

Nutritional properties of minor millets: neglected cereals with potentials to combat malnutrition

Millet is a general term for a wide range of cereals. Minor millets are a group of grassy plants with short slender culm and small grains possessing remarkable ability to survive under adverse conditions like limited rainfall, poor soil fertility and land terrain. Minor millets categorized as coarse cereals are staple food for the tribal people where cultivation of major cereals like rice, wheat and maize is either not popular or fail to produce substantial yield¹. Millets differ from one another by their appearances, and morphological features, maturity, grain type, etc. (Figure 1). India is considered as hub for these minor crops, according to the latest data, the world total production of millet grains at last count was 762,712 metric tonnes and the top producer was India with an annual production of 334,500 tonnes contributing 43.85% (ref. 2). In Bastar district of Chhattisgarh, which is one of the largest congregations of tribal population (67.4%), inhabitants mainly grow millets and form major component of their daily food consumption. In addition to be nutritionally rich, the advantage of growing minor millets is that it is a rainfed crop which forms part of a multi-cropping system, in the sense that it is mostly grown along with legumes and oilseeds^{3,4}. On the darker side, these are underutilized and neglected crops owing to their lower preference driven by affluence, longer time and efforts involved in processing of the millets and the lower cooking quality. If these problems could be solved, their high nutritional value can make them doubly valuable as food for farming families and a potential source of income.

The present study reports the nutritional difference among the five minor millets and their genotypes in terms of protein, amino acids (lysine and tryptophan) and micro-nutrient (Fe and Zn) composition. Further, the study also emphasizes on identifying millet genotypes with high nutritive value taking into consideration the diverse collection of millets available in tribal Chhattisgarh. The plant materials used consists of five different minor millets namely Kodo millet, Finger millet, Little millet, Barnyard millet and Foxtail millet (Figure 1). Four different genotypes of Kodo millet, Little

millet and Finger millet and one variety each of Barnyard and Foxtail millets were taken for estimating their nutritive value. Whole grains were taken for the estimation of protein and micronutrients while the grains were powdered using pestle and mortar prior to the estimation procedure for grain amino acid contents, lysine and tryptophan. Crude protein content was determined according to micro-Kjeldahl method⁵. The coefficient 6.5 was multiplied with percentage of nitrogen calculated from the formula described by Johri *et al.*⁵ to obtain the crude protein content in the samples. Amino acids (lysine, tryptophan) were determined by spectrophotometer-based method. Similarly, iron and zinc contents were estimated using atomic absorption spectrophotometer (AAS-200) as described by Johri *et al.*⁵.

The protein content in whole grains of minor millets varied from 4.76% in Finger millet to 13.10% in Foxtail millet. Foxtail and Barnyard millet showed comparable amounts of crude protein which was highest among all the millets studied. These were followed by Little millet, Kodo millet and Finger millet (Table 1). Different minor millets were observed to vary from one another in their protein contents. A fairly good amount of grain protein was observed in minor millet genotypes compared to the staple food crops like rice. Wider variability for GPC was recorded in Barn-

yard millet with a range 6.79–13.09%. The genotype ABM4-1 contains the highest amount of grain protein. Among different genotypes of Little millet, the protein content ranged from 7.96% in CO-2 to 10.66% in JK-8 variety. A relatively lesser variability for GPC was observed in Kodo millet (6.55–8.44%) and Finger millet (4.76–6.44%). Variations in protein contents from 5.8% to 8.25% among three genotypes of Finger millet, 5.05–11.20% in six varieties of common millet and 6.50–11.0% in four varieties of Foxtail millet have been reported⁶. Similarly, Baebau and Hilu found a broad range of 7.5–11.70% protein in eleven genotypes of Finger millet.

