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# Nutritional, Antioxidant and Antinutritional Quality of Millets in Comparison to Rice

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## ABSTRACT

**Background:** Millets are highly variable small-seeded annual grasses, primarily cultivated as grain crops in marginal lands. They are the sources of protein, minerals and vitamins and help in reducing the incidence of various diseases. These "Nutri Cereals" are considered as "famine reserves" and have comparable nutritional quality with that of rice, the staple food of the region.

**Methods:** Eight millet genotypes of Assam were evaluated and compared with a standard rice variety for nutritional, antioxidant and antinutritional constituents. Standard protocols were followed for the said estimations.

**Result:** Millets were found to have comparable proximate composition with rice. Total phenol and antioxidant activity ranged from 190.58-280.89 mg GAE/100 g and 163.07-335.73 µg/ml, respectively. Calcium and iron content ranged from 23.62-291.87 mg/100 g and 3.83-6.52 mg/100 g on dry weight basis, respectively. Tannin, phytate P and oxalate content ranged from 53.48-136.13 mg/100 g, 193.83-663.81 mg/100 g and 4.84-13.74 mg/100 g on dry weight basis, respectively. Millets were found to be superior to the rice variety in majority of the quality traits like crude fat, crude protein, crude fibre, ash, minerals, phenol, antioxidant activity, tannin, phytate P and oxalate content and therefore may be encouraged for inclusion in the common crop sequence for cultivation.


**Key words:** Antinutritional, Antioxidant activity, Finger millet, Foxtail millet, Nutritional composition.

## INTRODUCTION

Millets are annual grasses with highly variable small-seed, used as human food as well as fodder crop and is widely cultivated throughout the world. Originated in the regions of India and China (Vavilov, 1926), millets are generally cultivated in marginal lands of varied climates because of their wide adaptability and short growing season (65-75 days). They are apparently free from grain storage pests and remain viable up to 2-3 years, if appropriately stored (Seetharam *et al*., 1986).

Millets are good sources of inexpensive proteins, minerals and vitamins and this might be very worthy in making up any deficiency in a vegetarian diet, besides providing these nutrients to the poor people where the need for such nutrients are high, in general. Millets are superior to staple cereals like wheat and rice as they are bestowed with excellent nutrients and thus have the potential to provide nutritional security (Anbukkani *et al*., 2017). Unlike wheat, millets are gluten free and all millets are high in their antioxidant activities and also act as probiotics. Incidence of chronic diseases such as diabetes, hypertension, cardiovascular diseases *etc*. may be delayed with consumption in the form whole/flour/dalia of millets in diet. Because of their higher nutritive values and better health benefits than other cereals, Govt. of India renamed millets as "Nutri Cereals", instead of "coarse cereals" to boost its demand and to fetch the farmer higher prices (Bhat *et al*., 2018). Millets are also known as "famine reserves" because of their prolonged and easy storability without pest damage under normal storage conditions.

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Out of the world's total millet production, India accounts for about 37% followed by Nigeria and China (FAOSTAT, 2018). In certain parts of Assam, finger millet and foxtail millet are cultivated in about 4,400 ha during 2012-13 with productivity of 494 kg/ha (IPNI, 2018). The average consumption was found to be 18.82 kg/household/month (Anbukkani *et al*., 2017). Farmers with inadequate resources of this region prefer to grow foxtail and finger millets because of their adaptation to the marginal land. They mostly grow the local lines and improved germplasm of these millets. However, information on the nutritional and antinutritional characters of these germplasm is not exploited till date. The present study was carried out to evaluate and compare the nutritional, antioxidant and antinutritional properties of commonly grown millet germplasm of this region to identify nutritionally superior germplasm and also to generate baseline information for nutrition breeding on millets.

## MATERIALS AND METHODS

### Collection and preparation of samples

Dehusked finger millet and foxtail millet were collected at physiological maturity from Regional Agricultural Research Station (RARS), Gossaingaon (Kokrajhar District), Assam Agricultural University (AAU), Jorhat, Assam during 2019-20. Finger millet [*Eleusine coracana* (L.) Gaertn.] genotypes are Curling, Straight, WN-562, VR-1117 and KMR-652 while foxtail millet [*Setaria italica* (L.) P. Beauv.] genotypes are Local, White and Red. Among the millet genotypes collected for the study, WN-562, VR-1117 and KMR-652 are released varieties whereas Curling, Straight, Local, White and Red are local genotypes. Mahsuri, a rice variety popularly known by its vernacular name, *Aijong*, collected from the market as milled and polished rice was also used in the study for comparison. The samples were dried and grounded to powder which were stored in the desiccator for further analysis and all the works were carried in the Department of Biochemistry and Agricultural Chemistry, Assam Agricultural University, Jorhat, Assam, India.

