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Formulation, Nutritional Evaluation and Glycaemic Response Assessment of Kodo Millet (*Paspalum scrobiculatum*) *Pulav* in Normoglycaemic Subjects

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Abstract

Minor millets play an important role in achieving food and nutritional security and also address life style disorders. Millets including kodo contains a high proportion of complex carbohydrate, dietary fiber and possess low to medium GI which helps in lowering blood glucose response among diabetic patients. Hence, the present study was undertaken to formulate kodo millet *pulav* and to assess the postprandial glycaemic response in normal healthy volunteers. Kodo millet *pulav* was standardized by incorporating kodo millet rice with broken rice/rice grits at 50 per cent (KPT1), 75 per cent (KPT2) and 100 per cent (KPT3) and control *pulav* was prepared from 100 per cent broken rice (KPC). Among the variations highest scores for sensory attributes were recorded for KPT1 and hence was selected for the development of kodo millet *pulav* mix, which was safe for consumption for three months when packed in MPP (multi layered polypropylene) covers at ambient temperature. Except carbohydrate and energy content all macro nutrients and micro nutrients were higher in test *pulav* (KPT1) compared to control *pulav.* Test food (kodo millet *pulav*) was effective in reducing the mean blood glucose levels at 30 and 60 minutes (115 mg/dL and 104 mg/dL) compared to reference (126.3 and 118.1mg/dL, respectively) and control *pulav* (121 and 110.5mg/dL, respectively). Test *pulav* had the moderate glycemic index (67.66) when compared to the standard white bread (100) and control *pulav* (84.69) and test *pulav* can be classified under moderate glycemic index food.

Keywords : Kodo millet -RTC *pulav* mix,Glycaemic response, Glycemic index, Health benefit

Millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture, grown throughout the world that belong to the family Poaceae. Millets are unique because of their richness in calcium, dietary fibre, polyphenols, carbohydrates (70-80%) and protein (9-14%). It is a gluten-free cereal and also rich in phyto chemicals which help to lower cholesterol level and reduced cancer risk due to its phytate content (Shadang & Jaganathan, 2014 and Nityashree & Vijaylaxmi, 2022) and hence are termed as 'nutri-cereals' (Bravo, 1998).

The kodo millet (*Paspalum scrobiculatum*) is one among the minor millets also known as cow grass, rice grass, ditch millet, Native Paspalum or Indian Crown Grass. The local names of kodo varies from region to region and it is called as Haraka in Kannada. Kodo millet is rich source of fiber (9%), as compared to rice (0.2%) and wheat (1.2%). Kodo millet contains carbohydrates 66.6g and energy 353 Kcal per 100g, when compared to other millets. Kodo millet can help diabetics and even the obese due to it's low carbohydrate content and slow digestibility (Deshpande *et al*., 2015). Rapid urbanization, industrialization and consequent changes in eating habits of people have led to development of instant dry mixes and ready-to-eat convenience foods. Provision of such RTE foods based on nutritious grains such as millets would be more meaningful in the modern times in the management of life style disorders (Takhellamban & Chimmad, 2015 and Latharani & Jamuna, 2023). One of the potential products that can be developed into an instant food is functional *pulav* mix. Glycemic index is an important tool used in treating people with diabetes (Brand-Miller, 2003), cardiovascular disease management and weight regulation programs (Pawlak *et al*., 2002). Kodo millet contain water soluble fiber and this property may be utilized for maintaining or lowering blood glucose response among diabetic and CVD patients. Glycemic load (GL) representing both quality and quantity of carbohydrate in a food and allows comparison of the likely glycemic effect of realistic portion of the different foods. In this context RTC/RTE millet mixes are gaining importance. Hence, the present study was undertaken to develop RTC kodo millet *pulav* mix and to assess the postprandial glycaemic response of kodo millet *pulav* in comparison to a rice *pulav* in normal healthy volunteers.

