ORIGINAL ARTICLE

Comparative study on nutritional and sensory quality of barnyard and foxtail millet food products with traditional rice products

Suman Verma · Sarita Srivastava · Neha Tiwari

Abstract Millets have the potential to contribute to food security and nutrition, but still these are underutilized crops. The present study was undertaken with a view to analyse the physico-chemical, functional and nutritional composition of foxtail millet, barnyard millet and rice and to compare the sensory quality and nutritive value of food products from foxtail and barnyard millet with rice. Analysis of physico-chemical and functional characteristics revealed that the thousand kernel weight of foxtail millet, barnyard millet and rice was 2.5, 3.0 and 18.3 g, respectively and thousand kernel volume was 1.6, 13 2.0 and 7.1 ml, respectively. The water absorption capacity of foxtail millet, barnyard millet and rice was 1.90, 1.96 and 1.98 ml/g, respectively and water solubility index was 2.8, 1.2 and 1.0 %, respectively. Viscosity was measured for foxtail millet (1650.6 cps), barnyard millet (1581 cps) and rice (1668.3 cps). Analysis of nutritional composition showed that the moisture content of foxtail millet, barnyard millet and rice was 9.35, 11.93 and 11.91 %, respectively. The total ash, crude protein, crude fat, crude fibre and carbohydrate of foxtail millet were 3.10, 10.29, 3.06, 4.25 and 69.95 %, respectively, for barnyard millet were 4.27, 6.93, 2.02, 2.98 and 71.87 %, respectively and the corresponding values for rice were 0.59, 6.19, 0.53, 0.21 and 80.58 %, respectively. The energy value for foxtail millet, barnyard millet and rice was 349, 407 and 352 Kcal, respectively. The foxtail millet contained 30.10 mg/100 g calcium and 3.73 mg/100 g iron whereas barnyard millet contained 23.16 mg/100 g calcium and 6.91 mg/100 g iron. Values of 10 mg/100 g calcium and 0.10 mg/100 g iron were observed for rice. The formulated products viz. *laddu, halwa and biryani* from foxtail millet, barnyard millet and rice (control) were analysed for their sensory qualities. Among the products prepared, there was non significant difference with regard to the colour, flavor, texture, appearance and overall acceptability of foxtail and barnyard millet *laddu* and *halwa* when compared to control. Foxtail millet *biryani* was most acceptable compared to barnyard millet and control *biryani*. Nutritive value of formulated products was calculated and it was compared with the rice. The protein, fat and fibre content of the formulated products from foxtail and barnyard millet were higher than the rice products. Thus from the present study it was concluded that the foxtail millet and barnyard millet are superior in nutritive value to rice and have potential for use in traditional food products.

Keywords Millets · Traditional food products · Nutritional quality

Introduction

The name millet is applied to numerous small seeded grasses which originated in Asia or Africa. They have in general wide adaptation and can fit into almost any situation. Millet is one of the most important drought-resistant crops and the 6th cereal crop in terms of world agriculture production. Also, millet has resistance to pests and diseases, short growing season, and productivity under drought conditions, compared to major cereals (Devi et al. 2011). Millets include five genera, *Panicum, Setaria, Echinochloa, Pennisetum,* and *Paspalum.* The most important cultivated species of millets are foxtail (*Setaria italica*), pearl or cattail millet (*Pennisetum glaucum*), proso (*Panicum miliaceum*), Japanese barnyard millet (*Echinochola crusgalli*), fingermillet (*Eleusine coracana*), browntop millet *(Panicum ramosum)*, kodo or ditch millet (*Paspalum scrobiculatum*), and teff millet (*Eragrostis tef*). Various millets grown in India are finger millet *(Eleusine*

S. Verma · S. Srivastava · N. Tiwari (✉)
College of Home Science, G.B.P.U.A. &T. Pantnagar, Pantnagar, Uttarakhand, India
e-mail: nehatiwari41@gmail.com

coracana), foxtail millet *(Setaria italica),* kodo millet *(Paspalum scrobiculatum),* barnyard millet *(Echinochloa frumentacea)* and little millet *(Panicum milliare)* (Baker, 2003).

