

# Barnyard Millet as a Substitute of Rice in Preparation of *khichdi* for Diabetics

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**Abstract:** Diabetes is among one of the most prevalent chronic disease where diet has a major role to play. *Khichdi* is a nutritious traditional food most commonly consumed in India. *Khichdi* contains goodness of both cereal and pulses. Cereal proteins are generally deficient in lysine and pulses (legumes) contain low amount of methionine. However, when both cereals and pulses (legumes) are present in the diet in proper proportions, nutrients from both sources combine to make perfect combination. PRJ-1 variety of barnyard millet was used in preparation of barnyard millet *khichdi* and Swarna variety of rice was used in preparation of rice *khichdi*. Bengal gram (legume) was used as common ingredient in preparation of both barnyard millet *khichdi* and rice *khichdi*. The results on proximate analysis reveal that except carbohydrate and physiological energy all the values were higher for barnyard millet *khichdi*. The protein, fat, crude fibre, total minerals, carbohydrate and physiological energy values were 12.28 g, 3.84 g, 6.44 g, 2.61 g, 63.7 g and 338 Kcal/100 g for barnyard millet *khichdi* and 8.65, 2.67, 0.61, 1.05, 76.84 and 365 Kcal/100 g for rice *khichdi*, respectively. Mineral composition viz; calcium, iron, zinc, magnesium, chromium and phosphorus values for barnyard millet *khichdi* were 27.4, 4.44, 4.36, 87.19, 0.039 and 225.3 mg/100g whereas for rice *khichdi* the values were 18.73, 3.64, 1.44, 52.87, 0.005 and 171.89 mg/100g, respectively. A non significant difference was observed in sensory characteristics of both barnyard millet *khichdi* and rice *khichdi*. Both were under acceptable range of score card and Hedonic scale. The glycemic index of rice *khichdi* was significantly higher (62.5) than barnyard millet *khichdi* (34.96) The data thus obtained depict the slow sugar releasing property of barnyard millet making it a best substitute for people suffering from diabetes.

**Keywords:** Diabetes, *khichdi*, barnyard millet, rice, glycemic index

## 1. Introduction

The word diabetes has originated from Greek, and it means a "siphon". Thomas Willis in 1965 added mellitus to the term diabetes, although it is commonly referred to simply as diabetes. The latin means of Mel is "honey" as the urine and blood of people with diabetes has excess glucose, and glucose is sweet like honey. So the literal meaning of Diabetes mellitus is "siphoning off sweet water". In ancient times, Chinese people observed that ants attract to some people's urine, because it was sweet which gave rise to the term "Sweet Urine Disease" [1]. When food is digested, the glucose enters the bloodstream. The body cells use this glucose for energy and growth. However for glucose to enter the body cells, insulin is needed. Insulin is a hormone that is produced by the pancreas. After consuming food, pancreas itself releases an adequate quantity of insulin to transport the glucose present in blood to the cells and as soon as glucose enters the cells, blood glucose level drops [2]. Diabetes is a condition in which the concentration of glucose in the blood is elevated (hyperglycemia) because either the body does not produce enough insulin, produces no insulin, or the cells do not respond properly to the insulin the pancreas produces. *Khichdi* is a preparation made from rice and pulses. It is the most common traditional recipe of rice consumed in India. *Khichdi* is inspired from popular Egyptian dish kushari [3]. Rice due to its high glycemic index is considered unsuitable for people suffering from diabetes. Drastic change in the diet is not desirable in diabetes and dietary modifications in food product make it feasible for the person to consume a diet with habitual and familiar food items. Glycemic index is an important tool used in diet management of people with diabetes and in weight loss programs. Low glycemic index

