nutrient composition of barnyard millet and rice

Results on nutritional composition clearly depicts that barnyard millet has appreciably higher nutrient content as compared to rice. Results on proximate composition indicate that except moisture, carbohydrate and physiological energy all values are significantly higher for barnyard millet (Table 2). The crude protein, crude fat, crude fibre, total ash content of local cultivar of barnyard millet was 9.39, 2.0, 6.3, 2.23 per cent, respectively. The mineral composition of barnyard millet

is incomparable to rice. Calcium, iron, zinc, magnesium, chromium and phosphorus content of local cultivar of barnyard millet was 24.16, 6.53, 2.61, 78.40, 0.019 and 228 mg per cent, respectively significantly higher than *Mahsuri* variety of rice (Table 2) Minerals like magnesium and chromium play a protective role in diabetes by enhancing insulin action (Connell, 2001). Table 2 depicts that rice has significantly low total dietary fibre content (1.92%) and resistant starch (0.98 %) as compared to barnyard millet. The ability of dietary fibre (especially soluble dietary fibre) to retard food digestion and nutrient absorption certainly has an important influence on lipid and carbohydrate metabolism (Riccardi and Rivellese, 1991). Additional benefits of dietary fibre intake are that many of the foods that contain fibre also contain antioxidants, which are generally good for body cells and overall health. The tannin content (67.8%) and total antioxidant activity (59.23%) of barnyard was also significantly higher than *Mahsuri* variety of rice. Tannins also infer antioxidative property by reducing various mutagenic activities occurring in body (Chung *et al.* 1998). Millets are known to contain a wide range of phenolic compounds which are good sources of natural antioxidants. By reducing oxidative damage antioxidants help in improving body's immune function and thus reduce risk of various infectious diseases (Mohankumar and Vaishnavi, 2012). The results depicts the excellent nutritional profile of barnyard millet as compared to rice.

Sensory quality of jeera jhangora and jeera rice

Sensory evaluation is important criteria in judging the acceptability of food product. The overall acceptability of *jeera jhangora* prepared from local cultivar of barnyard millet was 7.8 whereas the overall acceptability of *jeera rice* prepared from *Mahsuri* variety of rice was 8.1 (Table 3) *Jeera jhangora* and *jeera* rice, both fall under "Good" category of score card and

Table 2: Nutrient composition of barnyard millet and rice

S.No	Nutrients (per 100g)	Barnyard millet (local cultivar) (mean ± SD)	Rice (variety Mahsuri) (mean ± SD)	t-value
1	Moisture (g)	10.48± 0.01	11+0.06	0.17^{ns}
2	Crude protein (g)	9.39±0.21	6.57±0.16	26.09*
3	Crude fat (g)	2.0±0.02	0.51±0.02	11.91*
4	Crude fibre (g)	6.3±0.05	0.22±0.02	9.67*
5	Total ash (g)	2.23±0.03	0.53±0.05	33.77*
6	Carbohydrate (g)	69.60±0.01	81.23±0.03	8.78*
7	Physiological energy (Kcal)	334±0.03	356±0.02	7.56*
8	Calcium (mg)	24.16±0.03	9.74±0.04	9.56*
9	Iron (mg)	6.53±0.01	2.96±0.01	19.2*
10	Zinc (mg)	2.61±0.02	1.28±0.02	6.73*
11	Magnesium (mg)	78.40±0.08	44.40±0.01	13.02*
12	Chromium (mg)	0.019±0.10	0.002±0.01	29.9*
13	Phosphorus (mg)	228±0.01	152±0.02	26.15*
14	Total dietary fibre (g)	11.4±0.03	1.92±0.04	11.2*
	Insoluble	7.9±0.04	1.09±0.01	
	Soluble	3.5±0.01	0.83±0.02	
15	Resistant starch (g)	12.81±0.07	0.98±0.03	33.5*
16	Tannin (g)	67.8±0.05	24.4±0.05	25.14*
17	Total antioxidant activity (%)	59.23±0.27	19.26±0.32	21.34*

* & ns stands for significant and non significant difference

Table 3: Sensory quality of *jeera jhangora* and *jeera* rice using score card method