MATERIAL AND METHODS

Procurement of Raw Materials

Kodo millet was procured from the local farmers of Gopalanahalli of Chikkanayakanahalli taluk of Tumkur district of Karnataka, India. Kodo millet grains were dehulled into kodo millet rice by using millet dehulling machine (Dhumketi *et al.,* 2018) in millet processing unit of farmers grower's association, Gopalanahalli of Tumkur district.

Formulation of Kodo Millet *Pulav*

Vegetable *pulav* is one of the traditional cuisine of the South India. Kodo millet *pulav* was standardized by incorporating kodo millet rice with broken rice at 50 per cent (KPT1), 75 per cent (KPT2) and 100 per cent (KPT3) and control *pulav* was prepared from 100 per cent broken rice (KPC). Sensory evaluation of the control and all the variations was done with the help of nine point hedonic scale by a panel of twenty one semi trained judges.

Ready-to-Cook (RTC) Kodo Millet Pulav Mix : The best accepted product variation from kodo millet *pulav* variations (KPT1 50%) was selected for the development of *pulav* mix. Preparation of Ready to cook (RTC) Kodo millet millet *pulav* mix is given in Fig. 1. For control *pulav* mix KPC 100 per cent rice

To prepare kodo millet pulav mix, the soaked and dried kodo millet rice (50 g) and rice grits (50g), were roasted in stainless steel till the roast attained 150 ± 3 °C

↓

Known volume of oil was heated (180 ± 5 °C) in a pan, spices and dehydrated vegetables (cleaned, washed, peeled blanched for 3-5 minutes and dried in tray drier at 60°C for 12 to 14 hours) were added and sauted

↓

Preprocessed and roasted kodo millet rice and broken rice and salt were added and mixed properly with oil

↓

The samples were cooled and packed and stored at ambient condition (20–35 °C)

Fig. 1: Flow chart for the preparation of ready-to-cook (RTC) Kodo millet millet *pulav* mix

grits were used and other ingredients and procedure is same as for the kodo millet *pulav* mix.

Method of Preparation of RTC Pulav Mix : To one cup of Kodo millet *pulav* mix three cups of water added with salt and pressure cooked for three whistles.

Nutrient Composition of *Pulav Mixes*

All analysis were done by following the AOAC (1980) official protocols. Moisture was determined from sample weight loss after drying at 110 °C for 4 h. Protein (g) content was determined by Kjeldahl method. The Soxhlet method was used for total fat (g) determination. Crude fiber was estimated by treatment of sample first with acid and subsequently with alkali. The loss in weight was the crude fibre content. Carbohydrate and energy by difference method. Ash by muffle furnace, micronutrients (mg) iron, zinc and copper by using Atomic Absorption Spectrophotometer and calcium and magnesium by titration method. All samples were analyzed in triplicates.

Glycemic Index Study

The glycemic index is defined as the incremental area under the blood glucose response curve of a 50g carbohydrate portion of test food expressed as a per cent of the response to the same amount of carbohydrate from a standard food taken by the same subjects (FAO/WHO, 2003).

Study Subjects

Ten healthy volunteers who were clinically normal and normoglycemic, aged between 21 to 35 years were selected from Krishi Vigyana Kendra, Konehalli, Tumkur, district. Informed consent was taken from all study subjects after explaining about methods of study.

Anthropometric Measurements

All the anthropometric measurements were taken following the standard techniques (WHO, 2004). Height and weight were measured to the nearest 0.1 cm and 0.5 kg, respectively, using an anthropometric rod and standard weight scale, respectively.

The ratio of waist to hip is an indicator of central obesity. The abdominal obesity was assessed by waist to hip ratio (Lean *et al.,* 1995) using a tape measure.

Standard Food

After fasting for 10-12h, subjects arrived to the laboratory at 8 am in the morning and blood samples were obtained. Fasting blood sugar was estimated and postprandial blood sugar was taken at 30, 60, 90 and 120 min interval after consumption of measured quantity of white bread (50g of carbohydrate).

Test Foods

Controll *pulav* was standardized in lab using 100 per cent rice grits and kodo *pulav* was developed by incorporating kodo millet rice at 50 per cent level. Fifty g of available carbohydrate for each test foods was calculated from the results of proximate analysis and the measured portion of food was served to the subjects.

