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Physical, functional properties and nutritional composition of Kodo millet and Red rice

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Abstract
Physical properties are necessary for design of different machineries to store and transport grains from one place to another, with the knowledge of physical, chemical, functional properties of red rice and kodo millet may help to develop different food products with high nutritional value, which may help the food industries to satisfy the consumer needs. The physical properties like 1000 kernel weight, 1000 kernel volume, bulk density and functional properties like hydration capacity, swelling capacity, hydration index and swelling index, proximate composition of kodo millet and red rice were discussed to boost the knowledge and to develop the new machineries.

Keywords: 1000kernel weight, 1000kernel volume, swelling capacity, hydration index

Introduction
Millets are cereal crop plants in the *Gramineae* grass family. The term millet refers to a group of small seeded annual grasses belonging to five genera: *Panicum*, *Setaria*, *Echinocloa*, *Pennisetum*, and *Paspalumin* the tribe. *Paniceae* and *Eleusine*, both in the *Chlorideae* tribe. They have been cultivated since the beginning of time. There are approximately 6,000 millet varieties grown worldwide. Many developed countries underutilize millets. Millet grains have enormous potential for processing into value-added foods (Chandrasekara and Shahidi, 2010) [2].
Millets are rich source of dietary fibre, phytochemicals, micronutrients and nutraceuticals; hence they are termed as "Nutri-cereals". Because of their protein, fatty acids, minerals, vitamins, dietary fibre and polyphenols content. Their protein is high in essential amino acids, particularly sulphur-containing amino acids (cysteine and methionine). They are abundant in antioxidants such as phenolic acids and glycated flavonoids.
One of the oldest grains in the world is kodo millet (*Paspalum scorbiculatum*). Originated from Africa and domesticated in India few thousand years ago and it is a draught resistant plant. *Paspalum scorbiculatum* belongs to the family *Poacea* and is cultivated in arid and semi-arid regions of African and Asian countries. In India, Kodo millet is grown mostly in the Deccan region and the cultivation extends to the foothills of Himalayas. It is a hardy crop that is drought tolerant and can survive on marginal soils where other crops may not survive, and can supply 450–900 kg of grain per hectare. It is commonly known by several names, such as Arka (Kannada), Kodra (Hindi), Arikelu (Telegu), Varagu (Tamil), Varak (Malayalam) and Bajra (Punjabi). It is grown in India from Kerala and Tamil Nadu in the south to Rajasthan, Uttar Pradesh and West Bengal in the north.
Paspalum scorbiculatum grain is composed of 8% protein. The major protein fraction in kodo millet is glutelin (Sudharshana *et al.*, 1988) [11]. Kodo millet is an excellent source of fiber (9%), as opposed to rice (0.2%), and wheat (1.2%). Kodo millet contains 66.6 g of carbohydrates and 353 kcal per 100g of grain, comparable to other millets. It also contains 1.4% fat and 2.6% minerals. The iron content in kodo millet ranges from 25.86 ppm to 39.60 ppm). Kodo millet has good DPPH quenching capability as it required only 18.5 µl for 50% quenching as compared to 0.946 µmol/ml of Vitamin C and 0.348 µmol/ml Vitamin E to achieve the same (50% DPPH quenching).
Nearly half of the world's population eats rice (*Oryza sativa* L.), a staple grain that is primarily consumed as a source of protein and carbohydrates. For Asians, rice is a symbol of food and is referred to as the grain of life. It has a medicinal value as well, which was fully understood by the medical systems centuries ago, in addition to being a staple food and an essential component of social rites, rituals, and festivals in practically all Asian countries.

The pigmented rice contains phenolic compounds especially anthocyanin that also act as a colour pigment. The anthocyanin compounds in rice are in the form of cyanidin-3-O-glucoside, peonidine-3-O-glucoside and their derivatives (Escribano *et al.*, 2004; Wang *et al.*, 2008) [4, 12]. Anthocyanins have been recognized as nutritious functional food ingredients, located in outer layers of the rice kernel which possess antioxidant activity, anticancerous, hypoglycemic and have anti-inflammatory effects.

Coloured rice (black and red) consumption is rapidly growing due to their healthy functional food ingredients. However, fortification of this paddy with iron and other micronutrients to prevent malnutrition has to be attempted. This could be an optimal approach to reduce the high prevalence of iron deficiency anaemia (Cook and Reusser, 1983) [3]. Red rice contains 12.7% of moisture content, 1.81% of fat content, 2.71% of fibre content, 10.49% protein, 70.19% of carbohydrates along with micro nutrients like iron and zinc at 5.5 and 3.3 mg/100 g respectively (Raghuvansh *et al*. 2017) [7].

Materials and Methods

Procurement of raw materials: The major Raw material, red rice and kodo millet were procured directly from the Regional Cooperative Organic Farmer's Association Federation Limited, Davanagere, Karnataka, India.

Methodologies

Thousand kernel weight: Thousand kernel weight was determined using the method given by Williams *et al*. (1983) [13]. One thousand sound seeds were counted and weighed using an electronic balance. 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) [13]. 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 the difference between final volume and initial volume.

Bulk Density: The ratio between the weights of thousand grains to its volume was calculated as bulk density (Hadimani and Malleshi, 1993) [6].

