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Evaluation of physical, functional and nutritional quality parameters of kodo millet flour

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Abstract
Evaluation of quality characteristics of millets help in development and promotion of millet based products. Evaluation of physical and functional properties revealed that bulk density, rehydration ratio, water activity, water holding capacity, water absorption index and water solubility index was 0.68 ± 0.00 g/ml, 2.14 ± 0.07%, 0.48 ± 0.00, 0.53 ± 0.00, 8.00 ± 0.00 g/100g and 8.06 ± 0.02 g/100g respectively. Water activity and rehydration ratio were within the acceptable range indicating good storage stability, freshness. The nutritional composition of kodo millet flour was moisture, protein, fat, ash and crude fiber, carbohydrate, energy, vitamin C, dietary fiber, in vitro protein digestibility and per cent radical scavenging activity was 9.64 ± 0.13%, 7.60 ± 0.1%, 1.24 ± 0.15%, 1.39 ± 0.05% and 4.06 ± 0.03%, 76.04 ± 0.12%, 345.77 ± 0.9 K. Cal/100g, 0.67 ± 0.12 mg/100g, 14.78 ± 0.11 g/100g, 74.58 ± 0.35 and 55.22 ± 1.60% respectively.

Keywords: Millets, food security, nutritional security, climate smart, antioxidants, malnutrition

Introduction
Modern world is burdened with large number of inevitable troubles like ever growing population, reduction of area under cultivation, reduced fertility of soils, increased rate of metabolic disorders and dual burden of malnutrition. In this context, several novel research strategies in agricultural sector came into existence i.e., usage of high yielding varieties, synthetic fertilizers and farm mechanization which resulted in sufficient food availability (Kumar *et al*., 2018) [1]. Drastic climatic changes and reduced irrigation facilities are heading to increase the percent of dry lands and posing threat to food production and subsequently food and nutritional security. 40% of the global land surface is dry land and 78% dry land expansion is expected to occur in developing countries by 2100 (Huang *et al*., 2016) [2].
Hence, focus should be shifted to find sustainable solution that quench's world hunger and improve the quality of life. Role millets cannot be overlooked in achieving sustainable food and nutritional security. International crops research institute for the semi-arid tropics (ICRISAT) is focusing on increasing the productivity of millets and has included finger millet (*Eleucine corcana*) as sixth mandatory crop (ICRISAT, 2017) [3].

Materials and methods
The word millet is derived from the French word "mille" which means thousand, implying that a handful of millet contains thousands of grains (Taylor *et al*., 2008) [4]. Millets are group of small seeded grasses popularly grown as cereal crops for food or fodder. Millets are often known as coarse grains or poor people's crops. Millets have been in the cultivation in the East Asia for about 10,000 years. Sorghum, pearl millet, finger millet, foxtail millet, kodo millet, proso millet, barnyard millet and little millet are commonly cultivated millets in India (Rao *et al*., 2017) [5].
Millets are important nutritional bio sources due to its richness in starch, protein, fiber, niacin, magnesium, phosphorus, manganese, iron, potassium, essential amino acids and vitamin E. In addition to being as a good source of nutrients, millets have various therapeutic benefits such as prevention of heart diseases, diabetes, migraine, cancer and gastro intestinal diseases (Das *et al*., 2016) [6].
In the recent years minor millets have gained the attention due to their ability to grow in poor soil and adverse climatic conditions. They provide nutritious grain and fodder in a short span of time (Michaelraj *et al*., 2013) [7]. Hence, Minor millets play food based approach for achieving food, nutritional security and also address life style disorders.
Kodo millet (*Paspalum scrobiculatum*) is one among the minor millets also known as avaragu, haraka and arakalu, is widely grown in damp habitats of tropic and sub tropics of the world. In India it is widely grown in Uttar Pradesh, Tamilnadu and Kerala (Rao *et al*., 2017) [5].