### Analytical methods

The moisture content (%) of the powdered millet and rice samples was determined at 100°C in an Electronic Moisture Analyser (Sartorius, Model MA 35, Germany). Crude fat, crude protein, crude fibre and ash content were determined by the standard methods suggested by AOAC (2000). The starch content was determined by the anthrone method as described by Hodge and Hofreiter (1962) and amylose content by the method as described by McCready *et al.* (1950). Slinkard and Singleton's (1977) method was used to estimate the total phenol content and expressed as mg Gallic Acid Equivalents. The DPPH radical scavenging ability of the millets and rice methanolic extracts was quantified by the method described by Nahak and Sahu (2010). $IC_{50}$ value, the concentration of substrate that causes 50% loss of the DPPH activity was calculated by the linear regression plots of the percentage of antiradical activity against the concentration of the tested samples and was compared with ascorbic acid (standard). The iron content of the samples was determined by the method as described by Wong (1928) and calcium by AOAC (1990). Waterman and Mole's (1994) method was used to estimate the tannin content and was expressed as mg Tannic Acid Equivalents, phytic acid by Wheeler and Ferrel (1971) and expressed as Phytate P (mg/100 g sample) and oxalate content by AOAC (1970).

### Statistical analysis

The data in triplicate obtained from laboratory experiments were analyzed by using IBM ® SPSS ® for Windows version 25.0. The differences between mean values among different parameters were compared by one-way analysis of variance (ANOVA). The results were presented as Mean±Standard Error of Mean (S. EM). The varietal means were ranked by using Tukey's honestly significant differences (HSD) post-hoc test at P<0.05 significance level.

## RESULTS AND DISCUSSION

Nutritional quality evaluation of millet and rice germplasm consisted of moisture, crude fat, crude protein, crude fibre, ash, starch, amylose, minerals (calcium and iron), antioxidant activity (total phenol and $IC_{50}$ value) and antinutritional factors constitute tannin, phytic acid and oxalate content.

### Nutritional composition

There were significant differences in the nutritional composition of the germplasm under study (Table 1). Rice (Mahsuri) had the highest moisture content among the evaluated genotypes (12.35%) whereas average moisture contents were 10.75% and 11.36% for finger millet and foxtail millet germplasm respectively. Foxtail millet genotypes showed comparatively higher crude fat with average of 3.05 % compared to finger millet with an average of 2.01%. The lowest amount of crude fat among the evaluated genotypes was observed in the rice variety (1.44%). Similar trend was seen for crude protein content with highest average for foxtail millets (11.30%) and lowest average in rice (4.70%). The crude fat and crude protein were found similar to the results published earlier (Saleh *et al*., 2013; Sharma and Niranjan, 2017). Crude fibre content in millet genotypes ranged from 3.85-7.58%, with an average of 5.39%. Foxtail millet genotypes had higher crude fibre content (6.34-7.58%) with an average of 7.14% than finger millet (3.85-4.77%), averaging 4.34%, with Mahsuri exhibiting 0.64%, only brown rice had higher fibre contents. The results were found to be similar as reported by earlier works (Lansakara *et al*., 2016; Saldivar, 2003). The foxtail millet genotypes had comparatively higher ash content (3.09-3.27%) than finger millet genotypes (2.07-3.24%) which were found *at par* to the published reports (Bora *et al*., 2019; Gopalan *et al*., 2012). Rice had the lowest ash content (0.40%); only rice husk is reported unusually high in ash content.

Finger millet genotypes had higher calcium content ranging from 229.59-291.87 mg/100 g with an average value of 254.94 mg/100 g whereas foxtail millet ranged from 23.62 to 34.24 mg/100 g, with 28.61 mg/100 g as an average. These findings were found similar to those already reported (Kandel *et al*., 2019; Shankaramurthy and Somannavar, 2019). Rice exhibited the lowest calcium content (15.92 mg/100 g). Iron content of millet genotypes followed the similar trend with that of calcium and ranged from 3.83-6.52 mg/100 g. The results obtained in this study were found to be similar to the values already reported (Ratnavathi, 2017). Rice had the lowest iron content (1.23 mg/100 g). Finger millet showed exceptionally high calcium content over the other genotypes. Millet genotypes were found to have a better calcium and iron contents than rice.