S.No.	Characteristic	*Jeera jhangora* (mean+SD) Local	*Jeera* rice (mean+SD) Mahsuri	t-value
1	Colour	7.8±0.63	8±0.81	0.68^{ns}
2	Aroma	7.8±0.56	7.9±0.63	0.29^{ns}
3	Taste	7.9±0.67	8.1±0.73	0.89^{ns}
4	Appearance	7.9±0.48	7.9±0.63	-
5	Overall acceptability	7.8±0.48	8.1±0.73	0.63^{ns}

ns stands for non significant difference

statistically no significant difference was found between sensory quality of *jeera jhangora* and *jeera* rice. The results of nine point Hedonic scale also revealed non-significant difference between sensory quality of *jeera jhangora* and *jeera* rice.

Glycemic index of jeera jhangora and jeera rice

Optimal glycemic control is fundamental to the management of diabetes. Both fasting and postprandial plasma glucose levels correlate with the risk of complications related to diabetes. Thus, glycemic control is regulation and maintenance of blood glucose levels within normal range (Imran *et al.* 2013). According to Kirpitch and Maryniuk (2011) optimal *glycemic control* in diabetes *can be achieved by proper food* intake. Thus use of glycemic index in meal planning is very much important with respect to diabetes management.

The anthropometric characteristics of the subjects under glycemic index study revealed that the average height and weight of the subjects was 1.58 m and 57.06 kg. Their body mass index (BMI) lie between 20.3 to 23.5 kg/m^2 with an average of 22.51 kg/m^2. The value of BMI indicates that all the subjects were under normal category. All the subjects were free from disease and were not on any kind of medications, fasting and feasting. The blood pressure of all the subjects was found normal. Twenty four hour recall method for one day was used to assess the dietary intake of the subjects which revealed that the average value for carbohydrate, protein, fat and energy of subjects was 260.7g, 48.6g, 19.0g and 1855 kcal/day, respectively.

Table 4 reveals that the highest peak was observed after 30 minutes of intake of glucose, *jeera jhangora* (local cultivar) and *jeera* rice (variety *Swarna*). Highest peak was observed for glucose (158 mg/100ml) where as lowest peak was for *jeera jhangora* (108 mg/100ml) (Fig 1).

Table 4: Blood glucose levels at different time intervals for *jeera jhangora* (local cultivar) *jeera* rice (variety Mahsuri) against glucose (mean ±SD)

Time interval (minutes)	Glucose (mg/100ml)	*Jeera jhangora* (Local cultivar) (mg/100ml)	*Jeera* rice (variety Mahsuri) (mg/100ml)
0	80.5±3.13	79.7±4.39	78.5±7.60
30	158.0±5.88	108.3±6.20	141.7±11.93
60	125.3±27.01	99.4±5.71	104.0±8.96
90	106.8±17.29	92.7±3.74	95.4±7.25
120	100.8±12.86	88±3.01	91.7±7.07
150	89.2±5.96	83±3.09	85.9±8.27