The study also revealed interesting data on the content of essential amino acids lysine and tryptophan. The lysine content in whole grains of minor millets varied from 1.43 g/16 g N in Finger millet to 2.85 g/16 g N in Kodo millet. Among five millets, Kodo, Barnyard and Foxtail millet showed comparable amounts of lysine which was higher as compared to Little and Finger millets. Tryptophan content in the whole grains varied from 0.095 g/16 g N in Little millet to 0.32 g/16 g N in Barnyard millet. A relatively narrow (although significant) range of variation for tryptophan content was observed as a general trend (Table 1). This trend was more prominently visible in case of Finger millet and Little millet.



Figure 1. Different minor millets, their panicles, standing crop view and whole grains.

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Table 1. Protein, lysine, tryptophan, iron and zinc contents estimated in full grains of different minor millets (range of data shown)

Minor millet	Protein content (%)	Lysine content (g/16 g N)	Tryptophan content (g/16 g N)	Iron content in full grain (ppm)	Zinc content in full grain (ppm)
Barnyard millet (<i>Echinochloa frumentacea</i>)	6.79–13.09	2.30–2.98	0.14–0.32	20.00–44.92	36.40–40.20
Little millet (<i>Panicum sumatrense</i>)	7.96–10.66	1.86–2.48	0.09–0.15	32.20–35.1	30.30–33.00
Finger millet (<i>Eleusine coracana</i>)	5.27–6.44	1.43–2.72	0.18–0.21	31.20–39.40	20.70–28.10
Kodo millet (<i>Paspalum scrobiculatum</i>)	6.50–10.66	2.19–2.85	0.21–0.31	25.86–39.96	19.60–24.00
Foxtail millet (<i>Setaria italica</i>)	13.10*	2.42*	0.31*	27.19*	40.40*

*Mean value of replicated data of a single genotype of Foxtail millet.

Table 2. Mean protein, lysine and tryptophan content in full grains of minor millets (mean \pm SE values from data of three replications)

Minor millets	Genotypes	Protein content (%)	Lysine content (g/16 g N)	Tryptophan content (g/16 g N)	Iron content in full grain (ppm)	Zinc content in full grain (ppm)
Kodo millet	GPUK-3	7.19 \pm 0.08	2.68 \pm 0.03	0.21 \pm 0.015	30.44 \pm 0.71	23.9 \pm 0.79
	RBK-155	8.44 \pm 0.34	2.19 \pm 0.04	0.31 \pm 0.003	25.86 \pm 0.43	23.5 \pm 0.17
	RK-80	6.5 \pm 0.17	2.64 \pm 0.02	0.27 \pm 0.008	33.24 \pm 0.54	19.6 \pm 0.35
	RK-92	8.06 \pm 0.20	2.85 \pm 0.02	0.22 \pm 0.005	39.96 \pm 0.76	24.0 \pm 0.22
Little millet	JK-8	10.66 \pm 0.11	1.86 \pm 0.01	0.09 \pm 0.003	31.82 \pm 0.57	33.0 \pm 0.24
	RLM-37	9.67 \pm 0.34	1.92 \pm 0.01	0.09 \pm 0.0005	32.20 \pm 0.53	32.4 \pm 0.19
	CO-2	7.96 \pm 0.07	2.48 \pm 0.06	0.09 \pm 0.0008	31.72 \pm 0.49	33.0 \pm 0.82
	IGL-68	9.38 \pm 0.09	2.07 \pm 0.01	0.14 \pm 0.003	35.1 \pm 0.91	30.3 \pm 0.59
Finger millet	Ratnagiri	5.27 \pm 0.05	2.24 \pm 0.20	0.21 \pm 0.0098	31.2 \pm 0.84	28.1 \pm 1.11
	VR-762	5.74 \pm 0.12	2.72 \pm 0.06	0.21 \pm 0.0029	39.4 \pm 0.88	23.3 \pm 0.54
	VL-149	6.44 \pm 0.11	2.39 \pm 0.02	0.19 \pm 0.0064	34.4 \pm 0.94	24.4 \pm 0.56
	GPU-48	4.76 \pm 0.01	1.43 \pm 0.12	0.18 \pm 0.0008	31.6 \pm 0.44	20.7 \pm 1.03
Barnyard millet	ABM4-1	13.09 \pm .05	2.35 \pm 0.01	0.32 \pm 0.0084	44.92 \pm 0.51	36.7 \pm 0.74
	VL-209	7.43 \pm 0.15	2.30 \pm 0.01	0.16 \pm 0.0008	46.2 \pm 0.51	36.4 \pm 0.57
	VL-29	6.79 \pm 0.090	2.80 \pm 0.01	0.14 \pm 0.0006	30.69 \pm 0.56	39.5 \pm 0.81
	RAU-12	8.05 \pm 0.112	2.98 \pm 0.01	0.15 \pm 0.0007	20.00 \pm 0.41	40.2 \pm 0.85
Foxtail millet	RAU-8	13.1 \pm 0.24	2.42 \pm 0.10	0.31 \pm 0.0068	27.19 \pm 1.07	40.4 \pm 0.26