Nutritive value of these millets is quite comparable to wheat and rice. The non availability of refined and processed millets in ready- to- use form has limited their wider use and acceptability. Millets are therefore confined to traditional consumers and also to the people of lower economic strata. Millets are unique among the cereals because of their richness in calcium, dietary fibre, polyphenols and protein (Devi et al. 2011). The protein content is very close to that of wheat, but in addition they are also rich in B vitamins, especially niacin, B6 and folacin, calcium, iron, potassium, magnesium, and zinc. Foxtail millet *(Setaria italica)* is also known as Italian millet. In India cultivation of foxtail millet is mainly confined to lower Deccan plateau including high lands of Andhra Pradesh, Karnataka and Tamilnadu which *accounts for 90% in the country.* It is mostly grown mixed with other crops like cotton, castor, pigeon- pea, bajra, groundnut and finger millet.

Barnyard millet *(Echinochloa frumentacea)* is short and fastest growing millet (Veena et al. 2005). Nutritionally too, 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 (Veena et al. 2005). 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. Although barnyard millet like any other minor millet is nutritionally *superior to other cereals,* yet its utilization is limited. The major factor discouraging its cultivation and consumption with improvement in living standard or urbanization is the drudgery associated with its processing. However, there is a need to restore the lost interest in millets that deserves recognition for its nutritional qualities and potential health benefits.

Even though the nutritional qualities of millet have been well recorded, its utilization for food is confined to the traditional consumers in tribal populations, mainly due to non-availability of consumer friendly, ready-to-use or ready-to-eat products as are found for rice and wheat. In recent years, millets have received attention, mainly because of their high fiber content and efforts are under way to provide it to consumers in convenient forms (Deshpande and Poshadri 2011). In many African and Asian areas, millets serve as a major food component and various traditional foods and beverages, such as bread (fermented or unfermented), porridges, and snack foods are made of millet, specifically among the non affluent segments in their respective societies (Chandrasekara et al. 2012).

Hence the study was carried out to study physico-chemical and functional properties of millet flour and compare the millets incorporated products with traditional food products for its sensory and nutritional quality characteristics.

Materials and methods

Source of raw material

Milled barnyard millet *(Echinochloa frumentacea)* and rice *(Oryza sativa)* were purchased from local Pantnagar market and foxtail millet *(Setaria italica)* was obtained from local market of Lohaghat.

Cleaning and milling of grains

For cleaning, grains of millet and rice were manually cleaned to remove stones, grit, chaff and other impurities. The seeds were then milled in milling machine (Atta master flour mill, Navdeep products, Bheempore- Daman (UT)). The flour made was sieved out manually through 40 mesh sieve and after there the prepared sample was packed in air tight containers and stored at room temperature until used.

Physico-chemical and functional characteristics

Physico-chemical and functional characteristics were analysed using the sample in triplicates.

Thousand kernel weight

Thousand kernel weight was determined using the method given by Williams et al. (1983). One thousand sound seeds were counted and weighed. Weight was *calculated* in grams.

Thousand kernel volume

Thousand kernel volume was determined using graduated cylinder by water displacement method given by Williams et al. (1983). One thousand sound seeds were counted, transferred to 50 ml measuring cylinder and 25 ml of distilled water was added to it. The cylinder was slightly shaken to ensure that no air bubble was trapped within and then the seed volume was recorded as total volume minus 25 ml.

Particle size distribution

For determining the particle size distribution, hundred gram of sample was sieved in a series of 25, 44, 60, 85 and 120 mesh standard sieves. The sieves were shaken for 15 min in a ro-top type electric sieve shaker. Weight of the samples retained over 25, 44, 60, 85 and 120 and through 120 mesh sieve was recorded. Particle size distribution was quantitated on percentage basis.

Water absorption capacity

Water absorption capacity of flour was estimated according to the method given by Smith and Circle (1974) for soyflour. Exactly 5 g of flour was mixed well with 30 ml. distilled water in a centrifuge tubeusing a glass rod. After 5 min the contents were centrifuged at 2000 rpm for 5 min. The supernatant was measured using a graduated cylinder. Volume of water absorbed equals to 30 minus supernatant. Water absorption capacity was recorded as follows.

$$\text{Water absorption capacity(ml/g)} = \frac{\text{volume of water absorbed}}{\text{Weight of sample}}$$