Analysis of Blood Glucose in the Subjects

All screened subjects made to fast over night (10-12 h). Capillary blood glucose levels were taken at the fasting level and subjects were immediately presented with the white bread or control *pulav* or kodo millet *pulav* were required to consume the foods within 10 minutes. Their blood sample was collected through finger prick using a hypodermic needle or lancets. Each blood sample was inserted into a calibrated glucometer (ACCU CHEK-Active/one touch) which gave direct reading after 45 seconds based on glucose oxidase assay method. The determination of blood glucose was taken at different intervals *i.e.,* 0 (fasting) min, 15, 30, 45, 60, 90 and 120 min during the 2 hour study visit after feeding the reference food and test foods to the subjects. To assess the glycemic index of all samples ensuring a wash out period of one week between the samples.

Computation of Glycemic Index (GI)

Blood glucose response curves will be plotted for both glucose and test foods. Blood glucose area under curve (IAUC) was calculated using the trapezoidal rule. Glycemic index was calculated by using the following formula :

$$GI = \frac{\text{IUAC of the test food}}{\text{IAUC for reference food}} \times 100$$

Glycemic Load

Glycemic load (GL) was estimated indirectly by multiplying the amount of carbohydrate contained in a serving size with GI value of specific food divided by 100 (Salmeron *et al.,* 1997).

$$GL = \frac{\text{GI x carbohydrate net content per portion in g}}{100}$$

Results and Discussion

Development of Product Kodo Millet *Pulav* and Sensory Evaluation

Kodo millet p*ulav* was standardized by incorporating kodo millet rice with broken rice at 50 per cent (KPT1), 75 per cent (KPT2) and 100 per cent (KPT3) and control pulav was prepared from 100 per cent broken rice (KPC). The mean scores of *pulav* prepared from kodo millet incorporated with broken rice is depicted in Fig. 2.

Control *pulav* had the highest scores for all the sensory parameters. Among the variations highest scores for appearance, colour, flavour, texture, taste and overall acceptability (7.98, 7.98, 8.07, 7.89, 8.08 and 8.11, respectively) were recorded for 50 per cent kodo millet incorporated *pulav*. However, the difference in scores for all the sensory parameters among the variations was found to be statistically significant ($p<0.05$) as depicted in Fig. 2.

Verma *et al.* (2015) *formulated* the *biryani* from foxtail millet, barnyard millet and rice (control) and analysed for their sensory qualities. He revealed that the colour, flavour, taste and overall acceptability of *biryani* based on foxtail millet were rated very good against barnyard millet and control which were rated good. Barnyard millet and foxtail millet *biryani* showed significant difference (at 5% level of significance) in all the sensory evaluation parameters.

Kodo Millet RTC *Pulav* Mix

The best accepted product variation from kodo millet *pulav* variations (KPT1 50%) was selected for the development of *pulav mix.* Kodo millet *pulav mix* (KPT) was prepared using the preprocessed and roasted kodo millet rice (50%) and rice grits (50%), dehydrated vegetables, oil and spices. For control

