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Elucidation of physical grain traits and antinutritional constraints in Kodo millet (*Paspalum scrobiculatum* L.) Germplasm

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Abstract

The present investigation entitled “Elucidation of Physical Grain Traits and Antinutritional Constraints in Kodo Millet (*Paspalum scrobiculatum* L.) Germplasm” was carried out in the laboratory of the Department of Biochemistry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh (India). Ten germplasm along with one check variety (KK-1) were evaluated in a Completely Randomized Design (CRD) for physical and antinutritional parameters. The physical evaluation revealed variation in seed shape (spherical to ellipsoidal) and seed colour (brown to dark brown). The maximum seed size, test weight (5.23 g) and grain:husk ratio (1:3.5) were recorded in Kodo-5, while the minimum test weight was observed in Kodo-8 (4.27 g). Antinutritional analysis showed significant variation among the germplasm for total phenols, phytic acid and tannins. The lowest total phenol content (18.89 mg/100 g), phytic acid (125.87 mg/100 g) and tannin content (106.80 mg/100 g) were recorded in Kodo-5, indicating its nutritional superiority from the antinutritional point of view. On the basis of overall performance, Kodo-5 was found to be the superior germplasm with desirable physical traits and lower levels of antinutritional factors.

Keywords: Kodo millet, physical traits, antinutritional factors, total phenols, phytic acid, tannins

Introduction

Kodo millet, scientifically known as *Paspalum scrobiculatum* L., is a type of small grain cultivated for many years all over the world, particularly in South Asia and other Asian countries. *Paspalum scrobiculatum* L., an ancient grain belonging to the Gramineae family, is cultivated across Africa, Asia, the Philippines, Nepal, and India [9]. While the wild variety *Paspalum scrobiculatum* var. *commersonii* originates from Africa, the cultivated variety *Paspalum scrobiculatum* var. *scrobiculatum* is primarily grown in India [9]. In India, *Paspalum scrobiculatum* L. is cultivated within various states including M.P., A.P., T.N., U.P., Bihar, M.H., Gujarat, and Orissa [3]. M.P., covering 33.4% of India's land area, contributes significantly to the country's small millet production, accounting for 26.6% [3]. Kodo millet serves as a minor cereal crop in regions facing water scarcity [18]. It is recognized for its ability to thrive in challenging agricultural environments, making it well-suited for cultivation in drought and semi-drought regions. Its drought-resistant nature is particularly valuable in areas with scarce water supplies. The grains of *Paspalum scrobiculatum* L. are tiny and spherical, ranging in colour from brown to dark brown, light brown or black, depending on the variety [2]. This resilience is especially beneficial for communities residing in drought-prone regions where resources are limited [18]. The task of providing food for everyone poses a considerable challenge to scientists engaged in various aspects of production, processing, storage, and nutrition aimed at alleviating hunger and poverty. Millets, regarded as ancient grains, were domesticated millennia ago throughout the earlier period of human civilization. Some indications suggest that millet cultivation dates back approximately 4000 years [3]. *Paspalum scrobiculatum* L. is nutritionally dense, containing ample dietary fiber, vitamins, and minerals, making it a wholesome dietary option [4]. It provides carbohydrates, protein, and vital nutrients such as iron, calcium, and B vitamins. Its nutrient profile positions it as a beneficial constituent of a well-rounded diet and has become increasingly popular as a nutritious substitute for rice and wheat [4].

Kodo millet finds application in diverse culinary dishes, including porridge, rice alternatives, and flour for making flatbreads [6]. Its adaptability to various climates, coupled with its nutritional advantages, has sparked renewed interest in this ancient grain as a sustainable and healthful dietary choice [20]. Consuming entire grains like Kodo millet has been linked to several health benefits, including the prevention of conditions like impaired insulin sensitivity, cardiac infarction, diabetes mellitus, cerebral ischaemia, obesity, breast cancer, reactive airway disease, and early death [19]. Millets are gaining more acknowledgment for their potential to be incorporated into functional foods and nutraceuticals, earning them the title of “nutricereals” [17]. Their important role in enhancing national food security and their probable health-promoting properties in fighting against various diseases further underscore their importance [4]. Small grains are now receiving increased interest from food processors, technologists, and nutritionists [5].

Materials and Methods

The experiment was conducted in the laboratory of the Department of Biochemistry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, U.P., during the Kharif season of the year 2023-24. Ten germplasms of Kodo millet, namely Kodo-1, Kodo-2, Kodo-3, Kodo-4, Kodo-5, Kodo-6, Kodo-7, Kodo-8, Kodo-9 and Kodo-10, and one check variety KK-1 (ICK 7125), a popular variety in U.P., were selected for the evaluation of physical and antinutritional composition. It was observed that the length, width and thickness of Kodo millet increased with increasing moisture content [6]. The colour of seeds was recorded by visual observation. The shape of the Kodo grains was measured using a Vernier calliper. Ten random grains were selected from each sample to obtain a representative estimate of the seeds [11]. One thousand seeds of Kodo millet were randomly counted manually and weighed with the help of an electronic balance, and the test weight was recorded [11]. The husk to kernel ratio was recorded from 100 g seeds of Kodo millet in the departmental laboratory. The husk of the seeds was removed with the help of okhali and the weight of husk and kernel were recorded separately using an electronic balance [11].