Kodo millet has around 11% protein and is found to superior to other cereals in terms of dietary fiber and antioxidant potential (Patil *et al*., 2014) [8].
Hence evaluation of quality of millets would help understanding, diversifying the usage the millets in ensuring food, nutrition security in the ever changing modern world.

Materials and methods: Kodo millet grains were procured from local market of Hyderabad, Telangana, India. Grains were cleaned and milled. Flour was used to assess the quality.

Physical and functional properties of kodo millet flour:
The bulk density of samples was determined by procedure given by Stojceska *et al*. (2008) [9] and calculated using below formula.

$$\text{Bulk density} = \frac{W_2 - W_1}{\text{Volume (ml)}}$$

Rehydration ratio of the samples was estimated by procedure given by Haleem *et al*. (2014) [10]. Water activity of samples was determined according to the procedure given by Abramovic *et al.* (2008) [11]. Water holding capacity of samples was determined by the procedure given by Traynham *et al*. (2007) [12] and Ettoumi *et al*. (2015) [13] using below formula.

$$\text{WHC} = \frac{(\text{Wt of the bottle after decanting} - \text{Wt of dry bottle}) - \text{sample weight (g)}}{\text{Sample weight (g)}}$$

Water absorption index of the samples was analyzed by the procedure given by Thilagavathi *et al*. (2015) [14] using below formula.

$$\text{WAI (g/ 100g)} = \frac{\text{Weight of sediment}}{\text{Weight of sample}}$$

Water solubility index of the samples was assessed by following the procedure given by Thilagavathi *et al*. (2015) [14] using below formula.

$$\text{WSI (\%)} = \frac{\text{Weight of dissolved solid in supernatant}}{\text{Sample weight (g)}} \times 100$$

Nutritional properties of kodo millet flour
Moisture content of sample was analyzed by the standard procedure of AOAC, (2005) [15]. Protein content of the sample was analyzed by the standard procedure of AOAC, (2005) [16]. Fat content of the sample was analyzed by the standard procedure of AOAC, (1997) [17]. Ash content of the sample was analyzed by the standard procedure of AOAC, (2005) [15] using Centex digital muffle furnace. Crude fiber content of the sample was analyzed by the standard procedure of AOAC, (1990) [18]. Carbohydrate and energy content of the sample was computed by the standard procedure of AOAC, (1980) [19] Dietary fiber of kodo millet flour was analyzed by the standard procedure of AOAC, (1995) [20] and Vitamin C content of the sample was analyzed by the standard procedure of AOAC, (2000) [21]. In vitro protein digestibility of sample was estimated as per Schecterle and Pollak (1973) [22]. Antioxidants of sample were analyzed by the procedure given by Dorman *et al*. (2004) [23].

Results and Discussion
Physical and functional properties of kodo millet flour
Physical and functional properties such as, bulk density, rehydration ratio, water activity, water holding capacity, water absorption index, water solubility index were discussed in figure:1.
The bulk density of kodo millet flour was 0.68 ± 0.00 g/ml. Gull *et al*. [24] reported similar results with respect to bulk density in finger millet flour. Rehydration characteristics are usually used as the index for quality of the dried foods. The rehydration ratio of kodo millet flour was 2.14 ± 0.07%. Water activity of kodo millet flour was 0.48 ± 0.00, indicating high microbial stability as Haleem *et al*. (2014) [10] reported that the activity of all microorganisms would be inhibited at a water activity level less than 0.6. Traynham *et al*. (2007) [12] stated that, water holding capacity is the ability of a protein matrix to absorb and retain bound, hydrodynamic, capillary, and physically entrapped water against gravity. A water holding capacity of 0.53 ± 0.00 was seen kodo millet flour. Water absorption index and water solubility index of kodo millet flour was 8.00 ± 0.00 g/100g and 8.06 ± 0.02 (g/100g). The water absorption and water solubility indices of the present investigation were similar with the results reported by Thilagavathi *et al*. (2015) [14].