Finger millet genotypes had higher starch content (68.09-72.87%) than foxtail millet genotypes (63.38-66.20%), in the same trend as already reported by (Bora *et al*., 2019). Rice had the highest starch content (86.02%). The amylose content of the evaluated millet genotypes ranged from

**Table 1:** Nutritional composition of millets and rice genotypes.

| Parameters/ Genotypes | Finger millet-curling | Finger millet-straight | Finger millet-WN-562 | Finger millet-VR-1117 | Finger millet-KMR-652 | Finger millet-average | Foxtail millet-local | Foxtail millet-White | Foxtail millet-red | Foxtail millet-average | Rice (Mahsuri) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Moisture content (%) | 11.06±0.22$^{bcd}$ | 10.76±0.15$^{abc*}$ | 10.28±0.29$^{ab*}$ | 9.59±0.21$^{a*}$ | 12.04±0.09$^{cd}$ | 10.75±0.20 | 12.24±0.07$^{d}$ | 10.67±0.21$^{ab*}$ | 11.18±0.57$^{bcd}$ | 11.36±0.28 | 12.35±0.21$^{d}$ |
| Crude fat (%) | 1.79±0.09$^{ab}$ | 2.60±0.08$^{d*}$ | 1.85±0.17$^{abc}$ | 2.16±0.06$^{bcd*}$ | 1.64±0.12$^{ab}$ | 2.01±0.10 | 3.49±0.13$^{e*}$ | 2.39±0.10$^{cd*}$ | 3.27±0.12$^{e*}$ | 3.05±0.12 | 1.45±0.07$^{a}$ |
| Crude protein (%) | 6.67±0.26$^{b*}$ | 6.76±0.08$^{b*}$ | 7.18±0.23$^{b*}$ | 6.68±0.14$^{b*}$ | 7.07±0.10$^{b*}$ | 6.87±0.16 | 11.19±0.23$^{cd*}$ | 10.68±0.14$^{c*}$ | 12.04±0.14$^{d*}$ | 11.30±0.17 | 4.70±0.28$^{a}$ |
| Crude fibre (%) | 4.77±0.29$^{b*}$ | 3.85±0.19$^{b*}$ | 4.35±0.16$^{b*}$ | 4.15±0.23$^{b*}$ | 4.57±0.14$^{b*}$ | 4.34±0.20 | 6.34±0.29$^{c*}$ | 7.49±0.14$^{d*}$ | 7.58±0.17$^{d*}$ | 7.14±0.20 | 0.64±0.03$^{a}$ |
| Ash (%) | 2.55±0.13$^{bcd*}$ | 3.24±0.15$^{e*}$ | 2.87±0.13$^{cde*}$ | 2.07±0.19$^{b*}$ | 2.38±0.12$^{bc*}$ | 2.62±0.14 | 3.27±0.07$^{e*}$ | 3.09±0.10$^{de*}$ | 3.19±0.20$^{de*}$ | 3.18±0.12 | 0.41±0.09$^{a}$ |
| Calcium (mg/ 100 gm) | 241.20±1.27$^{b*}$ | 229.59±1.05$^{b*}$ | 268.44±1.40$^{c*}$ | 291.87±1.12$^{d*}$ | 243.61±3.45$^{b*}$ | 254.94±1.66 | 27.97±2.90$^{a}$ | 34.24±1.74$^{a}$ | 23.62±1.94$^{a}$ | 28.61±2.19 | 15.92±0.80$^{a}$ |
| Iron (mg/ 100 gm) | 4.87±0.51$^{bc*}$ | 4.90±0.16$^{bc*}$ | 5.18±0.21$^{bcd*}$ | 6.52±0.14$^{d*}$ | 4.53±0.28$^{bc*}$ | 5.20±0.26 | 5.43±0.19$^{cd*}$ | 3.83±0.33$^{b}$ | 4.76±0.25$^{bc*}$ | 4.67±0.26 | 1.23±0.32$^{a}$ |
| Starch (%) | 70.74±0.45$^{def*}$ | 68.59±0.94$^{cde*}$ | 68.09±0.41$^{bcd*}$ | 72.87±0.94$^{f*}$ | 71.67±0.47$^{ef*}$ | 70.39±0.64 | 63.38±0.69$^{a*}$ | 64.76±0.66$^{ab*}$ | 66.20±0.25$^{abc*}$ | 64.78±0.53 | 86.02±0.84$^{g}$ |
| Amylose (%) | 31.34±1.13$^{cde}$ | 27.43±0.91$^{bcd}$ | 24.10±0.79$^{ab}$ | 32.26±0.73$^{de*}$ | 32.76±0.98$^{e*}$ | 29.58±0.91 | 20.99±0.85$^{a*}$ | 22.89±1.29$^{ab}$ | 24.05±0.93$^{ab}$ | 22.64±1.02 | 26.89±1.44$^{bc}$ |

