Tannins and Phytate Content in Proso Millets (*Panicum miliaceum*)

K. LORENZ, Department of Food Science and Nutrition, Colorado State University, Fort Collins 80523

ABSTRACT

Cereal Chem. 60(6):424-426

Phytate and tannin contents of 24 proso millets (*Panicum miliaceum*) were determined. Phytate content ranged from 0.17 to 0.47% and tannins from 0.055 to 0.178% catechin equivalents. Dark-colored seeds had higher tannin contents than light-colored seeds. Dehulling of the seeds greatly reduced the levels of phytate and tannin.

The term "millet" is used for any of several small-seeded annual grasses that are of minor importance in the West but a staple in the diets of African and Asian people. Millets, which can be cultivated in a wide range of soils and climates, are of special importance in semiarid regions because of their short growing seasons (Schery 1963). Five millets are common: *Setaria italica, Pennisetum glaucum* or *P. typhoideum, Eleusine coracana, Echinochloa frumentacea,* and *Panicum miliaceum. Panicum miliaceum*, also known as proso millet, hershey, broom corn, or hog millet is the only economically important species in the United States (Casey and Lorenz 1977).

Proso millet is used without dehulling in livestock rations and bird seed. Suggested food applications of dehulled proso millet in the United States include puffed or cooked breakfast cereal or replacement of wheat flour in certain baked products (Hinze 1972).

Very little research has been conducted with proso millets compared with other cereal grains. There are no reports in the literature about phytate content of these millets, which is of nutritional interest because of possible mineral complexing. Tannins (phenolic substances) bind protein and reduce its digestibility.

The present study was conducted to determine the effect of variety on phytate and tannin content in proso millets.

MATERIALS AND METHODS

Sample Identification

This study included 24 samples of proso millet, grown on summer-fallowed land at the Colorado State University Experiment Farm in Springfield. The hybrids, selections, and selections from a cross of Leonard by an Akron selection are identified and described in Table I. The color (L and ΔE values) of ground samples of each of the millets was determined with a Hunter Color Difference meter.

Proximate Analyses

Millets were analyzed for moisture, crude fat, ash, nitrogen, and crude fiber by AACC approved methods 44-15A, 30-10, 08-01, 46-11, and 32-15, respectively (AACC 1969).

Phytate and Tannin Determination Procedures

Unfortunately, there are neither good standards nor very standardized methods for either phytate or tannin. Phytate content was determined by the method of Wheeler and Ferrel (1971) because it has been used frequently in recent years for the analysis of phytates in grains. Values can, therefore, be compared with others in the literature. The phytate is extracted with trichloroacetic acid and precipitated as the ferric salt. The iron content of the precipitate is determined colorimetrically and the phytate phosphorus content calculated from this value, assuming a constant 4:6 (iron–phosphorus) molecular ratio in the precipitate. The standard curve for iron was prepared, using 3.2 *N* sulfuric acid to prevent formation of $Fe(OH)_3$. Four-gram samples of ground material (nondehulled and dehulled grain) and 1-g samples of ground hulls were used for the determinations. Samples were ground in a Udy Cyclone mill (0.4-mm screen). Separation of hulls from nondehulled grains was done by hand.

Tannin content was determined colorimetrically, using the vanillin-HCl method of Burns (1963, 1971), as modified by Maxson and Rooney (1972). The amount of tannin measured was expressed as catechin equivalent. Two-gram samples of the ground nondehulled and dehulled grains and 0.8 g of ground hulls were used for analyses.

All values represent the means of three analytical replications.

RESULTS AND DISCUSSION

Proximate Composition and Color

The proso millet samples used in this study ranged from creamy white to very dark brown. The Hunter color values (Table I) reflect these differences.

There is little information about the mineral composition of millets and how it is affected by soil, growing conditions, water supply, and varietal differences. Compared to wheat, corn, and sorghum, the mineral content of millets is high (Lorenz et al 1976). Reported ash values for varieties of *E. coracana, P. typhoideum, S. italica,* and *P. miliaceum* range from 2.6 to 3.9% (Joseph et al 1959, Kurien 1967, Burton et al 1972). Several of the cultivars used in this study had ash contents in excess of those reported previously by others (Table II).