Water solubility index

The water solubility index was determined using method of AOAC (1990). The supernatant liquid was decanted into a weighed evaporation dish, oven dried at 100 °C for 2 h and reweighed. The weight of dried solids recovered by evaporation of the supernatant was expressed as water solubility index.

$$\text{Water solubility index(\%)}$$
$$= \frac{\text{weight of dissolved solids in supernatant} \times 100}{\text{Weight of sample}}$$

Viscosity

Viscosity was determined by the viscometer (Anton Paar). Individual flours were prepared in 15 % (w/v) concentration. A paste was made by mixing 30 g of flour with 50 ml of distilled water in a 1 beaker. To the paste, 150 ml of boiling distilled water was added and mixed well with a glass stir rod. The flour slurry was heated in a boiling water bath, stirred every 5 min, and held at 95 °C for 10 min. Viscosity was measured with a viscometer (Digital Viscometer DV-1P. Anton Paar GmbH, Karntner Strasse 322, A-8054 Graz/ AUSTRIA- EUROPE) and spindle (L-4) at 100 rpm and 40 °C.

Proximate composition

The chemical analysis of prepared samples was done in triplicates. Moisture, crude protein, crude fat, total ash, and crude fiber contents were estimated according to AOAC, 1995. Calcium content was *determined* following AOAC (1984) method. Iron is determined colorimetrically by Wong's method (1923) as given by Ranganna (1986)

Preparation of food products

Three products viz. *laddu*, *halwa* and *biryani* based on foxtail millet, barnyard millet and rice were prepared. Rice based food products were used as control. The particle size of flour for *laddu* and *halwa* was taken less than 355 m (mesh size) and more than 125 m.

Laddu

Laddu is a sweetened food product, prepared by using wide variety of cereals, millets, legumes and oilseeds, sugar and shortening, that is shaped into a ball and is more popular in North India.

Method of preparation

Ingredients

Flour–100 g
　Sugar powder–55 g
　Ghee–50 g
　Elaichi powder–½ tsp

Halwa

Halwa is a dessert (sweet Indian dish) made from various kinds of fruits, vegetables, grains and lentils boiled with milk, almonds, sugar, butter and cardamom It is made in the Middle East, Central Asia and India.

Method of preparation

Ingredients

Flour - 30 g
　Ghee/oil -15 g
　Sugar -30 g
　Water - 250 ml

Vegetable biryani

Vegetable *biryani* is an Indian dish made with highly seasoned rice and vegetables flavored with saffron or turmeric.

Method of preparation

Ingredients

Rice or foxtail/barnyard millet- 70 g
　Mixed vegetables- 80 g
　Onion- 40 g
　Tomato- 40 g
　Refined oil- 2 tbsp
　Green chilli- 2

Cloves - 4
Turmeric powder- ½ tps
Red chilli powder- ¼ tps
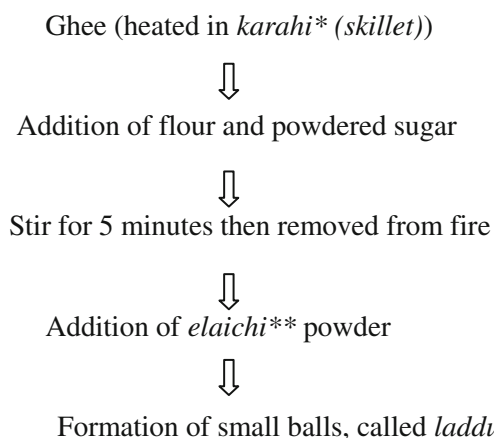
Sensory evaluation

The food products prepared were evaluated for sensory quality by score card method. The evaluation of food products was done by a semi trained panel of 10 members from department of Foods and Nutrition for various attributes viz. colour, texture, taste, flavor, appearance and overall acceptability (Lawless and Heymann, 2010). The panelists were asked to score the food products for their colour, flavor, texture, taste, appearance and overall acceptability.

Nutrient composition of food products

Food products viz. *laddu, halwa* and *biryani* based on foxtail millet, barnyard millet and rice (control) were prepared (Figs. 1, 2 and 3). Weight of all 3 cooked products was recorded. The nutritive value of formulated products was obtained by the calculation method (Gopalan et al. 2007). Nutrients were calculated per 100 g of cooked food product.