Total phenol content was estimated by the method of Swain and Hillis (1959) [10]. One gram of sample was extracted with 80% ethanol and centrifuged, and the supernatant was used for analysis. An aliquot was treated with Folin-Ciocalteu phenol reagent followed by sodium carbonate solution, and the volume was made up with distilled water. After incubation for 1 h, the intensity of the blue colour developed was measured at 750 nm using a spectrophotometer against a reagent blank. Total phenol content was calculated from a standard curve prepared using gallic acid and expressed as mg/100 g of sample [10]. Phytic acid content was determined following the method of Wheeler and Ferrel (1979) [12]. Two grams of finely ground sample were extracted with 3% trichloroacetic acid (TCA) and filtered. An aliquot of the extract was treated with ferric chloride solution and heated in a boiling water bath to precipitate ferric phytate. The precipitate was washed, dissolved in sodium hydroxide and nitric acid, and the iron content was estimated colorimetrically using potassium thiocyanate. Absorbance was recorded at 480 nm, and phytic acid content was calculated from a standard curve

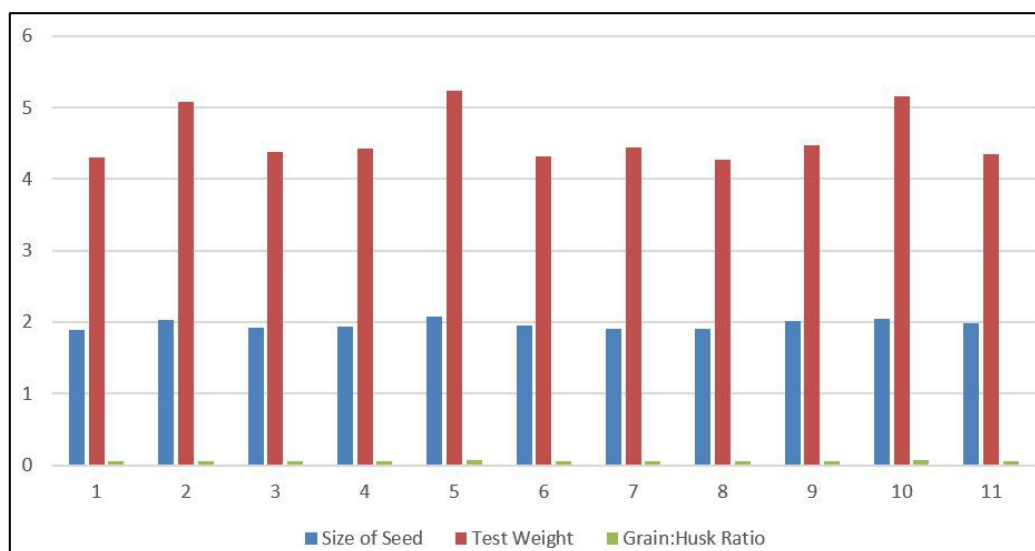
and expressed as mg/100 g of sample [12]. Tannin content was estimated by the method of Rangana (1986) [14]. Five grams of sample were extracted with hot distilled water and filtered. An aliquot of the extract was treated with Folin-Denis reagent followed by sodium carbonate solution, and the volume was made up with distilled water. The intensity of the blue colour developed was measured at 760 nm using a spectrophotometer against a blank. Tannin content was calculated using a standard curve prepared with tannic acid and expressed as mg/100 g of sample [14].