Frequent references to the need to preserve whole grain millet and millet flours in airtight containers to minimize the development of rancidity serves as a reminder of the high lipid content of millets. Lipid contents ranging from 3.0 to 6.5% have been reported (Pruthi and Bhatia 1970, Freeman and Bocan 1973, Burton et al 1972, Lorenz et al 1976), which are higher than those of corn, wheat, rice, or sorghum. All but one of the proso millet varieties used in this study were higher in crude fat than values reported previously for other millets (Table II).

The reported range of protein in millets varies from 5.6 to 14.8% (Deosthale et al 1971, Burton et al 1972, Casey and Lorenz 1977). Protein contents of millets in this study fall within the reported range. Crude fiber values of proso millets varied from 4.4 to 9.7%, which is quite high compared to other cereal grains. Such high fiber values can reduce digestibility of millets considerably (Joseph et al 1959, Deosthale et al 1971). Joseph et al (1959) reported that the fiber in millets is so high that a sudden change from a rice diet to a millet diet usually causes digestive problems in habitual rice eaters.

Phytate Contents

Phytates are widely distributed in plants, especially in seeds. The primary role of phytate may be to store phosphorus, which is gradually utilized during germination (Nahapetian and Bassiri 1976). Numerous studies have indicated that phytate reduces the bioavailability of dietary Mg, Ca, Zn, and Fe in monogastric animals (Bassiri and Nahapetian 1977).

Because millets have a relatively high calcium content, especially varieties of *E. coracana*, they have been used in several calcium-balance studies. These studies have shown that a high phytate content in millets inhibits calcium absorption. Kurien (1967) stated that only 43% of the calcium in *E. coracana* was retained by rats. Some studies (Deosthale et al 1970, Goswami et al 1970) reported relatively high iron contents in millets such that one half-ounce serving would provide one third of the USRDA. No studies have been conducted, however, on the bioavailability of iron in millets. The high phytate content found in millets could also depress iron absorption. The phytate content of proso millets is, therefore, a nutritional concern.

Phytate values of proso millets used in this study are given in Table III. Values ranged from 0.17 to 0.47%. The values are higher than phytate values of rice, which have been reported to be 0.10–0.14% (Barber 1972). The outermost layers (1.5–2.5% by weight of the milled kernel of rice) had phytate contents 14–34 times those of the original rices. Corn and durum wheat have higher phytate contents than the proso millets. O'Dell (1969) reported 0.90% phytate in corn. Tabekhia and Donnelly (1982) found phytate to range from 0.98 to 1.43% in durum wheats.

Dehulling of proso millets resulted in a 27–53% reduction in phytate content in the dehulled grain (Table IV). Hulls contained 2–6 times as much phytate as the dehulled grains.

The ferric-ion precipitation method used here may have underestimated somewhat the phytate content in the concentration range reported for millets. Ellis and Morris (1983) reported that the method is less sensitive at low concentrations of phytate.

Furthermore, recent work by Thompson and Erdman (1982) with ferric phytate precipitated from soybean extracts indicated that the iron-phosphorus molar ratio may be subject to variations.

Tannin Contents

Phenolic substances (tannins) have been reported at significant levels in some cultivars of barley and sorghum (Maxson and Rooney 1972). Normal cooking procedures do not overcome the harmful effects of tannins in sorghum (Price et al 1980), which include lower digestibility, reduced mineral bioavailability, possible carcinogenic effects, lower palatability due to astringency, and lower growth rates in animals (Hoseney et al 1981).

The effect of tannins on animal growth is thought to be due to their ability to bind proteins, thereby making them insoluble and indigestible. Tannins also bind to starch (Hoseney et al 1981).