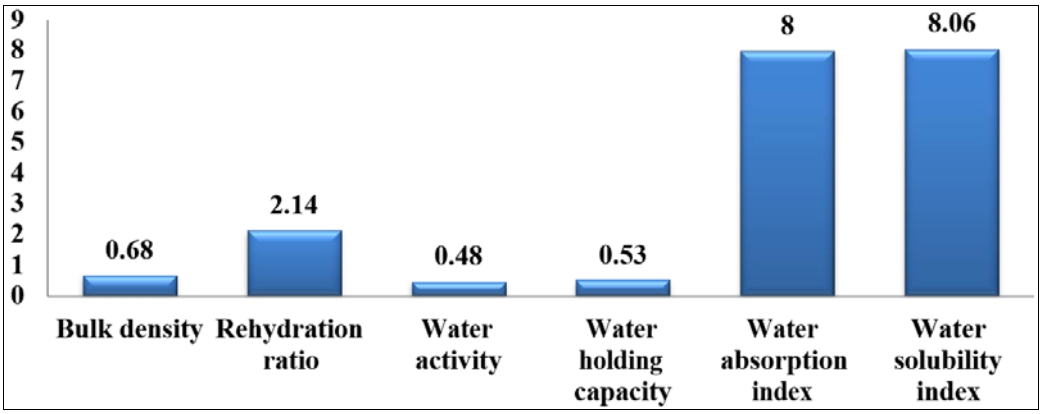

Fig 1: Physical and functional properties of kodo millet flour

Nutritional properties kodo millet flour
Nutritional properties of kodo millet flour were presented in the table 1.
The moisture content of kodo millet flour was 9.64 ± 0.13%, protein was 7.60 ± 0.1%, fat was 1.24 ± 0.15%, ash was 1.39 ± 0.05% and crude fiber content was 4.06 ± 0.03%. Moisture, protein, fat, ash and crude fiber content of kodo millet flour of present investigation were found to be similar to results of kodo millet flour reported by Thilagavathi *et al.* (2015) [14]. The carbohydrate and energy content of kodo millet flour was

76.04 ± 0.12 g/100g and 345.77 ± 0.9 K. Cal/100g respectively and were found to be in similar with the results reported by Devi (2012) [25]

Wakeel. (2007) [26] declared that dried products containing moisture content less than 10% indicate a good keeping quality. Hence it was clear that moisture content of the flour was with in the acceptable range and indicates a good keeping quality.

Vitamin C content of kodo millet flour was 0.67 ± 0.12 mg/100g. The dietary fiber content of kodo millet flour was 14.78 ± 0.11 g/100g indicating that kodo millet is superior to many cereals and plays important role in managing life style disorders.

The in vitro protein digestibility of kodo millet flour was 74.58 ± 0.35%. It was found that in vitro protein digestibility of kodo millet flour was found to be similar to yellow and white varieties of foxtail millet (Mohamed *et al.*, 2009) [27].

Per cent radical scavenging activity of kodo millet flour was found to be 55.22 ± 1.60.

Table 1: Nutritional properties of kodo millet flour

Nutritional parameter	kodo millet flour
Moisture (%)	9.64 ± 0.13
Protein (%)	7.60 ± 0.10
Fat (%)	1.24 ± 0.15
Ash (%)	1.39 ± 0.05
Crude fiber (%)	4.06 ± 0.03
Carbohydrates (%)	76.04 ± 0.12
Energy (K. Cal/100g)	345.77 ± 0.9
Vitamin C (mg/ 100g)	0.67 ± 0.12
Dietary fiber (g/100g)	14.78 ± 0.11
In vitro protein digestibility (%)	74.58 ± 0.35
Antioxidant capacity %	55.22 ± 1.60

Values are mean ± standard deviations

Conclusion

Quality of kodo millet with respect to nutrient composition and other phyto-chemicals was found to be superior to other cereals; hence increasing the consumption of kodo millet would play food based approach to attain food and nutritional security. Diversifying millet consumption through new product development and promotion could be climate smart strategy for enhancing nutritional and health status of community.

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