Results and Discussion

Considerable variation was observed among the kodo millet germplasm for physical characteristics such as seed shape, seed colour, seed size, test weight and grain:husk ratio (Table 1). The seed shape varied from spherical to ellipsoidal, while seed colour ranged from light brown to dusky olive brown, indicating noticeable morphological diversity among the genotypes. Seed size ranged from 1.89 to 2.08, with the maximum size recorded in Kodo-5 (2.08) followed by Kodo-10 (2.04) and Kodo-2 (2.03), whereas the minimum seed size was observed in Kodo-1 (1.89). Test weight varied from 4.27 to 5.23 g, with the highest value in Kodo-5 (5.23 g) followed by Kodo-10 (5.16 g) and Kodo-2 (5.08 g), while the lowest was recorded in Kodo-8 (4.27 g). The grain:husk ratio also showed wide variation, ranging from 1:12 to 1:35. The highest grain:husk ratio was observed in Kodo-5 (1:35) followed by Kodo-10 (1:33) and Kodo-9 (1:31), whereas the lowest ratio was recorded in Kodo-1 (1:12). Higher test weight and grain:husk ratio are desirable traits for processing and yield efficiency, and the superior performance of Kodo-5 indicates its potential for quality improvement and utilization. Significant variation was recorded among the germplasm for antinutritional factors, viz., total phenols, phytic acid and tannins (Table 2), indicating substantial genetic variability. Total phenol content ranged from 18.89 to 21.86 mg/100 g. The highest value was recorded in Kodo-1 (21.86 mg/100 g) followed by Kodo-6 (21.15 mg/100 g), while the lowest was observed in Kodo-5 (18.89 mg/100 g). Lower phenolic content is generally desirable as high levels may reduce nutrient bioavailability. Phytic acid content varied from 125.87 to 136.48 mg/100 g. The maximum phytic acid content was recorded in Kodo-1 (136.48 mg/100 g) followed by Kodo-6 (135.98 mg/100 g) and Kodo-9 (134.62 mg/100 g), whereas the minimum was observed in Kodo-5 (125.87 mg/100 g) and Kodo-10 (125.91 mg/100 g). Since phytic acid is known to chelate minerals and reduce their bioavailability, genotypes with lower phytic acid content are nutritionally preferable. Tannin content ranged from 106.80 to 124.54 mg/100 g. The highest tannin content was recorded in Kodo-1 (124.54 mg/100 g) followed by Kodo-6 (122.26 mg/100 g) and Kodo-9 (121.40 mg/100 g), while the lowest was observed in Kodo-5 (106.80 mg/100 g). Lower tannin content is desirable as tannins can interfere with protein digestibility and mineral absorption. Among the evaluated germplasm, Kodo-5 exhibited superior physical traits (higher seed size, test weight and grain:husk ratio) along with the lowest levels of antinutritional factors (total phenols, phytic acid and tannins). This indicates that Kodo-5 is a promising genotype for nutritional quality improvement and for use in breeding programmes aimed at developing kodo millet varieties with better processing quality and reduced antinutritional constraints.

Table 1: Physical parameters of kodo millet

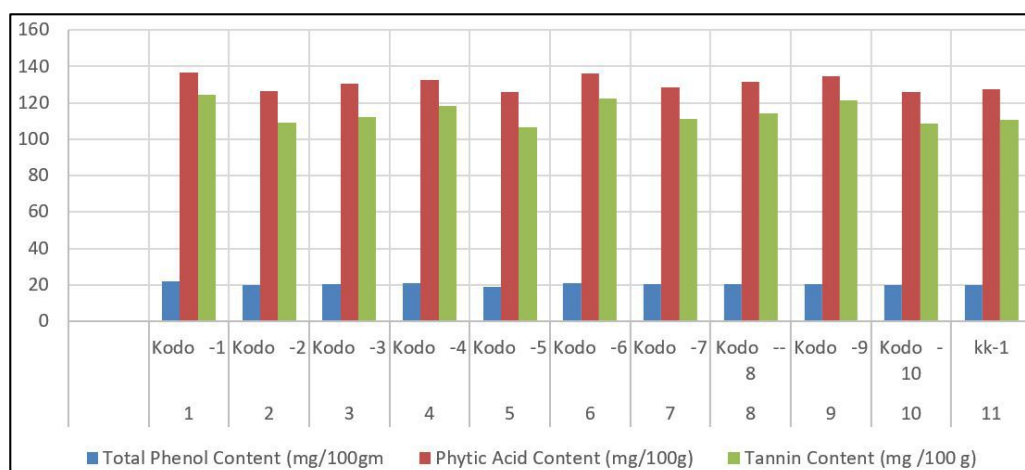
S. No.	Germplasm	Shape of Seed	Colour of Seed	Size of Seed	Test Weight	Grain:Husk Ratio
1	Kodo-1	Ellipsoidal	Brown	1.89	4.30	1:12
2	Kodo-2	Spherical	Dusky Brown	2.03	5.08	1:29
3	Kodo-3	Ellipsoidal	Dusky Brown	1.92	4.38	1:19
4	Kodo-4	Ellipsoidal	Light Brown	1.93	4.43	1:17
5	Kodo-5	Spherical	Dusky Brown	2.08	5.23	1:35
6	Kodo-6	Ellipsoidal	Brown	1.95	4.31	1:23
7	Kodo-7	Ellipsoidal	Light Brown	1.91	4.44	1:21
8	Kodo--8	Spherical	Dusky Brown	1.90	4.27	1:13
9	Kodo-9	Ellipsoidal	Brown	2.01	4.47	1:31
10	Kodo-10	Spherical	Light Brown	2.04	5.16	1:33
11	kk-1	Ellipsoidal	Dusky Olive Brown	1.98	4.34	1:26



Physical Parameters of Kodo Millets

Table 2: Antinutritional Factors of Kodo millet

S. No.	Germplasm	Total Phenol Content (mg/100 gm)	Phytic Acid Content (mg/100 g)	Tannin Content (mg/100 g)
1	Kodo-1	21.86	136.48	124.54
2	Kodo-2	19.92	126.36	109.32
3	Kodo-3	20.55	130.81	112.42
4	Kodo-4	20.72	132.48	118.31
5	Kodo-5	18.89	125.87	106.80
6	Kodo-6	21.15	135.98	122.26
7	Kodo-7	20.22	128.63	111.16
8	Kodo--8	20.61	131.58	114.28
9	Kodo-9	20.66	134.62	121.40
10	Kodo-10	19.82	125.91	108.66
11	kk-1	19.95	127.62	110.54



Antinutritional Factors of Kodo Millet

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