foods, by virtue of the slow digestion and absorption of their carbohydrates, produce a more gradual rise in blood sugar and insulin levels and are increasingly associated with health benefits. Low glycemic index foods have thus been shown to improve the glucose tolerance in both healthy and diabetic subjects [4]. Studies on glycemic index have shown that pulses have low glycemic index value and glycemic index of food is the sum total effect of the ingredients used in the preparation. Physical factors like dietary fibre and its viscosity, high unabsorbable carbohydrate contents and delay gastric emptying are responsible for low glycemic index value of pulses [5]-[6]. Barnyard millet is a nutritious millet rich in minerals, protein, dietary fibre, resistant starch and antioxidants [7]. Barnyard millet is consumed in scattered pockets of India in boiled form i.e cooked similar to rice hence it may serve as substitute of rice in formulation of *khichdi*. The study therefore was undertaken with the objective of formulating barnyard millet *khichdi* and comparing its nutritive value, sensory quality and glycemic index with rice *khichdi*.

## 2. 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. Barnyard millet *khichdi* was prepared using PRJ-1 variety of barnyard millet and rice *khichdi* was prepared using Swarna variety of rice with Bengalgram dhal. The ratio of barnyard millet/rice: Bengal gram dhal was 5:1 as suggested by ICMR [8]. According to International Rice Research Institute (IRRI) Swarna variety of rice is commonly consumed in India and has glycemic index value less than 60. Proximate

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analysis of PRJ-1 variety of barnyard millet and *Swarna* variety of rice was done using standard method [9]. Estimation of minerals like calcium, iron zinc, magnesium and chromium was done using atomic absorption spectrophotometer whereas phosphorus was estimated using chemical method [10]. The total dietary fibre content of barnyard millet and rice was estimated using standard method [11] The above nutrient for Bengal gram except total dietary fibre were calculated using food composition tables given by [12]. The sensory evaluation of barnyard millet *khichdi* and rice *khichdi* was done using 9 point Hedonic scale and score card method [13].

For evaluation of glycemic index study 10 normal female adult human volunteers of age group between 24-26 years were selected from Gloden 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 barnyard millet *Khichdi* (raw amount:81g) / rice *Khichdi* (raw amount: 64.8g) 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.

GI of barnyard millet *khichdi* and rice *khichdi* was calculated according to the formula given below [14]

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

The ingredients used in barnyard millet *khichdi* have been given in Table 1. No spices were used in preparation of barnyard millet *khichdi* and rice *khichdi* to avoid effect of spices in their sensory quality and glycemic index.

### 3. 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 sensory quality and glycemic index values of barnyard millet *khichdi* and rice *khichdi* whereas one way ANOVA was applied to find out significant difference between area under blood glucose response curve of glucose, barnyard millet *khichdi* and rice *khichdi*.

**Table 1:** Ingredients used in preparation of *khichdi* using barnyard millet and rice

Ingredients	Amount	
	Barnyard millet (variety PRJ-1)	Rice (variety <i>Swarna</i> )
Barnyard millet /rice	65g	54g
Bengal gram dhal	13 g	10.8g
Salt	1.10g	1.10g
<i>Jeera</i>	0.50g	0.50g
Oil	½ tsp	½ tsp
Water	130ml	150ml

### 4. Results and Discussion

#### Nutrient composition of barnyard millet *khichdi* and rice *khichdi*

The data on nutrient composition of barnyard millet *khichdi* and rice *khichdi* presented in Table 2 depicts that except carbohydrate and physiological energy all the values were higher for barnyard millet *khichdi*. The results on proximate analysis suggest that protein, fat, crude fibre, total minerals, carbohydrate and physiological energy values were 12.28 g, 3.84 g, 6.44 g, 2.61 g, 63.7 g and 338 Kcal/100g for barnyard millet *khichdi* and 8.65, 2.67, 0.61, 1.05, 76.84 and 365 Kcal/ 100 g for rice *khichdi*, respectively. Protein, fat, NDF, carbohydrate and energy in barnyard millet *khichdi* have been reported as 4.01g, 3.67g, 6.13 g, 13.08 g, 101 Kcal/100g [15]. Regarding mineral composition calcium, iron, zinc, magnesium, chromium and phosphorus values for barnyard millet *khichdi* and rice *khichdi* were 27.4, 4.44, 4.36, 87.19, 0.039 and 225.3 and 18.73, 3.64, 1.44, 52.87, 0.005 and 171.89 mg/100g, respectively (Table 2).the results on total dietary fibre content of barnyard millet and rice revealed that barnyard millet had significantly higher dietary fibre content (13.3g/100g) as compared to rice (2.96 g/100g).

