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Phytate and Tannin Content of Amaranth

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ABSTRACT

The phytate and tannin contents of eight varieties of amaranth were determined. The phytate content of amaranth (0·52–0·61%) was higher than that of rice and millet, but lower than that of corn and wheat. Phytate is distributed throughout kernels of amaranth. Phytate content cannot be reduced by removal of the seed coat.

Tannin levels of amaranth (0·043–0·116% catechin equivalent) were small in comparison with those in sorghum and millet. Tannin levels in the seed coat of amaranth are higher than those in the starchy perisperm.

INTRODUCTION

For centuries both vegetative and grain varieties of amaranth have been a dietary staple for humans in Mexico, Central and South America, as well as in certain areas of Africa and Asia (Sauer, 1950).

Amaranth is fast growing in almost any soil. It is resistant to moisture stress and produces good yields in heads similar to those of sorghum (Pal & Khoshoo, 1974). Recent growing trials on experimental farms and garden plots in various areas of the USA have produced grain yields of up to 2300 lbs per acre (Ruttle, 1976). The nutrient composition of Amaranth grain—total protein, amino acid composition, mineral and vitamin compositions—has been comparable or even better than that of common cereal grains (Ruttle, 1976; Becker *et al.*, 1981).

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The leaves of the plant are edible. The grain can be milled into flour to be used in various baking applications (Lorenz, 1981).

There are no reports in the literature about the phytate and tannin (phenolic substances) contents of various amaranth species. These compounds are of concern from a nutritional standpoint because of possible mineral complexing of phytate and the binding of tannins to proteins with a reduction in digestibility.

The present study was conducted to determine the effect of variety on phytate and tannin contents of amaranth.

MATERIALS AND METHODS

Sample identification

This study included eight samples of Amaranth—four accessions from a germplasm collection of *A. cruentus*, two samples from a collection of *A. hypochondriacus*, one sample of *A. hybridus* and a cross between *A. hypochondriacus* and *A. hybridus*. The samples were grown on experimental plots at the Organic Gardening and Farming Research Center of the Rodale Press in Kutztown, Pennsylvania.

Proximate analysis

Samples were analyzed for moisture, crude fat, ash and nitrogen by AACC approved methods 44–15A, 30–10, 08–01 and 46–11, respectively (AACC, 1966).

Phytate and tannin determination procedures

Unfortunately, there are neither good standards nor very standardized methods for either of these compounds. Phytate content was determined by the method of Wheeler & 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 trichloracetic 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 Fe:6 P molecular ratio in the precipitate. The standard curve

for iron was prepared using 1·6M sulfuric acid to prevent $Fe(OH)_3$ formation. Four-gram samples of ground material (non-dehulled and dehulled grain) and 0·5-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 non-dehulled grains was done by hand.

Tannin content was determined colorimetrically using the vanillin–HCl method of Burns (1963, 1971) as modified by Maxson & Rooney (1972). The amount of tannin measured was expressed as catechin equivalent. Two-gram samples of the ground non-dehulled and dehulled grains and 0·4 g of ground hulls were used for analyses.

All values represent the means of three analytical replications.

RESULTS AND DISCUSSION

Proximate composition

Proximate composition and seed coat color of amaranth varieties included in this study are given in Table 1. *A. hybridus* is a black-seeded

TABLE 1
Proximate Analysis of Amaranth Grains*

Sample	*Color of seed coat*	*Ash* (%)	*Crude fat* (%)	*Nitrogen* (%)	*Protein*[a] (%)
A. cruentus					
I	Golden brown	3·3	8·1	2·22	13·9
II	Golden brown	3·2	7·2	2·12	13·2
III	Black	3·4	6·5	2·17	13·6
IV	Black	3·6	6·3	2·24	14·0
A. hypochondriacus					
I	Golden brown	3·3	7·7	2·22	13·9
II	Golden Brown	4·1	7·1	2·22	13·9
A. hybridus					
	Black	4·2	6·4	2·25	14·0
A. hypochondriacus × *A. hybridus*	Golden brown	3·9	7·8	2·65	16·5

* On a dry matter basis.
[a] % Protein = % nitrogen × 6·25.

species, whereas *A. cruentus* and *A. hypochondriacus* may be either black or golden-brown seeded.

The proximate composition (ash, crude fat, nitrogen) of the grains of all amaranth varieties fell within the range of values reported in the literature (Saunders & Becker, 1983).

Phytate contents

Phytates are widely distributed in plants, especially in seeds. The primary rôle of phytate may be that of a phosphorus store that is gradually utilized during germination (Nahapetian & Bassiri, 1976).

