LEGACY

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Fourth National Amaranth Symposium Issue

From the President

Greetings from the Amaranth Institute and welcome to the National Amaranth Symposium, August 23-25, 1990, Airport Hilton Hotel, Bloomington, MN. We wish to thank our co-sponsors which include the American Society of Agronomy, the Univ. of Minnesota's Center for Alternative Plant and Animal Products, the Minnesota Extension Service, and Rodale Press, Inc.

Modern development of grain amaranths in this country is slightly over a decade old. Amaranth development seems to be moving rapidly when one compares a crop such as soybeans, which was in this country for over 100 years before it was effectively developed as an oil source. Overoptimism and high expectations are typical of the early stages of crop development. Amaranth has been no exception! Nevertheless, it appears that the 1990s will be the decade of the crop's commercialization. We have already passed through the developmental stages of germplasm collection, germplasm development, early breeding, and nutritional characterization.

Will amaranth succeed in becoming a minor staple or even a major staple crop? The answer lies in whether or not commercially viable products are developed hand-in-hand with agronomic and genetic advances. Capital and profits obviously drive the process. Already, we are glimpsing the new potentials for extruded, popped, and milled amaranth products.

Over the past decade, nutritional research has emphasized the usefulness of amaranth's protein. Dr. Ricardo Bressani's work at INCAP suggests that amaranth may be either a supplementary or a complementary source of amino acids for fortified cereals like corn, wheat, and rice. However, with the recent domestic interest in high fiber and complex carbohydrates sources, and cholesterol-lowering products, there is a greater possibility that amaranth will contribute some market-sensitive attributes in addition to protein fortification.

Some of the richest assets of grain amaranths are their genetic resources. Fortunately, many nations, including India, Nigeria, Peru, Mexico, and the United States, have begun to gather and preserve the genetic diversity of this ancient crop. Within the last year, the United States Department of Agriculture funded a pioneering amaranth mission to preserve the sea-beach amaranth--one of the most salt-tolerant amaranths known. This species, *Amaranthus pumilis* Raf., is an endangered one which grows predominantly on shorelines along the Atlantic coast. Belonging to the same part of the amaranth genus as the edible vegetables of Asia (*A. tricolor* L.), it seems unlikely that the sea beach amaranth will immediately be bred into the grains. However, with the advent of genetic engineering and further development of wide crosses in amaranths, the salt-tolerant genes may eventually be tapped. What is most reassuring is the foresightedness of the USDA to preserve this important resource. The same compliment with regards to saving grain and vegetable amaranths should be extended to the other major germplasm centers and the International Board for Plant Genetic Resources!

In an unrelated development, I have just received communication from the KUSA Society and KUSA Research Foundation, P.O. Box 761, Ojai, CA 93023. This society, through its

IN THIS ISSUE

THE AMARANTH UTRICLE

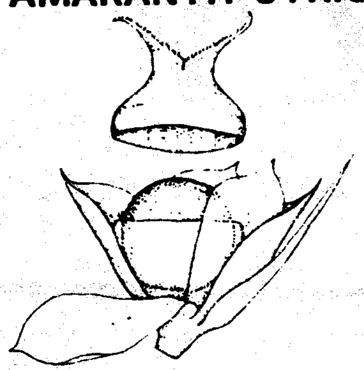

Figure 1. An adult female flower with dehiscent cap (X 8).

GLOSSARY

Abscise--to separate as in a fruit from a plant
Circumscissile--A fruit which dehisces by a horizontal, circular line
Dehisce--To split at maturity
Indehiscent--Not splitting at maturity

biannual magazine called *The Cerealist*, is involved with providing information and seed on edible seedcrops. They apparently are involved with "folk cereals, obsolete cultivars, and improved grain varieties." While I cannot vouch for the organization, it does seem timely that individuals and organizations are evolving that treasure and promote interest in the edible seedcrops. Aside from their professionally printed publicatons, they also are making rare seeds available to members. Perhaps this is in the same fashion as the Seed Saver's Exchange located in Decorah, IA. **I sugggest that the Amaranth Institute should also maintain a base collection of educational and rare seedstocks for public and membership dispersal.** Such a role is certainly not the domain of the underfunded national germplasm banks.

We hope that you enjoy the symposium and the interesting people involved with amaranth development worldwide. Also, we have made sure that copies of proceeding for the three previous U.S. amaranth symposia are available. Naturally, we invite interested people to join our ranks as members, thereby insuring the steady advance of this natural resource through meetings, information, and publications.