Values are mean (n=3) ± S. EM. Values with different superscript letter (a, b, c, d, e, f, g) in the same row are statistically different (P<0.05). Genotypes with an asterisk (*) as superscript are statistically different when compared with rice (P<0.05).

20.99-32.76%, with an average of 26.98%. Finger millet genotypes had higher amylose content than foxtail millet genotypes. Amylose content of rice variety, Mahsuri was 26.89%. These were similar to already published results by Annor *et al*. (2014). The released varieties of millets exhibited more starch and amylose content than the local genotypes. Polished rice variety Mahsuri had the highest starch content.

Variation in the nutritional composition may be due to differences in genetic makeup of genotypes used in the study, cultivation practices, stage of harvest, post-harvest processing, nutrient status and type of soil, the proportionate amount of chemical compound, environmental condition from where the sample was collected as well as the method used for estimation.

**Antioxidant activity**

Foxtail millet genotypes were found higher in total phenol content than finger millet genotypes (Table 2) which was also revealed by earlier works (Goudar *et al*., 2015; Kumar and Kaur, 2017). The rice variety, Mahsuri had the lowest total phenolic content (85.62 mg GAE/100 g) amongst the evaluated genotypes. It was found that the local genotypes of both finger and foxtail millet genotypes were nutritionally superior to the released varieties.

The $IC_{50}$ value is widely used to measure the antioxidant activity of test samples and is calculated as the concentration of antioxidants needed to decrease the initial DPPH concentration by 50%. Lower the $IC_{50}$ value is higher is the antioxidant activity. Finger millet genotypes showed higher $IC_{50}$ values in the range of 179.16-335.73 µg/ml with an average of 255.71 µg/ml than the foxtail millet genotypes (163.07-306.63 µg/ml) with an average of 236.42 µg/ml. Mahsuri had the highest $IC_{50}$ value (521.12 µg/ml) showing the lowest antioxidant activity. Such results were found in already published literatures (Lansakara *et al*., 2016; Singh and Naithani, 2014). It was also observed that the local genotypes showed comparatively better antioxidant properties than other genotypes and rice variety, Mahsuri.

**Antinutritional composition of millet and rice genotypes**

Antinutritional composition (tannin, phytic acid and oxalate) of millet and rice genotypes is presented in Table 3. The tannin content in the millet genotypes ranged from 53.48-136.13 mg TAE/100 g. Finger millet genotypes had lower tannin content in the range of 53.48-128.10 mg TAE/100g than foxtail millet genotypes (56.47-136.13 mg TAE/100g) as seen in earlier reports also (Amalraj and Pius, 2015; Ramachandra *et al*., 1977). Mahsuri, in the present study showed tannin content of 54.71 mg TAE/100 g. Phytic acid (phytate P) content of the evaluated millet genotypes ranged from 193.83-663.81 mg/100 g. Finger millet genotypes had slightly higher phytate P content than the foxtail millet genotypes as shown in earlier reports (Panwar *et al*., 2016; Pawar and Machewad, 2006). Mahsuri had phytate P content of 123.84 mg/100 g. Oxalate content of the evaluated millet genotypes ranged from 4.84-13.74 mg/100 g with higher content in finger millet genotypes than foxtail millet