**Table 2:** Nutrient composition of barnyard millet *khichdi* and rice *khichdi* (per 100g)

S.No	Nutrients (per 100 g)	Barnyard millet <i>Khichdi</i>	Rice <i>Khichdi</i>
1	Protein (g)	12.28	8.65
2	Fat (g)	3.84	2.67
3	Crude fibre (g)	6.64	0.61
4	Total minerals (g)	2.61	1.05
5	Carbohydrate (g)	63.7	76.84
6	Energy (Kcal)	338	365
7	Calcium (mg)	27.4	18.73
8	Iron(mg)	4.44	3.64
9	Zinc (mg)	4.36	1.44
10	Magnesium (mg)	87.19	52.87
11	Chromium (mg)	0.039	0.005
12	Phosphorus (mg)	225.3	171.89

#### Sensory quality of barnyard millet *khichdi* and rice *khichdi* using score card method

A non significant difference was observed in the sensory characteristics of *khichdi* prepared from barnyard millet (variety PRJ-1) and rice (variety *Swarna*). The overall acceptability of barnyard millet *khichdi* and rice *khichdi* was 8 and 8.1, respectively. Both were under "Good" category of score card (Table 3).

**Table 3:** Sensory quality of khichdi prepared from PRJ-1 variety of barnyard millet and Swarna variety of rice using score card

S. No.	Characteristics	Barnyard millet khichdi (mean±SD)	Rice khichdi (mean±SD)	S/NS
1	Colour	7.8±0.84	8.2± 0.42	NS
2	Aroma	7.9± 0.70	8±0.47	NS
3	Taste	8±0.67	8.1±0.52	NS
4	Appearance	8±0.63	8±0.73	NS
5	Overall acceptability	8±0.67	8.1±0.52	NS

S= significant difference, NS= non significant difference

**Sensory quality of barnyard millet khichdi prepared from PRJ-1 variety of barnyard millet and Swarna variety of rice using nine point Hedonic scale**

It is clear from Table 4 that Hedonic scale rating also showed non-significant difference in sensory characteristics of khichdi prepared from barnyard millet (variety PRJ-1) and rice (variety Swarna). Both were “liked very much” as per Hedonic scale rating.

**Table 4:** Sensory quality of khichdi prepared from PRJ-1 variety of barnyard millet and Swarna variety of rice using nine point Hedonic scale.

S. No	Food product	Score (Mean ±SD)	Preference
1	<b>Barnyard millet khichdi</b>	8.1±0.67	Like very much
2	<b>Rice khichdi</b>	8.3±0.67	Like very much
	t-value	0.43	
	S/NS	NS	

S= significant difference, NS= non significant difference

**Estimation of Glycemic Index**

The glycemic index (GI) can be defined as a ranking system that indicates how quickly a food containing carbohydrate raises blood glucose level which is determined by measuring the area under the curve within two hours of test food consumption [16]. Consumption of high-glycemic index (GI) foods result in more rapid as well as higher increase in blood glucose levels as opposed to consumption of low-glycemic (GI) index foods. [17].

**Anthropometric characteristics of subjects and their nutrient intake**

All the subjects were between the age group of 24-26 years. The average height and weight of the subjects was 1.58 m and 57.06 kg, respectively. The body mass index (BMI) of the subjects lies between 20.3 to 23.5 kg/m<sup>2</sup> with an average of 22.51 kg/m<sup>2</sup>. 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 respondents 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 intake of subjects was 260.7g, 48.6g, 19.0g and 1854.5 kcal/ day respectively as shown in Table 5.