Seed Shattering Control with Indehiscent Utricles in Grain Amaranths

David Brenner, Dept. of Agronomy, Iowa State University, Ames, IA 50011, and Holly Hauptli, 11240 West RD, Potter Valley, CA 95469

It is theoretically possible to control seed shatttering in commercial grain amaranths with characteristics from related plants. The commercial grain amaranths, such as *Amaranthus hypochondriacus* L. var. K343, have dehiscent (circumscissile) seed-holding utricles (Figure 1), that split open at seams on their equators, and allow the grains to fall away. The plants that hold special interest possess indehiscent, non-splitting utricles. Without seams, these utricles burst irregularly after abscising from the pedicel. An intermediate type, semi-indehiscent plant has utricles with equatorial seams, but the utricle halves cohere long enough to dry, and fall off the plant before splitting. Theoretically, plant breeders could combine both the indehiscent utricles and the non-abscising connection from pedicel to utricle, (as is already in cultivars) to get new cultivars with less shattering. The inheritance of these characteristics is unknown.

Indehiscent utricles are characteristic of four *Amaranthus* species that have some crossing compatibility with the grain amaranths (Murray, 1940; Sauer, 1955, 1967). The indehiscent character also occurs spontaneously in hybrid weed populations (Sauer, 1967). Four of the most usable sources of indehiscent utricles are listed below. These sources are usable because of good crossing ability with the commercial grain species (Murray, 1940).

1, Indehiscent utricles were found in *Amaranthus* weed populations in the Sacramento river delta, California. These plants are difficult to identify because they possess characteristics of *Amaranthus caudatus, A. cruentus, A. hybridus, A. powellii*, and *A. retroflexus* (Tucker and Sauer, 1958).

2. *Amaranthus powellii* is a widespread North American weed with either dehiscent or indehiscent utricles (Sauer, 1967).

3. *Amaranthus bouchonii* is a European weed species descended from New World plants. It characteristically has indehiscent utricles. Some taxonomists, such as J. D. Sauer (1967) include it in *A. powellii.*

4. Two indehiscent and two semi-indehiscent accessions are already available. These are black-seeded plants with utricles that

WATCH FOR DETAILS ON THE AMARANTH INSTITUTE'S 1991 ANNUAL MEETING NEXT NOVEMBER AT LINCOLN, NEBRASKA

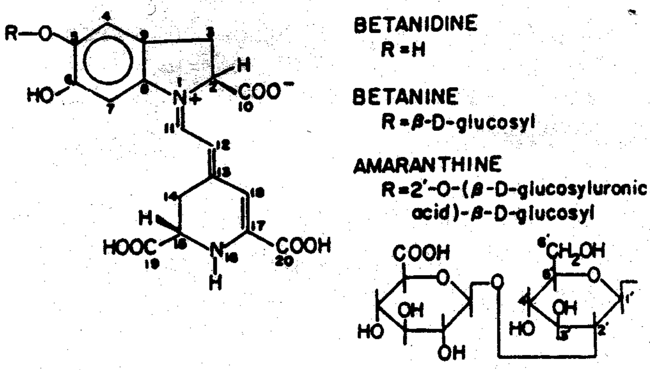

Figure 2. The chemical structure for the pigments amaranthin(e), betanine, and betaninide (Huang and von Elbe, 1986).

abscise before splitting. A hybrid ancestry could be the source of indehiscence in any of them. One of the authors (Hauptli) collected an indehiscent crop-weed hybrid in Peru (PI 511753), and also collected a semi-indehiscent vegetable cultivar, *A. hybridus*, in Mexico (PI 511724). The other two accessions are from Zimbabwe. A vegetable, *A. hybridus* cv. PI 526226, is semi-indehiscent.

Three indehiscent species are evolutionarily more distant from the grain amaranths than the above (Gleason, 1968; Sauer, 1955, 1967), but have some cross-compatability (Murray, 1940). They are: *A. australis*, *A. spinosus*, and *A. tuberculatus*. Many other amaranth species have indehiscent utricles (Gleason, 1968) but unknown cross-compability.

The idea of using indehiscent utricles to control shattering originated with Hauptli. Peter Kulakow of the Land Institute, Salina, KS, has observed a non-shattering plant. Brenner is assembling these plant materials. Those with "PI" numbers are already available for germplasm research, free of charge from the USDA's North Central Regional Plant Introduction Station, Iowa State University, Ames, IA 50011. If anyone can contribute seeds, comments, or collaboration, please contact the authors.

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PIGMENTS OF GRAIN AND FERAL AMARANTHS

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IDAP, Inc., Bricelyn, MN 56014

Red and violet pigments occur throughout the plant genus Amaranthus. These pigments are loosely related to the well-known sugar beet betacyanin called betanin. The aglycone of betanin, betanidin is the major betacyanin in sugar beets (Wyler et al., 1963) (Figure 2.) Coupled with betaxanthins, betacyanins are often termed betalines, which are but one of five plant pigment types, including the anthocyanins, carotenoids, chlorophylls, and curcurmins (Henry, 1950). In A. tricolor (a vegetable amaranth) and A. caudatus (a grain amaranth), the betacyanins were named amaranthin (the 5-0-[2-0-(β-D-glycopyranosyluronic acid)-β-D-glucopyranoside] of betanidine) and isoamaranthin (Piatelli et al., 1964; Piatelli and Minale, 1966; Piatelli et al., 1969).