Iron is an essential micronutrient extremely vital to human health. Studies focusing to identify sources and improve iron content in cereal grains would be a pertinent approach to combat its widespread malnutrition. The iron content in whole grains of minor millets varied from 44.92 ppm in Kodo millet to 46.20 ppm in Barnyard millets (Table 1). The observed values are higher than the average iron content present in major cereal crops such as rice, wheat, maize, etc. as well as other millets like sorghum and pearl millet. Barnyard millet showed highest concentration of iron (40.2 ppm) followed by Finger millet with 34.15 ppm, Little millet with 32.71 ppm, Kodo millet with 32.275 ppm and Foxtail millet with 27.19 ppm iron content in grains. The iron content in Kodo millet ranged from 25.86 ppm to 39.60 ppm with the variety RK-92 showing the highest iron content of 39.60 ppm. Among different genotypes of Little millet, the iron content ranged

from 31.72 ppm in CO-2 to 35.10 in IGL-68 variety (Table 2).

Similarly significant variations in the zinc content were also recorded for the five minor millet crops analysed. The zinc content ranged from 19.60 ppm in Kodo millet to 40.4 ppm in Foxtail millet. Foxtail millet showed the highest zinc content among all followed by Barnyard millet, Little millet and Finger millet. Similar findings have been reported elsewhere where different minor millets varied considerably from one another in their zinc content⁸. Their study showed 21.4 ppm sample zinc in Foxtail millet (highest among millets studied) and 15.0 ppm in Finger millet. Comparative account of millet genotypes for their zinc content also showed significant variation between millet genotypes as observed for protein, amino acid and iron content traits. The zinc content in Kodo millet ranged from 19.6 ppm to 24 ppm with variety RK-92 showing the highest

zinc content of 24 ppm. Among different genotypes of Little millet, a narrow range but higher Zn content was observed, which was 30 ppm in CO-2 to 33 ppm in JK-8. In case of Finger millet, the zinc content in the range of 20.70 ppm, in GPU-48 to 28.10 in RATNAGIRI genotypes was observed (Table 2). In a comprehensive work of deciphering the grain nutritive value of Indian foods, Gopalan *et al.*⁹ reported significantly wider variation among different millets for grain Fe and Zn contents. Wide variation in iron and zinc composition in minor millet has also been reported by several workers^{10,11}. The findings of our study are also supported by previous reports where a range of 1.76 mg/100 g to 2.31 mg/100 g of sample Fe and 3.60 mg/100 g to 7.31 mg/100 g sample of Zn have been observed in eight varieties of Finger millet¹². The five minor millets have significant difference in their iron and zinc content when analysed statistically at 5%

as well as at 1% level of significance. This indicates high genetic variability to exist for these grain nutritive traits among the collection of 14 millet genotypes selected for the study.

The study also reveals great variability existing among the collection of millets for grain nutritive traits which can be exploited by employing efficient breeding strategies to improve these traits. Millets identified with high nutritive values can also be exploited for the identification and mining of genes/alleles governing these traits in the foreseeable future.

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Received 28 June 2014; revised accepted 20 August 2014

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