TABLE I
Sample Identification and Color of Proso Millets

Sample	Color	Hunter Color Values[a] L	Hunter Color Values[a] ΔE
Red proso millets			
Turghai-Standard red I	Light brown	40.8	55.6
Turghai-Standard red II	Light brown	40.0	56.1
Akron-Colorado selection	Light brown	37.8	58.4
Big Red-Russian selection	Light brown	42.0	54.9
Leonard × Akron cross (LA-2)	Light brown	37.1	59.0
Leonard × Akron cross (LA-4)	Light brown	38.6	57.6
Leonard × Akron cross (LA-6)	Light brown	36.9	59.5
Leonard × Akron cross (LA-8)	Light brown	39.4	56.6
Leonard × Akron cross (LA-9)	Light brown	38.9	57.3
Leonard × Akron cross (LA-11)	Light brown	38.4	57.6
Leonard × Akron cross (LA-12)	Light brown	35.9	60.3
Leonard × Akron cross (LA-13)	Very dark brown	28.0	67.0
Leonard × Akron cross (LA-14)	Very dark brown	27.0	68.0
Leonard × Akron cross (LA-15)	Light brown	38.9	57.2
Leonard × Akron cross (LA-16)	Light brown	37.2	58.9
Leonard × Akron cross (LA-17)	Light brown	38.8	57.4
Leonard × Akron cross (LA-18)	Light brown	38.3	57.7
White proso millets			
Minco-White early type (Minnesota)	Creamy white	56.7	40.3
Abarr-Colorado release from common white	Creamy white	53.8	43.0
CW-21; selection from common white	Creamy white	57.7	39.8
CW-21-3; selection from CW-21	Creamy white	56.8	40.7
Leonard-Colorado release	Creamy white	52.4	44.9
Leonard-Colorado release (tan seeded)	Creamy white	49.9	46.7
Dawn-Nebraska release	Creamy white	52.4	44.0

[a] Grain samples ground in Udy Cyclone Mill (0.4-mm screen) before color measurements. Standard Hunter values: $L = 94.7; a = -0.6; b = 0.1; \Delta E = \sqrt{(\Delta L^2) + (\Delta a)^2 + (\Delta b)^2}$.

TABLE II
Proximate Composition of Proso Millets

Millet Sample	Moisture (%)	Ash[a] (%)	Crude Fat[a] (%)	Nitrogen[a] (%)	Crude Fiber[a] (%)
Turghai I	9.2	4.9	9.9	2.26	8.3
Turghai II	9.1	4.5	6.9	2.43	8.3
Akron	9.0	4.0	6.5	2.49	9.7
Dawn	8.5	8.1	8.6	2.47	7.1
Leonard	9.7	3.5	9.8	2.16	7.5
Leonard	9.4	3.6	9.7	2.24	8.1
Big Red	9.1	3.6	9.5	2.25	8.0
Minco	9.0	3.8	10.1	2.21	4.4
Abarr	9.3	3.6	9.8	2.28	4.8

[a] "As-is" basis.

TABLE III
Phytate and Tannin Content of Whole Grain Proso Millets

Millet	Phytate Content[a] (%)	Tannin Content Catechin Equivalent (%)[a]
Minco	0.31 ± 0.01	0.059 ± 0.003
Abarr	0.25 ± 0.04	0.064 ± 0.001
Turghai II	0.28 ± 0.01	0.100 ± 0.001
CW-21	0.29 ± 0.02	0.058 ± 0.001
CW-21-3	0.34 ± 0.00	0.055 ± 0.002
Leonard	0.28 ± 0.03	0.076 ± 0.003
Dawn	0.47 ± 0.02	0.071 ± 0.002
Turghai I	0.45 ± 0.03	0.093 ± 0.001
Akron	0.40 ± 0.02	0.109 ± 0.008
Big Red	0.31 ± 0.02	0.112 ± 0.008
Leonard	0.23 ± 0.01	0.065 ± 0.001
LA-2	0.28 ± 0.01	0.092 ± 0.008
LA-4	0.32 ± 0.03	0.097 ± 0.006
LA-6	0.32 ± 0.03	0.100 ± 0.004
LA-8	0.27 ± 0.03	0.088 ± 0.008
LA-9	0.29 ± 0.01	0.105 ± 0.008
LA-11	0.26 ± 0.02	0.097 ± 0.001
LA-12	0.17 ± 0.03	0.090 ± 0.001
LA-13	0.30 ± 0.03	0.178 ± 0.006
LA-14	0.26 ± 0.03	0.156 ± 0.010
LA-15	0.30 ± 0.00	0.093 ± 0.002
LA-16	0.35 ± 0.01	0.108 ± 0.010
LA-17	0.23 ± 0.01	0.081 ± 0.002
LA-18	0.26 ± 0.00	0.082 ± 0.001

[a] "As-is" basis.

