

LEGACY

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From the Amaranth Institute President:

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Welcome to the current issue of Legacy. I would like to formally invite all readers to become new members of the Amaranth Institute, and for old members to renew their memberships (if they have not done so already). Also, please consider attending our annual meeting being held 21-22 August at NDSU, