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Efficacy of barnyard millet and quinoa in substituting conventional rice cuisine

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Abstract
Rice is one of the staple and very popular cuisine in many parts of the world. But it is in common practice nowadays to avoid rice in diabetic diet because of its high glycemic index. In this regard, efforts has been made to explore efficacy of underutilized grains such as barnyard millet and quinoa as rice substitute. Among millets, barnyard millet is known for its high dietary fiber and iron content while quinoa is widely recognized for its rich protein content of high biological value and excellent balance of essential amino acids. Both the grains were studied for various quality parameters such as physical properties, cooking qualities and were thereafter cooked in a same way as cooking rice traditionally. Rice formulated using barnyard millet and quinoa was subjected to sensory analysis and owing to their wonderful organoleptic attributes, both products showed good acceptability which indicate their high potential to be utilized as rice substitute.

Keywords: barnyard millet, quinoa, diabetes, rice, cooking qualities, organoleptic properties

1. Introduction

Millets are ancient super grains belonging to family *Poaceae*. Barnyard millet (*Echinochloa frumentacea*) is one of the oldest minor millet known to mankind. It is mainly grown in China, India, Japan, Nigeria, Euthopia and Nepal. India is the largest producer of barnyard millet in the world with production of 0.147 mt during the last 3 years (IIMR, 2018) [8]. Maximum state wise average yield of barnyard millet was highest in Uttarakhand i.e. 1138kg/h for the variety PRJ-1 (Directorate of Millet Development, 2014) [5]. The nutritional profile of barnyard millet is superior to most of the commonly consumed cereals. It is known for its rich dietary fibre, minerals especially iron, protein and some essential amino acids content. Ugare *et al.* (2014) [30] reported dietary fibre as 12.6% in barnyard millet with appreciable amounts of soluble (4.2%) and insoluble fractions (8.4%). Thathola and Srivastava (2010) [29] found 31.73% of total dietary fibre in raw barnyard milet of which 21.98% was insoluble and 9.75% was soluble. The iron content of barnyard millet is 17.47 mg/100 g which can fulfill daily requirement of iron to great extent (Kumar *et al.*, 2018) [12].

Quinoa is one of the oldest crops belonging to the family *Chenopodiaceae* and has been cultivated in Andean regions of South America since 5000 B.C. It has demonstrated good yield and productivity under wide range of climatic stresses such as severe drought, reflecting its resistance for adverse environmental factors. Studies indicate that high seed quality and a yield level which is equivalent to that obtained from Andes region can be achieved in varied zones globally (Mujica *et al.*, 2001) [16]. Due to rapidly growing interest in quinoa worldwide it has now come out from its native boundaries of Andean region and has been introduced in various other continents such as Europe, North America, Asia and Africa. It is considered as a mother grain and a sacred herb by humans due its high level of protein and excellent balance of essential amino acids.

Pertaining to the excellent nutritional profile of barnyard millet and quinoa, many studies have shown their therapeutic benefits in prevention and treatment of chronic diseases like diabetes, dyslipidemia, obesity, celiac disease, lactose intolerance and osteoporosis. Therefore their usage as a main ingredient in development of food products is increasing day by day. Studies have shown their utilization in formulation of various conventional and non conventional products like buns, biscuits, pastries, cakes, cookies, muffins, noodle, extrudates, etc. (Wang and Zhu, 2016; Verma, *et al*., 2015; Goswami *et al*., 2015) [35, 33, 6].

Rice is popular staple cereal and an important part of Indian meals. India is top most producer of rice and contributes to about 20% of total rice production in the world. But its high glycemic index imposes limitation in diet of diabetic people.

On the other hand super grains like barnyard millet and quinoa have relatively low and slowly digestible carbohydrate content making them low glycemic index food. Moreover, their high dietary fiber content helps in regulation of increased blood glucose levels in diabetic people. One of the key point that barnyard millet and quinoa holds is that they both are cooked similar to traditional method of cooking rice and are consumed in rice form in their respective native regions (Sezgin and Sanlier, 2019; Yabuno, 1987; Joshi and Srivastava, 2016) [26, 40, 9]. Their unique aroma and health benefits make them suitable substitution of traditional rice for diabetic diet.

2. Material and Methods

The present study has been carried out in the Department of Foods & Nutrition, College of Home Science, G. B, Pant University of Agriculture and Technology, Pantnagar, India. For product development, local cultivar of barnyard millet (*Echinochloa frumentacea*) was procured from Almora district, Uttarakhand. Quinoa seeds (*Chenopodium quinoa* Willd.) were procured online from Organic India Pvt. Ltd.

2.1 Physical property of barnyard millet and quinoa

Thousand kernel weight, thousand kernel volume, hydration capacity and swelling capacity were determined by the method given by Williams *et al.* (1983) [37]. Bulk density was determined by method given by Narain *et al.* (1978) and was expressed as g/cc while true density was calculated by dividing thousand kernel mass from thousand kernel volume of a sample. It is expressed in g/ml. Pericarp colour of the barnyard millet and quinoa grain was determined using Munsell Soil Colour Chart (1954) [17]. The figures of hues and values were matched with the chart and equivalent colour was recorded. All the estimations were done in three replicates.

2.2 Processing of grains: The grains of barnyard millet and quinoa were cleaned free of dust, stones, grits and chaff. These were thoroughly washed 3-4 times under running water and then dried in oven at 50°C for 5-6 hours. Cleaned grains were subjected to pearling using Vivek Mandua Thresher cum Pearler, to remove outer most husk layers. Thereafter, pearled grains were stored in clean airtight containers at room temperature for further analysis.

2.3 Cooking quality of barnyard millet and quinoa

All the cooking parameters were analyzed in triplicate. Swelling power was determined using method given by Schoch (1964) [24]. Water uptake ratio was evaluated using the method given by Oko *et al.* (2012) [21]. Increase in weight after cooking was analyzed using procedure Ugare (2008) [30]. Cooking loss was determined by method of cooking sample in boiling water bath and weighing filtrate after drying as per the procedure given by IRRI (1981). Cooking time was determined by parallel plates method given by Ugare (2008) [30] with slight modification given by Bhattacharya and Sowbhagya (1971) [3]. Gelatinization temperature was determined by Chandra and Samsher (2013).

2.4 Formulation of rice from barnyard millet and quinoa.

Barnyard rice and quinoa rice were developed using a same procedure of conventional method of cooking rice. Pearled barnyard and quinoa grains were soaked in water for 30 min separately. Soaking is known to enhance cooking quality and remove bitterness of saponin content in quinoa grains (Demir and Bilgiçli, 2020; Pineli *et al*., 2015). Amount of water and cooking time used were based on previously conducted trials for product standardization.

Soak pearled barnyard millet /quinoa in excess water for 30 min

⇓

Keep close lid vessel on flam

⇓

Add 150 and 250 ml of water in barnyard millet and quinoa, respectively

⇓

Cook barnyard millet and quinoa for 13 and 20 min, respectively.

2.5 Sensory evaluation of barnyard millet and quinoa rice

Sensory analysis of barnyard millet and quinoa rice was done using score card method and nine point Hedonic scale (Amerine *et al.*, 1965) [1]. Sensory evaluation was done by a panel of 15 semi-trained members from the Department of Foods and Nutrition, College of Home Science, G.B.P.U.A &T, Pantnagar with no food allergies and diseases. The panelists were presented the samples along with a glass of water to rinse their mouth.

2.6 Statistical analysis

For simple statistical applications such as mean, standard deviation (SD), standard error (S.Em) and percentages Microsoft excel programme was used. One way ANOVA was used to determine significant difference among treatment for physical, cooking and sensory parameters using online available software "Agri -Stat".

3. Results and Discussion

3.1 Physical properties of barnyard millet and quinoa

Thousand kernel weight, thousand kernel volume, hydration capacity, swelling capacity, bulk density and true density of barnyard millet and quinoa were 3.47 g, 3.80 ml, 0.63g, 2.09 ml, 0.85g/cc and 0.91g/ml and 2.59g, 2.84 ml, 0.86 g, 5.04 ml, 0.72 g/cc and 0.90 g/ml, respectively. Significant differences were obtained between all parameters except for true density (Table 1). Pale brown and pale yellow color was found for pericarp color of barnyard millet and quinoa, respectively. The results obtained for physical properties of barnyard millet were well within the range given by Nazni and Devi (2016) [19]; Manimekalai *et al.* (2018) [14]; Shrestha (2017) [27], Veena *et al.* (2005) [32] and Tamaka (2019) [28]. Approximate results for quinoa in context to physical properties were also reported by Wang *et al.* (2020) [35]; Bhargava *et al.* (2006) [2]; Wu *et al.* (2014) [37]; Gargiulo *et al* (2019); Ogungbenle (2003) [20] and Vilche *et al.* (2003) [34].

Table 1: Physical properties of barnyard millet and quinoa

S. No.	Physical properties	Barnyard millet	Quinoa	C.V	CD at 5%
1	Thousand kernel weight (g)	3.47^{a}±0.20	2.59^{b}±0.17	8.03	0.85
2	Thousand kernel volume (ml)	3.80^{a}±0.19	2.84^{b}±0.11	1.70	0.19
3	Hydration capacity (g)	0.63^{a}±0.03	0.86^{b}±0.01	4.83	0.13
4	Swelling capacity (ml)	2.09^{a}±0.06	5.04^{b}±0.07	1.49	0.19
5	Bulk density (g/cc)	0.85^{a}±0.01	0.72^{b}±0.01	1.04	0.03
6	True density(g/ml)	0.91^{a}±0.03	0.90^{a}±0.02	4.71	-
7	Pericarp color	Pale brown	Pale yellow	-	-

All results are mean±SD for three individual determinations
CV- coefficient of variance, CD – critical difference

Different alphabets in superscript in each row show significant difference between values

3.2 Cooking quality of barnyard millet and quinoa

The results obtained for cooking quality of grains taken under study are shown in Table 2. Swelling power of quinoa was significantly higher than that of barnyard millet (3.05 g/g) and was found to be 19.75 g/g. Swelling power is the important functional property of starch that is well related to quality and texture of food products and it is considered as a desirable characteristic in rice cooking which affects the acceptability of end product to a great extent (Kaur *et al.,* 2011) [11]. Significant difference was found for water uptake ratio of barnyard millet and quinoa and was found to be 223.33 and 328%, respectively. Increase in weight after cooking for barnyard millet was found to be 135.33% while for quinoa was 212%. Increase in weight indicates the amount of water that is absorbed and is therefore an index for the swelling ability of the product (Schoenlechner *et al.,* 2010) [25]. Cooking loss in barnyard was 4.01% whereas in quinoa, it was 1.49%. Cooking loss has been reported to improve firmness, but decrease juiciness of the product (Rousset *et al.*, 1995) [23]. Cooking time of barnyard millet was found to be 13 min which was similar to cooking time reported by Joshi (2016) [9]. Cooking time of quinoa was found as 20 min. Higher the protein content, higher would be cooking time of grains (Mohapatra and Bal, 2006) [15]. According to Wu *et al.*, (2017) [38], cooking time of quinoa varied from 11.9 min in ‘Col.#6197’ to 19.2 min in ‘Black’ cultivar. The gelatinization temperature of barnyard millet (77.82 ºC) had significantly higher value than quinoa (67.11 ºC) in present study. In other studies done by Nazni and Devi (2016) [19]; Joshi (2016) [9]; Veena *et al.* (2005) [32] and Wu *et al.* (2017) [38]; Schoenlechner *et al.* (2010) [25] approximate results were reported for cooking qualities of barnyard millet and quinoa, respectively. Differences in cooking qualities between grains could be attributed to differences in proportion of crystalline and amorphous areas in the starch granules and amount of amylose- lipid proportion which are the major cause of variation in cooking properties of grain (Lawal, 2004) [13].

Table 2: Cooking quality of barnyard millet and quinoa

S. No.	Cooking quality	Barnyard millet	Quinoa	C.V	CD at 5%
1	Swelling power (g/g)	3.05^{a}±0.07	19.75^{b}±0.36	2.26	0.91
2	Water uptake ratio (%)	223.33^{a}±1.53	328^{b}±6.56	1.32	12.75
3	Increase in weight after cooking (%)	135.33^{a}±3.05	212^{b}±10.53	4.16	25.38
4	Cooking loss (%)	4.03^{a}±0.07	1.49^{b}±0.05	2.42	0.23
5	Cooking time (min)	13^{a}±1.00	20^{b}±1.00	7.42	4.30

All results are mean±SD for three individual determinations
CV- coefficient of variance, CD – critical difference
Different alphabets in superscript in each row show significant difference between value

3.3 Sensory quality of rice from barnyard millet and quinoa using score card method and nine point Hedonic scale

Non significant differences were found between sensory parameters of rice developed using barnyard millet and quinoa and both products were highly acceptable with overall acceptability score of 7.9 (Table 3) and were liked very much by sensory panel members (Table 4). The value of overall acceptability score for barnyard millet rice and quinoa rice obtained under study falls near to results reported for two cultivars of rice (8.2 for “ swarna” cultivar and 8.1 for “ Mahsuri” cultivar) by Joshi (2020) [9] using score card method.

Table 3: Sensory quality of rice from barnyard millet and quinoa using score card method

S. No	Characteristic	Barnyard rice	Quinoa rice	S.Em	CD at 5%
1	Colour	7.9^{a}±0.52	7.9^{a} ±0.67	0.24	0.68
2	Aroma	7.7^{a}±0.82	7.8^{a} ± 0.63	0.22	0.63
3	Taste	7.7^{a} ±0.73	7.8^{a} ±0.56	0.19	0.55
4	Appearance	7.8^{a} ±0.51	7.9^{a} ±0.48	0.22	0.64
5	Overall acceptability	7.9^{a} ±0.52	7.9^{a} ±0.67	0.24	0.68

All results are mean±SD for three individual determinations
S.Em –Standard error of mean, CD – critical difference
Similar alphabets in superscript in each row show non significant difference between values

Table 4: Sensory quality of rice from barnyard millet and quinoa using nine point Hedonic scale

S. No.	Food product	Mean ±SD	Preference
1	Barnyard rice	7.9 ^{a} ±0.67	Like very much
2	Quinoa rice	7.9 ^{a} ±0.52	Like very much
	S. Em	0.25	
	CD at 5%	0.69	

All results are mean±SD for three individual determinations
S.Em –Standard error of mean, CD – critical difference
Similar alphabets in superscript in each column show non significant difference between values

4. Conclusion
Keeping in mind the acceptability for barnyard millet and quinoa rice obtained in present study, it can be a good substitute for traditional rice. The preparation method for barnyard and quinoa rice formulation is easy and same as that of conventional procedure of rice cooking thus doesn't involve any extra efforts while cooking. Moreover, conventional rice has poor nutritional value and high glycemic index in comparison to barnyard millet and quinoa, so use of these underutilized nutritious and low GI value grains as rice substitute can be a boon for diabetic people.

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