TABLE IV
Phytate and Tannin Content of Proso Millet Hulls and Dehulled Grain Samples

Millet	Grain Samples	Phytate Content[a] (%)	Millet	Grain Samples	Tannin Content Catechin Equivalent, %[a]
Abarr	Hulls	0.65	Turghai II	Hulls	0.557
	Dehulled grain	0.18		Dehulled grain	0.023
Dawn	Hulls	1.60	Akron	Hulls	0.601
	Dehulled grain	0.27		Dehulled grain	0.027
Turghai II	Hulls	1.13	Big Red	Hulls	0.546
	Dehulled grain	0.33		Dehulled grain	0.024
Big Red	Hulls	0.54	Leonard	Hulls	0.357
	Dehulled grain	0.27		Dehulled grain	0.026
Leonard	Hulls	0.51	LA-13	Hulls	1.301
	Dehulled grain	0.18		Dehulled grain	0.034
			LA-14	Hulls	1.243
				Dehulled grain	0.034

[a] "As-is" basis.

Tannins in cereals were generally believed to be limited to grain sorghum (0.21–3.11% catechin equivalent) and barley (Maxson and Rooney 1972). No tannins were detected in pearl millets (Hoseney et al 1981). However, Ramachandra et al (1977), using the vanillin-HCl procedure to analyze 19 Indian and 10 African varieties of finger millet for tannins, found two Indian cultivars with tannin contents of more than 1% (catechin equivalent) and two African cultivars that contained more than 3% tannins. Amounts of tannins in proso millets in this study ranged from 0.055 to 0.178% catechin equivalent. The dark cultivars (LA 13 and LA 14) had the highest tanning contents, whereas the light-colored cultivars (all white proso millets) were comparatively low in tannins. This observation is in agreement with previous reports that state that dark seeds are generally higher in tannin content than light seeds (Ma and Bliss 1978).

Dehulling finger millets greatly lowered the tannin level and increased in vitro protein digestibility (Ramachandra et al 1977). Decreased tannin levels were also found when proso millets were dehulled (Table IV). Dehulling reduced tannin levels by 65–80%. The hulls contained 15–40 times as much tannin as the dehulled grains.

ACKNOWLEDGMENTS

We thank G. Hinze, Dept. of Agronomy, Colorado State University, and W. Dilsaver and B. Wright for technical assistance.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1969. Approved Methods of the AACC. Methods 08-01, 30-10, and 32-15, approved April 1961; Method 44-15A, approved October 1975; and Method 46-11, approved October 1976. The Association, St. Paul, MN.

BARBER, S. 1972. Milled rice and changes during aging. Page 215 in: Rice: Chemistry and Technology. D. F. Houston, ed. Am. Assoc. Cereal Chem., St. Paul, MN.

BASSIRI, A., and NAHAPETIAN, A. 1977. Differences in concentrations and interrelationships of phytate, phosphorus, magnesium, calcium, zinc, and iron in wheat varieties grown under dryland and irrigated conditions. J. Agric. Food Chem. 25:1118.

BURNS, R. E. 1963. Methods of tannin analysis for forage crop evaluation. Tech. Bull. N.S. 32, Georgia Agric. Exp. Stn., Athens.

BURNS, R. E. 1971. Method for estimation of tannin in grain sorghum. Agron. J. 63:511.

BURTON, G. W., WALLACE, A. T., and RACHIE, K. O. 1972. Chemical composition and nutritive value of pearl millet (*Pennisetum typhoides*). Crop Sci. 12:187.