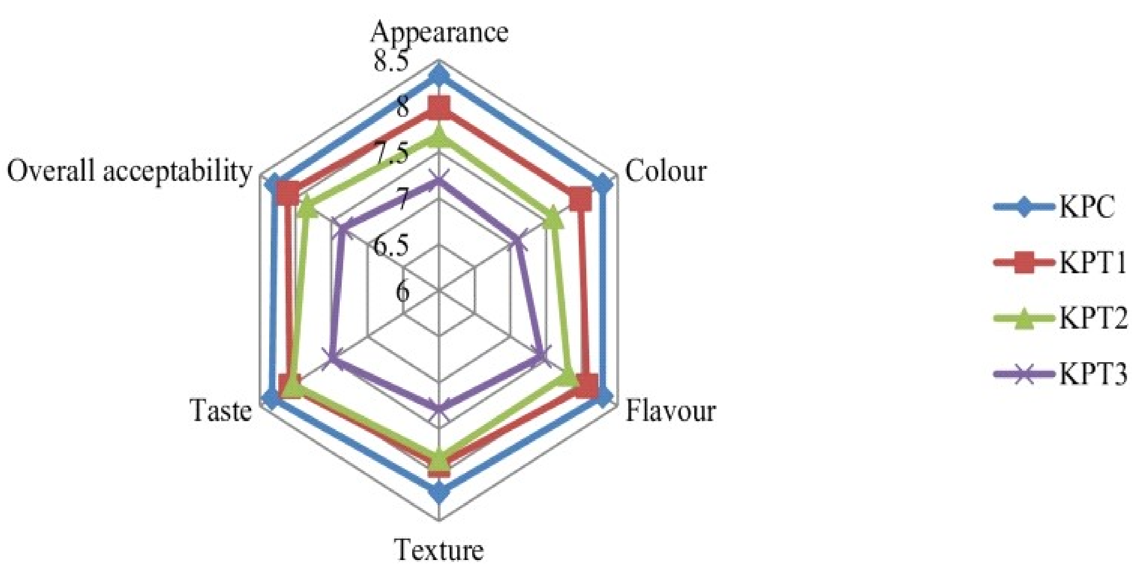

Fig. 2 : Mean Sensory scores of kodo millet *pulav*

pulav mix (KPC) 100 per cent rice grits were used and other ingredients was same as for the kodo millet *pulav* mix. Then samples were heat sealed in MPP (multi layered polypropylene) covers and stored at ambient condition (20-35 °C) for shelf life study.

Nutritional Composition of RTC *Pulav* Mixes

Table 1, shows nutrient composition of *pulav* mix per 100g. It was found that the protein content of kodo millet based *pulav* mix (KPT1) was higher (10.00 ± 0.1) than the control *pulav* mix (11.53 ± 0.15). Control *pulav* mix had relatively higher carbohydrate content (65.97g ± 0.32) and energy value (350.68Kcal ± 2.32). Carbohydrate content and energy value in kodo millet *pulav* mix was observed to be 60.39g ± 0.64 and 341.68Kcal ± 1.85. Fat content of kodo millet and control *pulav* mix were 5.20 ± 0.17g and 6.06g ± 0.20, respectively. Calcium content was also higher in millet based *pulav* mix (102.00 mg ± 2.00) than control *pulav* mix (86.00 mg ± 1.73). Magnesium iron, zinc, copper and manganese content of kodo millet *pulav* mix were 132.67mg ± 1.15, 5.32 mg ± 0.33, 2.46 mg ± 0.37, 0.43mg ± 0.02 & 0.52mg ± 0.04 and control *pulav* mix were 3.11mg ± 0.18, 91.00 mg ± 1.00, 1.77mg ± 0.11, 0.28 mg ± 0.06 & 0.71mg ± 0.09, respectively.

Study conducted by Verma *et al.* (2015) also reported that *biryani* prepared from barnyard millet and foxtail millet had higher contents of protein, fat, fibre, calcium and iron as compared to *biryani* prepared from rice (control). Satishkumar *et al.* (2017), also reported the proximate composition

TABLE 1

Nutrient composition of the best accepted RTC kodo millet *pulav* mix

Nutrients	*Pulav* mix per 100 g	
	Control *pulav* mix (KPC)	Kodo *pulav* mix (KPT)
Moisture (g)	6.49 ± 0.15	5.83 ± 0.59
Fat (g)	5.20 ± 0.17	6.06 ± 0.20
Protein (g)	10.00 ± 0.1	11.53 ± 0.15
Ash (g)	1.62 ± 0.10	1.9 ± 0.03
Crude fibre (g)	10.53 ± 0.28	14.27 ± 0.74
*Carbohydrate (g)	65.97 ± 0.32	60.39 ± 0.64
*Energy (Kcal)	350.68 ± 2.32	341.68 ± 1.85
Calcium (mg)	86.00 ± 1.73	102.00 ± 2.00
Magnesium (mg)	91.00 ± 1.00	132.67 ± 1.15
Iron (mg)	3.11 ± 0.18	5.32 ± 0.33
Zinc (mg)	1.77 ± 0.11	2.46 ± 0.37
Copper (mg)	0.28 ± 0.06	0.43 ± 0.02
Manganese (mg)	0.71 ± 0.09	0.52 ± 0.04