Hydration capacity and Hydration index: The hydration capacity of thousand kernel millet rice and red rice grains was calculated as the difference in weight of grains after soaking for 24 hours. It was expressed as weight per gram (Williams *et al*. 1983) [13]. In this method, randomly selected thousand kernel millet grains were soaked in distilled water (1:10 w/v) under ambient conditions. Hydration index was calculated by using the formula given by (Kantha *et al*., 1986) [5].

$$\text{Hydration index} = \frac{\text{Hydration capacity per 1000 seeds}}{\text{Original dry weight of 1000 grain}} \times 100$$

Swelling capacity and Swelling index: The swelling capacity of grains was assessed by the methods given by (Williams *et al*. 1983) [13]. The soaked seeds were blot dried, to remove the superfluous water and transferred to a measuring cylinder containing known volume of water. The change in volume was recorded and swelling capacity was calculated. Swelling index of grains was calculated as described by (Kantha *et al*., 1986) [5] using the formula.

$$\text{Swelling index} = \frac{\text{Swelling capacity per 1000 seed}}{\text{Seed volume per 1000 seeds}} \times 100$$

Nutrient composition of red rice and Kodo millet

Proximate composition like moisture content, protein, fat, crude fibre, ash content and for optimized product were determined by the method given by AOAC (1980) [1] and carbohydrates using difference method and presented in the table 2.

Results and Discussion

The physical parameters and functional properties of kodo millet and red rice are presented in Table 1.

The thousand kernel weight, thousand kernel volume, and bulk density of kodo millet rice were found to be 3.5 g, 3 mL and 1.16 g/mL respectively. Sharma, S.K. and Mandhyan, B.L. (1992) [9] reported that kodo millet's thousand kernel weight and volume as 3.0 g and 2.4 mL, respectively, whereas Srilekha *et al*. (2019) [10] reported kodo millet's bulk density as 0.68 g/mL.

Red rice has a thousand kernel weight of 28.5 g, thousand kernel volume of 22 mL and bulk density of 1.29 g/mL. Raghuvansh *et al*. (2017) [7] reported thousand kernel weight and thousand kernel volume and bulk density of red rice as 18.3 g, 20 mL and 0.82g/L respectively.

The hydration capacity, hydration index, swelling capacity, and swelling index of kodo millet were determined to be 2.29 g/1000grains, 65%, 4 mL/1000 grains and 133% respectively (Table.1). These results were consistent with the proso millet published values of 5.53 g/1000 grains, 118.41%, 4.05 mL/1000 grains, and 114.20% by Sarojini *et al*. (2021) [8].

Functional properties of red rice such as hydration capacity, hydration index, swelling capacity and swelling index were found to be 8.85 g/1000 grains, 31%, 29 mL/1000 grains and 131% respectively (Table. 1). These findings were in accordance with the reported values of 0.347 g/100 seeds, 19%, 1.6 mL/100 seeds and 141% by Raghuvansh *et al*. (2017) [7].

Table 1: Physical and functional properties of kodo millet and red rice

Parameters	Kodo millet	Red rice
1000 kernel weight (g)	3.5	28.5
1000 kernel volume (mL)	3	22
Bulk density (g/mL)	1.16	1.29
Hydration capacity (g/1000 grains)	2.29	8.85
Hydration index (%)	65	31
Swelling capacity (mL/1000grains)	4	29
Swelling index (%)	133	131

Proximate composition of kodo millet and red rice

Table 2 gives the relative composition of red rice and kodo millet in terms of moisture content, protein, fat, crude fibre, ash and carbohydrates.

The moisture content of kodo millet rice and red rice were found to be 11.92 and 12.80 percent, respectively. kodo millet was found to contain protein, fat, crude fibre, ash and carbohydrate content of about 11.52, 2.89, 1.85, 1.22 and 70.60 percent, respectively and the corresponding values for

red rice were found to be 10.50, 1.92, 2.71, 1.43 and 70.19 percent, respectively.

The moisture content of kodo millet grain was reported as 11.92 percent. Similarly, Devi (2012) reported 11.98 percent moisture content in kodo millet and moisture content of red rice was found to be 12.9 percent. This reading is in consistent with the reported value of 12.7 percent by Raghuvansh *et al*. (2017) [7].

According to the current study, kodo millet has roughly 11.92, 2.89, 1.85, 1.22 and 70.60 percent of each of the following nutrients: protein, fat, crude fibre, ash and carbohydrates. These results are in line with the Devi (2012), who discovered that the contents of protein, fat, crude fibre, ash, and carbohydrates were, respectively about 11.48, 2.85, 1.83, 1.25 and 70.61 percent.

The protein, fat, crude fibre, ash, and carbohydrate content of red rice were found to be approximately 12.8, 1.92, 2.89, 1.43 and 70.46 percent, respectively, in the current study. These findings are consistent with those reported by Raghuvanshi *et al*. (2017) [7], who found that protein, fat, crude fibre, ash, and carbohydrate content were approximately 10.49, 1.81, 2.71, 1.55 and 70.19 percent, respectively.

Table 2: Proximate composition of kodo millet and red rice

Nutrients	Kodo millet (%)	Red rice (%)
Moisture	11.92	12.80
Protein	11.52	10.50
Fat	2.89	1.92
Crude fibre	1.85	2.71
Ash	1.22	1.43
Carbohydrate	70.60	70.19

Conclusion

The present study was conducted to boost the knowledge of physical, functional, nutrient composition of red rice and kodo millet grains, by knowing all the engineering properties of red rice and kodo millet grain can induce the knowledge in the development of different transport facilities, and also in the development of new machineries, which may in turn help the different food industries to develop new technologies to process the other similar type of grains and this may lead to decrease the dependency of the labours and increases automation in the field of food industries.

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