Statistical analysis

Data on the chemical composition of foxtail millet, barnyard millet and rice and sensory of formulated products viz. *laddu, halwa* and *biryani* were subjected to statistical analysis using one way ANOVA to find out significant differences between control (rice) with foxtail millet and barnyard millet (Snedecor and Cochran, 1967).

Ghee (heated in *karahi* (skillet)*)
⇓
Addition of flour and powdered sugar
⇓
Stir for 5 minutes then removed from fire
⇓
Addition of *elaichi*** powder
⇓
Formation of small balls, called *laddu*

Fig. 1 Flow diagram for the preparation of *laddu*. * A bowl shaped frying pan with two handles used in Indian cookery. ** Cardamom

Roasting of flour in ghee for 10 minutes
⇓
Stirred to thick paste
⇓
Addition of sugar
⇓
Stirred for 2 minutes
⇓
Addition of dry fruits
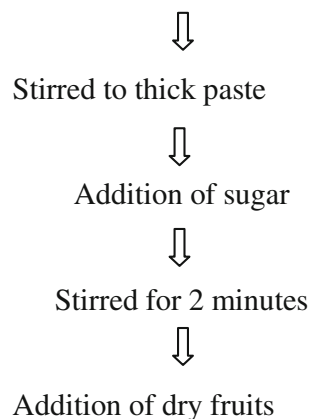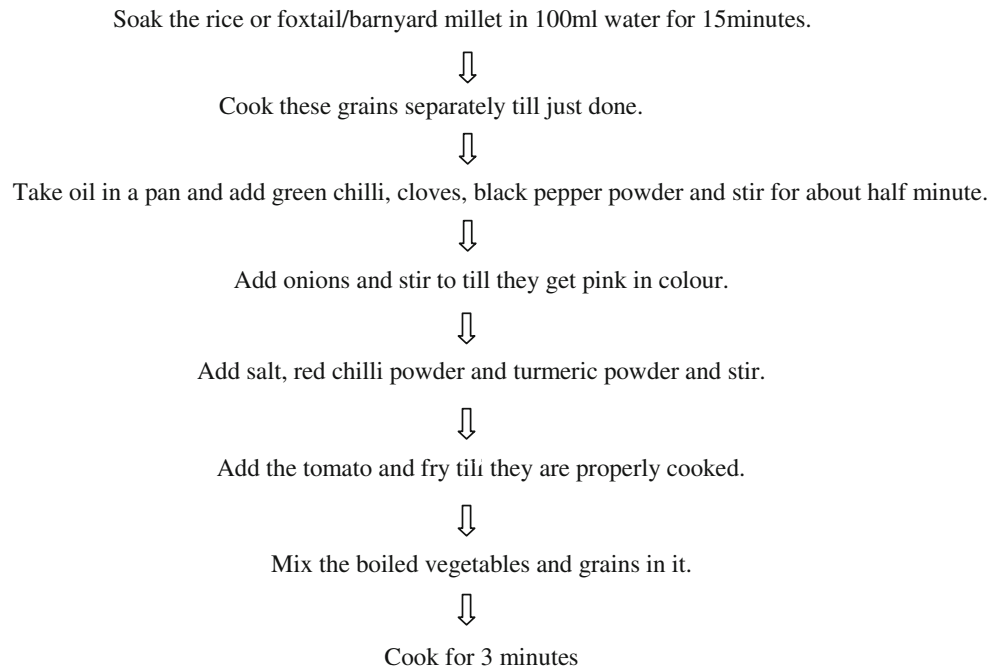
Fig. 2 Flow diagram for the preparation of *halwa*

Results and discussion

The results revealed that the thousand kernel weight of foxtail millet, barnyard millet and rice was observed to be 2.5, 3.0 and 18.3 g, respectively which are significantly different at 5 % level of significance in their value (Table 2). Hadimani and Malleshi (1993) reported thousand kernel weights of foxtail and barnyard millet as 2.6 and 3.0 g, respectively. The thousand kernel volume of foxtail millet, barnyard millet and rice was *found* to be 1.6, 2.0 and 7.1 ml, respectively (Table 2). All three samples were significantly different in thousand kernel volume at 5 % level of significance. Hadimani and Malleshi (1993) reported thousand kernel volume of foxtail and barnyard millet as 1.9 and 2.4 ml, respectively.