Values are mean of triplicates ± SD, *Carbohydrate-difference method *Energy - computation

TABLE 2

Anthropometric measurements of volunteers participating in the study

Parameters	Participants		Normal range
	Male	Female	
Age 23-34 years	7	3	
Weight (kg)	70.14 ± 6.54	56.93 ± 5.01	
Height (cm)	170 ± 4.39	153.66 ± 5.50	
BMI (kg/m^2)	24.47 ± 2.50	24,14 ± 1.84	<25
Waist circumference (cm)	84.14 ± 8.27	75 ± 4.35	
Hip circumference (cm)	95.41 ± 4.25	95 ± 5	
WHR	0.85 ± 0.05	0.78 ± 0.03	<0.95 Male <0.80 Female

Values are mean of triplicates ± SD

of foxtail millet puliogare mix stored at ambient temperature that foxtail millet puliogare mix contained 13.50 (g), 4.50 (g), 7.71 (g), 68.22 (g) and 365 (Kcal) and 8.20 (mg) of protein, fat, crude fibre, carbohydrates, energy and iron, respectively.

Glycemic Index of Kodo Millet *Pulav* Mix

In the present study total of ten healthy volunteers (7 male and 3 famale) in the age group of 23-34 years, with a normal BMI and WHR (Table 2) were selected based on inclusion and exclusion criteria explained in the methodology. Food habits and fitness of the participants is depicted in the Table 3. Eighty per cent of the participants were non vegetarian followed by vegetarian (10%) and ova vegetarian (10%). Cent percent participants have the meal pattern of 3 meals/ day. With regard to fitness habits, most of the participants excersise daily (50%) followed by walking (40%) and playing (20%) & jogging (20%).

Glycemic Index of Kodo Millet *Pulav*

Glycemic index study was carried out for the foods standard, control and kodo millet *pulav* among the ten healthy volunteers. A 50g of available carbohydrate from standard, control and test foods was given to participants at the interval of one week. The test foods were consumed in random order between the reference food sessions, with at least one week gap between measurements.

The mean blood glucose levels for the test foods (control and test *pulav*) in comparison with standard

TABLE 3

Food habits and fitness pattern of the participants

Parameters	Participants	Total	Percentage
Food habits			
Vegetarian	1	1	10
Ovo vegetarian	1	1	10
Non vegetarian	8	8	80
Meal pattern			
2 meals/day	0	0	0
3 meals/day	10	0	100
4 meals/day	0	0	0
Fitness deatails *			
Walking	4	4	40
Playing	2	2	20
Jogging	2	2	20
Excersise	5	5	50
Yoga	1	1	10