Historically, amaranth dyes have colored foods, beverages, and bread products in numerous New World locations: the southwestern U.S., Mexico, Bolivia, Ecuador, and Argentina. Even today religious festivals in Mexico include red amaranth flowers mixed with maize dough to form a red paste. Such preparations are strongly reminiscent of the religious ceremonies of the Aztec, Hopi, and Zuñi groups (Sauer, 1950). The Zuñi Indians in New Mexico also used alegría or amaranth juice as a women's facial rouge (Ruxton, 1861).

Few historical records of Old World amaranth dyes are known except in East Africa (Dammer, 1895). Elsewhere in Africa, the Tswana people of South Africa use an infusion of the purple pigment from A. thunbergii [amaranthin?] as a labor-inducing preparation (Watt and Breyer-Brandwijk, 1962). A. caudatus, too, is considered to be an abortifacent in South Africa.

Factors which should be considered in assessing the utility of any plant pigment include: identification and chemical isolation, stability in food applications, yield and seasonal availability, FDA acceptability, and economic analyses of extraction, processing, and storage (Taylor, 1984). Only limited testing of the first two factors has been done on amaranth pigments. For instance, Huang and von Elbe (1986) evaluated the stability of amaranthine from A. tricolor in solution and compared its stability with betanine (sugar beet pigment). They found the range for color stability was comparable to the typical range of most foods (pH 3.0-7.0). Greatest pigment stability was in the acidic pH range of 5.0-6.0.

Amaranthine had equivalent stability to betanine under surplus oxygen but was less stable than betanine when oxygen was absent. To overcome these stability problems, sugar beet dyes form stable tea-pigment complexes through tea polyphenols and have their "degradative enzymes inhibited (Taylor, 1984)." This technology, which makes tea and red beet dyes temperature- and pH-independent, has apparently not been applied to amaranthine. Also, the use of isoascorbic acid, low water activity, citric acid, and EDTA to stabilize amaranth pigments has not been explored (Pasch, 1980), although their use is betanin model systems has been postulated. Overall, unstabilized betalines are most suited to food applications which are exposed to little heat during processing, can tolerate a short shelf life, are marketed in a dry state, and are not exposed to light and oxygen (von Elbe, 1977).

Because amaranth pigments are very similar to sugar beet pigments, the likely applications include: "yogurt, sherbert, ice creams, fozen fruit desserts, candies, frostings, and puddings (Freund et al., 1988)" and bacon, sausage, and confections. Certainly, amaranthine will be in competition with betanin in such applications and will probably be blended with tumeric, carmine or carmel colors for a specific formulation. Unlike sugar beet dye extraction after sugar processing, grain amaranth stems and inflorescences would have to be harvested and then processed. Alternatively, tissue culture to produce amaranth pigments was proposed by Teutonico and Knorr (1985).

Another pigment stability study on A. tricolor, the Asian vegetable amaranth, revealed that low temperatures greatly increased pigment shelf-life (Shen and Sun Hwang, 1986). Half lives of the pigment were 0.77, 29, and 670 days at 20^{o} C, 4^{o}, and -15^{o} C., respectively. Oven drying of leaves at 80^{o} C. to a moisture content of 5% was found to be superior to solar and air drying. Pigment content of A. tricolor leaves reached a maximum content at 25 to 30 days after planting.

The biosynthesis of amaranth pigments and the interaction of these pigments with plant hormones like cytokinin have been extensively studied. Three examples will be given here. Garay and Towers (1966) found that the amino acid, L-tyrosine, was a good precursor of amaranthin biosynthesis in the variety A. sp. var. Molten Fire. Adminstering dihydroxyphenylalanine (DOPA) and tyrosine to young seedlings exposed to light increased amaranthin production 189% and 125%, respectively. More recently, Elliot (1983) investigated cytokinin effects on tyrosine hydroxylation prior to pigment production and Nishikawa et al. (1989) developed highly sensitive assays for cytokinin in A. caudatus seedlings.

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Now Available from the Amaranth Institute:

PROCEEDINGS OF THE FOURTH NATIONAL AMARANTH SYMPOSIUM: PERSPECTIVES ON PRODUCTION, PROCESSING AND MARKETING

Held In Minneapolis, MN, August 23-25, 1990

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WHAT IN A WORD?-- AMARANTH

Which is the meaning that we use for the Institute?

1. A plant of the genus *Amaranthus*
2. An imaginary flower supposed to never fade
3. A color described as dark reddish purple
4. A red azo dye used in coloring foods and beverages.

(Answer: No. 1)