Table 1 shows the specific *particle size distribution* or percentage of foxtail millet, barnyard millet and rice flour on each sieve size. All flours were classified as fine, because 98 % of all particles passed through the no. 44 sieve. Rice flour produced a higher percentage of particles that passed through the 85 mesh size (88.25 %) and the greatest percentage of fine particles, less than 125 μm in diameter, as seen in the collection pan. Except the 44 mesh size, particle size distribution of foxtail millet, barnyard millet and rice showed the significant difference in all the mesh size viz. 60, 253 85, and 120.

Among all three types of flours, significant difference was *found* in water absorption capacity of rice flour with that of foxtail millet flour at 5 % level of significance. Rice exhibited higher water absorption capacity (1.98 ml/g) than barnyard (1.96 ml/g) and foxtail millet (1.90 ml/g) (Table 2). Non significant difference was found between water absorption capacity of barnyard millet and rice. Foxtail millet showed significantly higher value for water solubility index as compared to

Fig. 3 Flow diagram for the preparation of *biryani*

Soak the rice or foxtail/barnyard millet in 100ml water for 15minutes.

⇩

Cook these grains separately till just done.

⇩

Take oil in a pan and add green chilli, cloves, black pepper powder and stir for about half minute.

⇩

Add onions and stir to till they get pink in colour.

⇩

Add salt, red chilli powder and turmeric powder and stir.

⇩

Add the tomato and fry till they are properly cooked.

⇩

Mix the boiled vegetables and grains in it.

⇩

Cook for 3 minutes

barnyard millet and rice (Table 2). There was non significant difference in water solubility index between barnyard millet (1.20 %) and rice flour (1.10 %). Table 2 illustrates the viscosity of single grain gruels (15% w/v). 261 Viscosity was more than 1,500±0.57 cps for all gruels. Rice consistently *recorded* significantly higher viscosity (1668.3±0.57 cps) rather than foxtail millet (1650.6 cps) and barnyard millet flour 263 (1581±1.0 cps). This is attributed to the availability of more starch for gelatinization (Griffith and Perez Castell 1998). All the three samples were significantly different at 5 % level of significance in their viscosity values.

The moisture content of foxtail millet flour, barnyard millet flour and rice flour was 9.35, 11.93 and 11.91 % respectively. Foxtail millet showed significantly lower moisture content than rice and barnyard millet. Barnyard millet and rice have almost same moisture content. Non significant difference was found between moisture content of barnyard millet and rice flour. Total ash represents the total mineral content of foodstuff. From the results presented in Table 3, it can be observed that total ash content in the foxtail millet flour was 3.10 %.

The value obtained is slightly lower than the value reported by Agarwal et al. (2005) which is 3.52 % and is very close to the result given by Verma and Raghuvanshi (2001) which is 3.0 %. Total ash content of barnyard millet was observed to be 4.27 % which is close to the result given by Hulse et al. (1980) who reported a value of 4.50 % for barnyard millet. Total ash content of rice flour was 0.59 % which is very close to the result given by Gopalan et al. (2007) and Rajyalakshmi and Geervani (1994) who have reported total ash content of rice as 0.60 %. Foxtail and barnyard millet have significantly higher total ash content at 5 % level of significance as compared to rice and therefore these are more mineral dense in comparison with rice. All the three samples viz. foxtail millet, barnyard millet and rice were significantly different (at 5 % level of significance) in total ash content.

Crude protein content of foxtail millet flour, barnyard millet flour and rice flour was 10.29, 6.93 and 6.19 % respectively, which was significantly different from each other. The crude fat content of foxtail millet, barnyard millet and rice flour was 3.06, 2.02, and 0.53 % respectively. It was found that foxtail millet has 2.54 %

Table 1 Particle size distribution of foxtail millet, barnyard millet and rice flour

Flour	Sieve No./Mesh Size (m)					
	25/600	44/355	60/250	85/180	120/125	Collection pan
Foxtail millet (%)	0.0	1.88±0.06	6.61±0.35	13.43±0.68	22.52±1.30	56.41±1.33
Barnyard millet (%)	0.0	1.68±0.21	5.56±0.72	12.59±0.53	21.36±10.76	58.80±1.52
Rice (%)	0.0	1.27±0.16	4.43±0.48	11.76±0.28	19.93±1.25	62.22±1.21
CD at 5%	**0.0**	**0.50**	**0.27**	**0.51**	**0.15**	**0.66**