Numerous studies have indicated that phytate reduces the bioavailability of dietary Mg, Ca, Zn and Fe in monogastric animals (Bassiri & Nahapetian, 1977). Human deficiencies in Ca, Zn and Fe have been reported to correlate with the presence of phytate in the diet (Walker *et al.*, 1948). Man has low phytase activity in the intestine and, therefore, is unable to cleave, completely, minerals from the phytate complex (Cosgrove, 1966). The phytate content of amaranth grain is, therefore, of concern from a nutritional standpoint.

Phytate values of whole grain amaranth used in this study are given in Table 2. Values ranged from 0·52 to 0·61 %. The values are higher than phytate values of rice, which have been reported to be 0·10 to 0·14% (Barber, 1972). Corn and durum wheat have higher phytate contents than

TABLE 2
Phytate and Tannin Contents of Whole Grain Amaranth*

Amaranth	*Phytate content* (%)	*Tannin content catechin equivalent* (%)
A. cruentus I	0·56 ± 0·02	0·059 ± 0·006
II	0·56 ± 0·02	0·043 ± 0·002
III	0·52 ± 0·02	0·105 ± 0·003
IV	0·54 ± 0·01	0·104 ± 0·006
A. hypochondriacus I	0·56 ± 0·02	0·054 ± 0·002
II	0·59 ± 0·03	0·065 ± 0·007
A. hybridus	0·61 ± 0·02	0·116 ± 0·010
A. hybridus × *A. hypochondriacus*	0·61 ± 0·03	0·060 ± 0·003

* On a dry matter basis.

amaranth grain. O'Dell (1969) reported 0·90 % phytate in corn. Tabekhia & Donnelly (1982) found phytate to range from 0·98 to 1·43 % in durum wheats.

Dehulling of cereal grains always results in a significant reduction in phytate content of the grain.

Dehulling of proso millets results in a 27–53 % reduction in phytate content in the dehulled grain. Hulls contained two to six times as much phytate as the dehulled grains (Lorenz, 1983). The endosperm of wheat and rice are almost devoid of phytate, while the outer layers of the grains are quite high in the compound (O'Dell *et al.*, 1972). Essentially all corn phytate is located in the germ (O'Dell & Boland, 1976).

Phytates in oilseeds occur however throughout the kernel (Martinez, 1977). This is also true for amaranth. Hulls and dehulled grains had very similar phytate contents (Table 3).

TABLE 3
Phytate and Tannin Contents of Amaranth Hulls and Dehulled Grain Samples*

Amaranth	*Phytate content* (%)	*Tannin content catechin equivalent* (%)
A. cruentus III—Hulls	0·48	0·547
Dehulled grain	0·50	0·094
A. hypochondriacus II—Hulls	0·44	—
Dehulled grain	0·55	—

* On a dry matter basis.

Tannin contents

Phenolic substances (tannins) have been reported at significant levels in some cultivars of barley and sorghum (Maxson & Rooney, 1972). No tannins were detected in pearl millets (Hoseney *et al.*, 1981). However, Ramachandra *et al.* (1977), using the vanillin–HCl procedure to analyse nineteen Indian and ten African varieties of finger millet for tannins, found two Indian cultivars with tannin contents of over 1 % (catechin equivalent) and two African cultivars which contained over 3 % tannins. Amounts of tannins in proso millets ranged from 0·055 to 0·178 % catechin equivalent (Lorenz, 1983).

In sorghum normal cooking procedures do not overcome the harmful

effects of tannins, 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; Price *et al.*, 1980).

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).

Amounts of tannins in amaranth species included in this study ranged from 0·043 to 0·116 % catechin equivalent. The dark varieties (*A. cruentus* III and IV, *A. hybridus*) had the highest tannin contents, while the light-colored varieties were comparatively low in tannins. This observation agrees with previous reports which state that dark seeds are generally higher in tannin content than light seeds (Yu Ma & Bliss, 1978).

Dehulling of millets greatly lowered the tannin level (Lorenz, 1983; Ramachandra *et al.*, 1977) and increased *in vitro* protein digestibility (Ramachandra *et al.*, 1977). Decreased tannin levels were also found when amaranth was dehulled (Table 3). The hulls contained approximately six times as much tannin as the dehulled grains.

CONCLUSIONS

Tannin levels in various species of amaranth were found to be small in comparison with levels of these compounds in other small food and feed grains such as sorghum and millet. Dehulling further reduces tannin content.

Phytate contents of amaranth were higher than those in rice and millet, but lower than those in corn and wheat. Phytates occur throughout kernels of amaranth and dehulling does not reduce phytate content of the dehulled grain.

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

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

However, since most recent phytate data of cereals in the literature were obtained using the ferric ion precipitation method, we felt justified using

this method to be able to compare phytate data of amaranth with those reported for other food- and feed-grains.

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