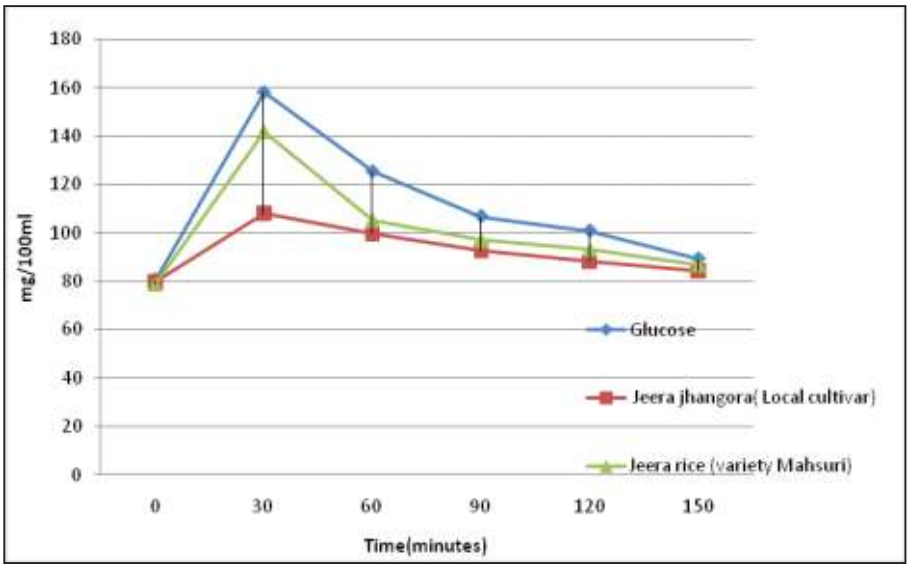

Fig. 1: Blood glucose response curve for Jeera jhangora (Local cultivar) and Jeera rice (variety Mahsuri) in comparison to glucose load of 50g

Table 5: Area under blood glucose response curve for glucose, *jeera jhangora* and *jeera* rice

S.No.	Food product	Area (mg min/100ml) (mean+SD)
1	Glucose	5009.2±326.2
2	Barnyard millet (*Jeera jhangora*)	1966.8±257.2
	Rice (*Jeera* rice)	
3	S.Em	3700.6±213.3
	CD at 5%	73.9
		149.5

Table 6: Glycemic index of *jeera jhangora* and *jeera* rice

S.No.	Food product	Glycemic index
1	*Jeera jhangora* (barnyard millet)	39.5
2	*Jeera rice* (rice)	73.9
	t- value	23.79*

*=significant difference

Likewise the area under blood glucose response curve was highest for glucose (5009.2 mg.min/100 ml) and lowest for *jeera jhangora* (1966.8 mg min/100 ml) (Table 5). The area under blood glucose response curve for *jeera* rice was 3700.6 mg min/100ml. The lowest area under blood glucose response curve on consumption of *jeera jhangora* suggests slow release of glucose, an essential property for maintaining normal blood glucose level. This characteristic of *jeera jhangora* is desirable in diabetes. Dietary fibre and resistant starch has a major role to play in maintaining glycemic control. Resistant starch works by improving insulin sensitivity via alterations in fatty acid flux between muscle and fat cells. Studies also indicate that ghrelin might increase with resistant starch consumption, improving insulin sensitivity. Resistant starch also help to lower blood fats which also improves insulin sensitivity (Bodinham, *et al*. 2014). Rice contains very little amount of dietary fibre and resistant starch as compared to millets which results in sharp increase in blood glucose level within few minutes of consumption.

Significant difference was observed between glycemic index of *jeera jhangora* and *jeera* rice. The glycemic index of *jeera jhangora* and *jeera* rice was 39.5 and 73.9, respectively (Table 6). According to classification given by Brand – Miller *et al.* (1999) the *jeera jhangora* has glycemic index value below 55 which classifies it under low glycemic index food whereas the glycemic index of *jeera* rice puts it under high glycemic index food category. According to Ugare *et al*. (2014) plain barnyard millet meal (without any hypoglycemic agents) exhibited a significantly low glycemic index of 41.7 and considers it very important for development of designer foods for diabetics.

CONCLUSION

Rice holds most important place in Indian meal pattern but due to its fast and high blood glucose raising capacity, it is not considered safe for people suffering from diabetes and even most of the diabetics feel it very difficult to exclude rice from their routine diet. Thus the study identifies the efficacy of barnyard millet as a substitute of rice for people suffering from diabetes. The results indicate that barnyard millet has much better nutrient profile as compared to rice. It has excellent mineral composition as compared to rice. Total dietary fibre and resistant starch content of barnyard millet is significantly higher as compared to rice and these two components are responsible for the low glycemic index of barnyard millet. It has higher total antioxidant capacity than rice which enhances its functional or therapeutic role. Being nutritionally superior to rice it can also be cooked and consumed similar to rice. Having low glycemic index barnyard millet indicates its ability to raise the blood glucose level more slowly and steadily in contrast with that of rice and this slow sugar releasing property of barnyard millet, high nutritional profile and good sensory quality makes it a best substitute of rice for people suffering from diabetes.

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