Table 2 Functional characteristics of foxtail millet, barnyard millet and rice flour*

Properties	Flour			
	Foxtail millet	Barnyard Millet	Rice	CD at 5 %
Thousand kernel weight (g)	2.5±0.01	3.0±0.05	18.3±0.01	0.06
Thousand kernel volume (ml)	2.0±0.05	1.6±0.05	7.1±0.05	**0.11**
Water absorption capacity (ml/g)	1.90±0.02	1.96±0.01	1.98±0.01	**0.02**
Water solubility index (%)	2.80±0.02	1.20±0.01	1.00±0.02	**0.014**
Viscosity (cps)	1650.6±0.57	1581±1.00	1668.3±0.57	**0.94**

*Average of triplicate values reported

CD Critical difference

and barnyard millet has 1.5 % more fat content as compared to rice. Crude fat content was significantly different (at 5 % level of significance) among foxtail millet, barnyard millet and rice.

The crude fibre content of foxtail millet was found as 4.25 % which is in accordance with the value of 4.8 % reported by Arya (2008). The crude fibre content of barnyard millet flour was 2.98 % and of rice flour was 0.21 % which is similar to the value of 0.20 % given by Gopalan et al. (2007) and Rajyalakshmi and Geervani (1994). Thus, millet grains have good amount of fibre as compared to the rice. Significant difference was observed among crude fibre content of all the three grains (at 5 % level of significance). The carbohydrate content of foxtail millet flour was 69.95 %. The carbohydrate content of barnyard millet flour was 71.87 % and of rice flour was 80.58 %. The carbohydrate content of foxtail millet and

Table 3 Proximate composition of foxtail millet, barnyard millet and rice on dry weight basis

Components	Foxtail millet	Barnyard millet	Rice	CD at 5 %
Moisture %	9.35±0.05	11.39±0.05	11.91±0.10	0.15
Ash %	3.10±0.06	4.27±0.02	0.59±0.05	0.08
Crude protein %	10.29±0.12	6.93±0.13	6.19±0.03	0.29
Crude fat %	3.06±0.20	2.02±0.06	0.53±0.03	0.25
Crude fibre %	4.25±0.15	2.98±0.12	0.21±0.17	0.11
carbohydrate by difference %	69.95±0.14	71.87±0.10	80.58±0.17	0.29
Energy (Kcal)/100 g	349±0.35	333±1.5	352±0.34	1.86
Calcium (mg/100 g)	30.10±0.58	23.16±1.50	10.00±1.210	0.14
Iron (mg/100 g)	3.73±0.05	6.91±0.11	1.23±0.05	0.10

*Average of triplicate values reported

CD Critical difference

Table 4 Sensory quality characteristics of laddu

Food base	Attributes					
	Colour	Flavor	Texture	Taste	Appearance	Overall acceptability
Foxtail millet	8.5	6.8	7.0	7.6	8.2	7.7
Barnyard millet	8.5	7.9	8.2	7.8	8.5	8.4
Rice (control)	8.1	7.7	7.2	7.2	8.3	7.6
SEM ±	0.257	0.325	0.305	0.282	0.323	0.349
CD at 5%	0.74	0.94	0.88	0.82	0.93	1.01

*Average of fifteen values reported

S.Em Standard error of mean

CD Critical difference

barnyard millet has been observed to be significantly lower than the carbohydrate content of rice. The carbohydrate content was significantly different (at 5 % level of significance) in both millets and rice flour.

The energy content of foxtail millet flour, barnyard millet flour and rice flour was observed to be 349, 333 and 352 Kcal/100 g respectively. Significant difference was observed in energy content of these three grains (at 5 % level of significance). Thus, these millet grains has low calorie with higher content of nutrients like minerals, protein, fat, fibre etc. as compared to rice.