**Table 5:** Nutrient intake of subjects per day

S.No	Nutrients	Average intake (Mean±SD)
1	Carbohydrate (g)	260.7±26.09
2	Protein (g)	48.6±4.81
3	Fat (g)	19.0±1.51
4	Energy(Kcal)	1854.5±66.67

**Glycemic index of barnyard millet khichdi and rice khichdi**

Blood glucose levels at 0, 30, 60, 90,120 and 150 min after consuming barnyard millet khichdi and rice khichdi containing 50 g of equicarbohydrate as compared to glucose load of 50 g are depicted in Table 6 and Figure 1. The highest peak was observed after 30 minutes of intake of glucose, barnyard millet khichdi and rice khichdi. On comparison of all the three curves it was observed that the lowest peak was for barnyard millet khichdi (variety PRJ-1) followed by rice khichdi (variety Swarna) and glucose.

**Table 6:** Blood glucose levels at different time intervals for barnyard millet khichdi and rice khichdi

Time interval (minutes)	Glucose (mg/100ml)	Barnyard millet khichdi (variety PRJ-1) (mg/100ml) (Mean ±SD)	Rice khichdi (variety Swarna) (mg/100ml) (Mean ±SD)
0	80.5±3.13	79.7±3.91	81.1±2.76
30	158.0±5.88	106.4±4.90	127.3±4.98
60	125.3±27.01	96±4.87	100.3±1.81
90	106.8±17.29	89.9±4.22	92.7±1.63
120	100.8±12.86	84.5±3.97	88.8±2.69
150	89.2±5.96	81.5±3.24	85.2±2.29

The area under blood glucose response curve was lowest for barnyard millet khichdi (1793.5mg min/100ml) followed by rice khichdi (3137.2 mg min/100ml) and glucose (5009.2 mg min/100ml) (Table 7). This indicates that on consumption of barnyard millet khichdi there is slow release of glucose which helps to maintain normal blood glucose level, a desirable characteristic for diabetes. The area under blood response curve for barnyard millet khichdi have been reported as 1840.03±382.09 mg.min/100 ml [15]. Legumes are categorised by National Diabetes Mellitus (DM) guidelines among the lowest glycemic index (GI) foods. Bengal gram dhal is among most commonly consumed legume in India. It has been reported that the low-glycemic index legume diet reduces glycosylated hemoglobin values by 0.5 per cent as compared to high wheat fibre diet which reduces glycosylated hemoglobin value up to 0.3 per cent. The study states that incorporation of legumes improves glycemic control and also reduces risk of cardiovascular disease risk in diabetic subjects [18]-[19].

**Table 7:** Area under blood glucose response curve for barnyard millet *khichdi* and rice *khichdi*

S. No	Food product	Area (mg min/100ml) (mean±SD)
1	Glucose	5009.2±326.2
2	Barnyard millet <i>khichdi</i>	1793.5±314.1
3	Rice <i>khichdi</i>	3137.2±235.7
	S.Em	98
	CD at 5%	117.6