CASEY, P., and LORENZ, K. 1977. Millet functional and nutritional properties. Bakers Dig. 51(1):45.

DEOSTHALE, Y. G., NAGARAJAN, V., and PANT, K. C. 1970. Nutrient composition of some varieties of ragi (*Eleusine coracana*). J. Nutr. Diet. 7:80.

DEOSTHALE, Y. G., RAO, K., NAGARAJAN, V., and PANT, K. C. 1971. Varietal differences in proteins and amino acids of grain bajra (*Pennisetum typhoides*). Ind. J. Nutr. Diet. 8:301.

ELLIS, R., and MORRIS, E. R. 1983. Improved ion-exchange phytate method. Cereal Chem. 60:121.

FREEMAN, J. E., and BOCAN, B. J. 1973. Pearl millet: A potential crop for wet milling. Cereal Sci. Today 18:69.

GOSWAMI, A. K., SHARMA, K. P., and SEHGAL, K. L. 1970. Chemical composition of bajra grains. 4. Indian varieties. Ind. J. Nutr. Diet. 7:67.

HINZE, G. 1972. Millets in Colorado. Bull. 553S. Colorado State University Experiment Station, Fort Collins. 12 pp.

HOSENEY, R. C., VARRIANO-MARSTON, E., and DENDY, D. A. V. 1981. Sorghum and millets. Page 71 in: Advances in Cereal Science and Technology. Vol. IV. Y. Pomeranz, ed. Am. Assoc. Cereal Chem., St. Paul, MN.

JOSEPH, K., KURIEN, P. P., SWAMINATHAN, M., and SUBRAHMANYAN, V. 1959. The metabolism of nitrogen, calcium and phosphorus in undernourished children. Br. J. Nutr. 13:213.

KURIEN, P. P. 1967. Nutritive value of refined ragi (*Eleusine coracana*) flour. Ind. J. Nutr. Diet. 4:96.

LORENZ, K., MacFARLAND, G., and HINZE, G. 1976. The mineral composition of proso and foxtail millets. Lebensm. Wiss. Technol. 9:357.

MA, Y. and BLISS, F. A. 1978. Tannin content and inheritance in common bean. Crop Sci. 18:201.

MAXSON, E. D., and ROONEY, L. W. 1972. Two methods of tannin analysis for *Sorghum bicolor* (L.) Moench grain. Crop Sci. 12:253.

NAHAPETIAN, A., and BASSIRI, A. 1976. Variations in concentrations and interrelationships of phytate, phosphorus, magnesium, calcium, zinc, and iron in wheat varieties during two years. J. Agric. Food Chem. 24:947.

O'DELL, B. L. 1969. Effect of dietary components upon zinc availability. Am. J. Clin. Nutr. 22:1315.

PRICE, M. L., HAGERMAN, A. E., and BUTLER, L. G. 1980. Tannin in sorghum grain: Effect of cooking on chemical assays and on antinutritional properties in rats. Nutr. Rep. Int. 21:761.

PRUTHI, T. D., and BHATIA, I. S. 1970. Lipids in cereals. I. *Pennisetum typhoideum*. J. Sci. Food Agric. 21:419.

RAMACHANDRA, G., VIRUPAKSHA, T. K., and SHADAKSHARASWAMY, M. 1977. Relationship between tannin levels and in vitro protein digestibility in finger millet (*Eleusine coracana* Gaertn.). J. Agric. Food Chem. 25:1101.

SCHERY, R. W. 1963. Plants for Man. Prentice-Hall, Inc., Englewood Cliffs, NJ.

TABEKHIA, M. M., and DONNELLY, B. J. 1982. Phytic acid in durum wheat and its milled products. Cereal Chem. 59:105.

THOMPSON, D. B., and ERDMAN, J. W., Jr. 1982. Structural model for ferric phytate: Implications for phytic acid analysis. Cereal Chem. 59:525.

WHEELER, E. L., and FERREL, R. E. 1971. A method for phytic acid determination in wheat and wheat fractions. Cereal Chem. 49:312.

[Received February 3, 1983. Accepted May 20, 1983.]