The calcium content of foxtail millet flour was observed to be 30.10 mg per 100 g and of barnyard millet, it was 23.16 mg/100 g (Table 3). Gopalan et al. (2007) reported the calcium content of barnyard millet as 20 mg/100 g. The calcium content of rice was found to be 9.96 mg/100 g. Yadav et al. (2007) reported the calcium content of milled rice as 10.0 mg /100 g. Foxtail millet, barnyard millet and rice were

Table 5 Sensory quality characteristics of halwa

Food base	Attributes					
	Colour	Flavor	Texture	Taste	Appearance	Overall acceptability
Foxtail millet	**8.9**	7.3	8.5	7.8	8.3	8.0
Barnyard millet	**8.3**	7.8	8.0	7.7	8.4	8.1
Rice (control)	8.0	8.3	8.8	8.6	7.9	8.7
SEM ±	0.337	0.270	0.365	0.375	0.281	0.327
CD at 5%	0.95	0.78	1.06	1.09	0.816	9.50

*Average of fifteen values reported

S.Em Standard error of mean

CD Critical difference

Table 6 Sensory quality characteristics of biryani

Food base	Attributes					
	Colour	Flavor	Texture	Taste	Appearance	Overall acceptability
Foxtail millet	**9.0**	9.1	8.9	9.1	8.9	9.0
Barnyard millet	**7.6**	7.6	7.7	7.4	7.0	7.3
Rice (control)	8.3	8.2	7.7	8.6	8.3	8.3
SEM ±	0.197	0.181	0.202	0.270	0.265	0.212
CD at 5%	0.57	0.52	0.58	0.78	0.76	0.61

*Average of fifteen values reported

S.Em Standard error of mean

CD Critical difference

significantly different in their calcium content (at 5 % level of significance). Foxtail millet and barnyard millet grains have approximately three and two times more calcium content than the calcium content of rice, respectively. Thus, it can be said that these millet grains contain higher calcium as compared to rice.

The iron content of foxtail millet flour was 3.73 mg/ 100 g, which is 0.93 mg higher than the value (2.80 mg) reported by Gopalan et al. (2007). The iron content of barnyard millet was found to be 6.91 mg /100 g which is close to the value of 7.31 mg/ 100 g reported by Mittal et al. (2004). The iron content of rice was 1.23 mg/100 g. Thus the result of present study is within the reported range. Yadav et al. (2007) reported the iron content of rice as 1.0 mg per 100 g. Comparing the value of iron i.e. 3.73 mg/100 g for foxtail millet and 6.91 mg/ 100 g rice, it was found that foxtail millet has 2.5 mg and barnyard millet has 5.68 mg/100 g more iron content as compared to rice. Iron content was significantly different among foxtail millet, barnyard millet and rice (at 5 % level of significance) (Table 4).

Food products namely, *halwa, laddu* and *biryani* were prepared by the method given in Figs. 1, 2 and 3. Sensory

Table 8 Nutrient composition of halwa

Food base	Foxtail millet	Barnyard millet	Rice
Protein (%)	1.89	1.26	0.99
Fat (%)	9.60	9.29	8.92
Fibre (%)	0.78	0.53	0.03
Carbohydrate (%)	30.70	30.61	32.00
Dietary Fibre (%)	3.9	1.6	0.44
Energy kcal/100 g	216	211	212
Calcium	5.6	4.2	1.8
Iron	0.73	1.27	0.22

quality evaluation of foxtail millet, barnyard millet and rice (control) food products viz. *laddu, halwa* and *biryani* was done using score card method. Regarding *ladoo*, shows a non significant difference in colour, flavor, texture, appearance and overall acceptability among *laddus* on foxtail millet, barnyard millet and rice (control). As per the evaluation proforma, all the sensory evaluation parameters of three types of *laddus* were observed to be good. For *halwa* all the sensory quality characteristics of control *halwa* viz., colour, flavour, texture, taste, appearance and overall acceptability were rated as good (Table 5). Non significant difference in colour, texture, taste, appearance and overall acceptability of *halwa* based on foxtail millet, barnyard millet and rice (control) were observed.

The data obtained on the sensory evaluation of the *biryani* 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. *Biryani* of all three different grains showed significant difference in colour and flavour. Barnyard millet and foxtail millet biryani showed significant difference (at 5 % level of significance) in all the sensory evaluation parameters (Table 6).

The nutritive value of formulated products was obtained by the calculation method. Nutrients were calculated per 100 g of cooked food product. The data on nutrient composition of *laddu* on cooked weight basis has been presented in Table 7.