**Table 2:** Antioxidant activity of millets and rice genotypes.

| Parameters/ Genotypes | Finger millet-curling | Finger millet-straight | Finger Millet-WN-562 | Finger millet-VR-1117 | Finger millet-KMR-652 | Finger millet-average | Foxtail millet-local | Foxtail millet-white | Foxtail millet-red | Foxtail millet-average | Rice (Mahsuri) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total phenol (mg GAE/100 gm) | 223.44±1.51$^{d*}$ | 256.14±1.39$^{f*}$ | 203.55±2.46$^{c*}$ | 190.58±1.63$^{b*}$ | 200.88±1.84$^{c*}$ | 214.92±1.76 | 233.65±1.31$^{e*}$ | 195.86±1.00$^{bc*}$ | 280.89±1.77$^{g*}$ | 236.80±1.36 | 85.62±2.29$^{a}$ |
| $IC_{50}$ (µg/ml) | 335.73±1.05$^{g*}$ | 179.16±0.91$^{b*}$ | 259.90±0.60$^{e*}$ | 256.78±0.51$^{e*}$ | 247.01±0.97$^{d*}$ | 255.71±0.81 | 306.63±0.94$^{f*}$ | 239.56±0.43$^{c*}$ | 163.07±0.76$^{a*}$ | 236.42±0.71 | 21.12±0.95$^{h}$ |

Values are mean (n=3) ± S. EM. Values with different superscript letter (a, b, c, d, e, f, g, h) in the same row are statistically different (P<0.05). Genotypes with an asterisk (*) as superscript are statistically different when compared with rice (P<0.05). GAE represents gallic acid equivalents.

**Table 3:** Antinutritional composition of millets and rice genotypes.

| Parameters/ Genotypes | Finger millet -curling | Finger millet-straight | Finger millet-WN-562 | Finger millet-VR-1117 | Finger millet-KMR-652 | Finger millet-average | Foxtail millet-local | Foxtail millet-white | Foxtail millet-red | Foxtail millet-average | Rice (Mahsuri) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tannin (mgTAE/ 100 g) | 128.10±1.67$^{d*}$ | 91.75±2.34$^{b*}$ | 111.72±5.59$^{c*}$ | 53.48±3.39$^{a}$ | 126.51±1.44$^{d*}$ | 102.31±2.88 | 92.31±3.08$^{b*}$ | 56.47±2.11$^{a}$ | 136.13±2.43$^{d*}$ | 94.97±2.54 | 54.71±1.41$^{a}$ |
| Phytate P (mg/ 100 gm) | 313.71±4.31$^{e*}$ $^{a}$ | 380.53±4.07$^{f*}$ | 523.94±2.87$^{h*}$ | 663.81±2.40$^{i*}$ | 273.83±2.85$^{d*}$ | 431.16±3.30 | 473.92±3.82$^{g*}$ | 193.83±4.39$^{b*}$ | 223.36±3.04$^{c*}$ | 297.04±3.75 | 23.84±2.73 |
| Oxalate(mg/ 100 gm) | 11.26±0.27$^{cd*}$ | 10.99±0.21$^{cd*}$ | 11.88±0.18$^{cde*}$ | 13.74±0.28$^{e*}$ | 12.13±0.41$^{de*}$ | 12.00±0.27 | 6.80±0.55$^{b*}$ | 9.66±1.02$^{c*}$ | 4.84±0.42$^{b*}$ | 7.10±0.66 | 0.80±0.13$^{a}$ |

Values are mean (n=3) ± S. EM. Values with different superscript letter (a, b, c, d, e, f, g, h, i) in the same row are statistically different (P<0.05). Genotypes with an asterisk (*) as superscript are statistically different when compared with rice (P<0.05). TAE represents tannic acid equivalents.

genotypes. Almost similar results were reported earlier (Amalraj and Pius, 2015; Sanusi and Ahmad, 2019). Mahsuri had the lowest oxalate content (0.80 mg/100 g). The millet genotypes, particularly finger millet genotypes exhibited higher antinutritional composition as compared to rice. Variation in the antinutritional content may be due to the difference in cultivars, method of estimation and expression, environmental conditions and degree of polishing.

## CONCLUSION

Millet genotypes were found to be superior to the rice variety in most of the quality traits studied, including crude fat, crude protein, crude fibre, ash and mineral contents, total phenolic contents and antioxidant activity. Finger millet genotypes VR-1117 and KMR-652 and foxtail millet genotypes Local and Red were found superior in nutritional quality over the others. However, higher antinutrient contents in millet cultivars may reduce their digestibility and food values. The presence of antinutrients limit the scope for biofortification in millets, hence, process optimization for minimizing antinutrients might be useful to give them the status of staple cereals in human diet.

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### Conflict of interest

All authors declare that they have no conflicts of interest.

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