S.Em – standard error of mean, CD – critical difference

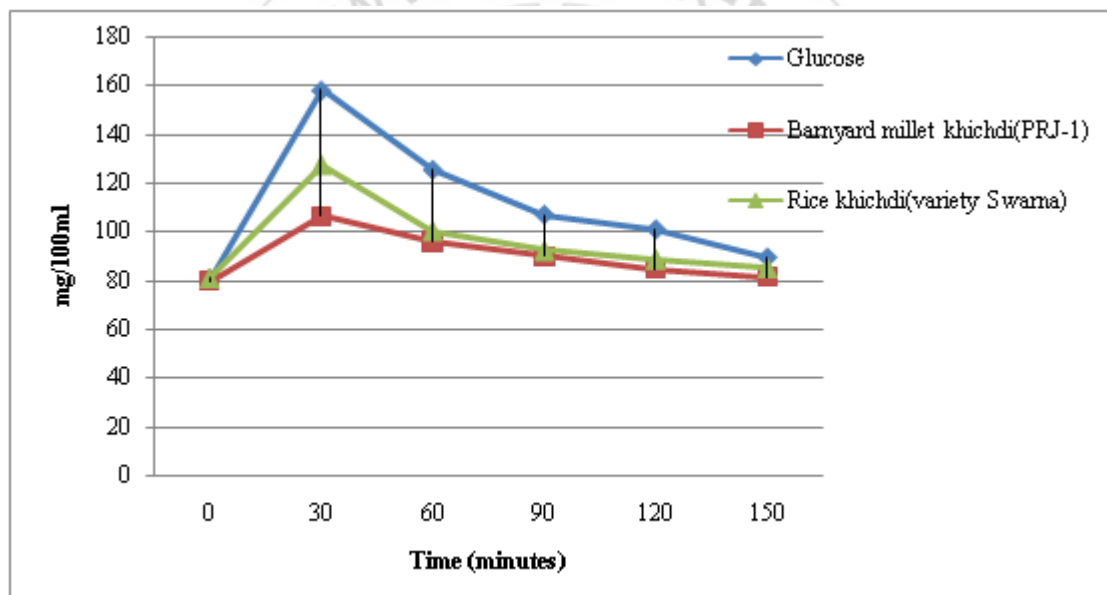
Therefore the glycemic index (34.96) of barnyard millet *khichdi* (variety PRJ-1) was comes under low glycemic index foods category according to the classification [20]. The risk of developing long term complications can be reduced dramatically by consuming right kind of food resulting in appropriate glycemic control in persons with diabetes. The glycemic index of rice *khichdi* (variety *Swarna*) was significantly higher than barnyard millet *khichdi*. Refined carbohydrates like white rice are devoid of fibre, raises blood glucose level much faster than their intact and unprocessed forms. When it is consumed, the blood

sugar level immediately shoots up and the body produces excess insulin to lower the blood sugar level. Barnyard millet due to presence of good amount of dietary fibre results in slow release of glucose in the blood rather than a sharp increase caused by consumption of rice making it a best substitute of rice for the people suffering from diabetes. The data thus obtained reveals that the barnyard millet *khichdi* had very slow release of blood sugar, a quality suited and desirable for diabetic patients.

**Table 8:** Glycemic index of barnyard millet *khichdi* and rice *khichdi*

S.No.	Food product	Glycemic index (mean±SD)
1	Barnyard millet <i>khichdi</i>	34.96±1.22
2	Rice <i>khichdi</i>	62.5 ±1.38
	t-value	4.67
	S/NS	S

S= significant difference, NS= non significant difference



**Figure 1:** Blood glucose response curve for barnyard millet *khichdi* (variety PRJ-1) and rice *khichdi* (variety *Swarna*) in comparison to glucose load of 50g

## 5. Conclusion

The study undertaken on barnyard millet as a substitute of rice in the form of *khichdi* was found suitable for diabetes. The nutritional analysis results suggest that except carbohydrate and physiological energy other proximate values viz; protein, fat, crude fibre and ash content of barnyard millet *khichdi* were higher as compared to rice *khichdi*. Similar results were observed for mineral composition suggesting that barnyard millet *khichdi* has higher values for calcium, phosphorus, iron, zinc, magnesium and chromium as compared to rice *khichdi*. No significant difference was observed in sensory quality of barnyard millet *khichdi* and rice *khichdi*. Highly significant difference was observed between glycemic index values of barnyard millet *khichdi* and rice *khichdi* suggesting slow sugar releasing property of barnyard millet *khichdi*.

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