Table 7 Nutrient composition of laddu

Food base	Foxtail millet	Barnyard millet	Rice
Protein (%)	5.00	3.41	3.04
Fat (%)	25.63	25.01	24.64
Fibre (%)	2.25	1.45	0.10
Carbohydrate (%)	62.90	64.00	68.40
Dietary fibre (%)	10.2	4.6	1.25
Energy kcal/100 g	503	495	68.40
Calcium(mg/100 g)	17.6	14.6	8.1
Iron(mg/100 g)	1.82	3.40	0.60

Table 9 Nutrient composition of biryani

Food base	Foxtail Millet	Barnyard Millet	Rice
Protein (%)	4.00	3.12	2.90
Fat (%)	7.06	6.75	6.31
Fibre (%)	1.67	1.52	0.79
Carbohydrate (%)	21.08	21.63	23.09
Dietary Fibre (%)	4.72	2.13	0.21
Energy kcal/100 g	163.86	159.75	160.75
Calcium	18.75	16.9	12.46
Iron	0.84	1.5	0.07

Foxtail and barnyard millet *laddu* had comparatively high protein content, 5.00 and 3.41 %, respectively compared to rice (control) *laddu* (3.04 %). Foxtail and barnyard millet based *laddu* had lower carbohydrate content. Foxtail millet, barnyard millet and control *laddu* have fat content of 25.63, 25.01 and 24.64 %, respectively and energy 503, 495 and 508 kcal/100 g, respectively. Crude fibre content of millet based *laddu* was also higher than control based *laddu*. Dietary fibre content of foxtail millet *laddu*, barnyard millet *laddu* and rice *laddu* was 10.2, 4.6 and 1.25 % respectively. Calcium content of foxtail millet *laddu* was higher (17.6 mg/100 g) followed by barnyard millet *laddu* (14.6 mg/100 g) and rice *laddu* (8.1 mg/100 g). Iron content of foxtail millet *laddu*, barnyard millet *laddu* and rice *laddu* was 1.82, 3.40 343 and 0.60 mg/100 g respectively.

Table 8 shows nutrient composition per 100 g of *halwa*. It was found that the protein content of foxtail and barnyard millet based *halwa* was higher that is 1.89 and 1.26 %, respectively than the rice (0.99 %). Control *halwa* had relatively high carbohydrate content. Carbohydrate in foxtail and barnyard millet *halwa* was observed to be 30.70 and 30.61 %, respectively. Fat content of foxtail millet, barnyard millet and control *halwa* was 9.60, 9.29 and 8.92 %, respectively. Dietary fibre of millet based *halwa* was higher than control *halwa*, which is 3.9, 1.6 and 0.44 % for foxtail millet *halwa*, barnyard millet *halwa* and rice *halwa*, respectively. Calcium content was also higher in millet based *halwa* than rice *halwa*. Iron content of foxtail millet, barnyard millet and rice *halwa* was 0.73, 1.27 and 0.22 mg/100 respectively.

In the current study it was found that the foxtail millet, barnyard millet and rice *biryani* had protein content of 4.00, 3.12 and 2.90 % and fat content of 7.06, 6.75 and 6.31 %, respectively. Control *biryani* had relatively low fibre content that is 0.79 % as compare to foxtail millet (1.67 %) and barnyard millet (1.52 %). Carbohydrate in foxtail and barnyard millet *biryani* was observed to be 21.08 and 21.63 % whereas control *recorded* 23.09 % of charbohydrate (Table 9). Dietary fibre of foxtail millet *biryani* was higher (4.72 %) than barnyard millet *biryani* and rice *biryani* (2.13 and 0.21 %, respectively). Calcium content of foxtail millet, barnyard millet and rice *biryani* was 18.75, 16.9 and 12.46 mg/100 respectively. Iron content was 0.84, 1.5 and 0.07 mg/100 respectively for foxtail millet, barnyard millet and rice *biryani*.

Conclusion

In the present study it was found that the millet based food products were acceptable as rice (control) food products. Foxtail millet *biryani* was more acceptable and was rated highest score for colour, appearance, texture, taste, appearance and overall acceptability as compared to rice *biryani*. *All the millet food products* had higher content of protein, fat and fibre as compared to rice (control) products. It was also found that millet based products viz., *laddu, halwa* and *biryani* was not only acceptable as rice products but also having good nutritional value regarding dietary fibre and major minerals like calcium and iron. This makes these products nutritionally more superior than rice products.

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