*Multiple responses

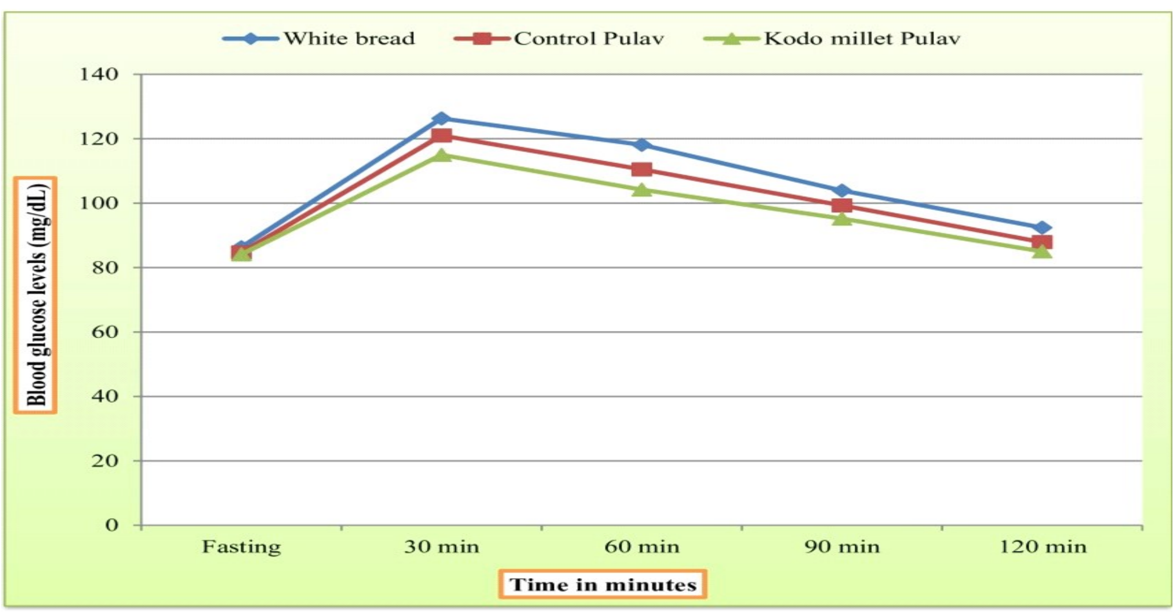

Fig. 3 : Mean blood glucose (mg/dL) levels after ingestion of standard and test foods (*pulav*)

TABLE 4

Glycemic index (GI) and glycemic load (GL) of the standard and test foods (*pulav*)

Aspects	Standard	Test food (*pulav*)	
	White bread	Control	Test
Glycemic index (GI)	100	84.69	67.66
Glycemic load (GL)	50	42.34	33.83
Glycemic index classification	High (>70)	High (>70)	Moderate (55-70)
Glycemic load classification	High (>20)	High (>20)	High (>20)

(white bread) among the ten normal volunteers is presented in Fig. 3. The fasting blood glucose levels ranged from 84.1 to 86.3mg/dL and no significant difference was observed in fasting blood glucose level among the standard, control and test food groups. A steady increase in mean blood glucose was observed after consuming white bread, control and test *pulav* and the peak was reached at 30 min. The mean peak value of test *pulav* was 115 mg/dL significantly lower ($p<0.05$) than the standard white bread (126.3mg/dL) and control *pulav* (121 mg/dL). Test food (kodo millet *pulav*) was effective in reducing the mean blood glucose levels at 30 and 60 minutes (115 mg/dl and 104 mg/dL) compared to reference (126.3 and 118.1mg/dL, respectively) and control *pulav* (121 and 110.5mg/dL, respectively). Significant differences were observed only at 30 min between reference and test foods and also between control and test *pulav*, but no significant differences were observed between fasting, 60 min, 90 min and 120 min.

Glycemic index (GI) and glycemic load (GL) of the test foods in comparison with standard food is shown in Table 4. Control *pulav* had the glycemic index of 84.69 when compared with the reference food white bread (100) and it can be classified under high glycemic index food. Test *pulav* had the moderate glycemic index (67.66) when compared to the standard white bread and control *pulav*. Glycemic load of control *pulav* (42.34) and test *pulav* (33.83) were classified under high glycemic load (>20). However test *pulav* classified under high glycemic load, showed slightly lower values compared to control *pulav*.

Similar findings were observed by Yadav *et al.* (2013) who evaluated the glycemic index (GI) of Kodo incorporated (60%) Idli and Sewai upma and their corresponding control products in ten normal subjects and reported that GI of Kodo based Idli [58.53 (SEM 1.48)] and Sewai upma [65.49 (SEM 1.01)] was considerably lower than the control Idli [67.11 (SEM 3.25)] and Sewai upma [69.49 (SEM 1.01)].

Minor millets play important role in achieving food and nutrional security and also address life style disorders. The RTC kodo millet mix was developed from the best accepted variation (50%). Except carbohydrate and energy content all macro and micro nutrients were higher in kodo millet based *pulav* mix compared to control *pulav* mix. Kodo millet *pulav* was significantly ($p<0.05$) effective in reducing blood glucose levels at 30 minutes and had moderate glycemic index (67.66) and glycemic load (33.83) values were lower compared to the standard white bread and control *pulav*.

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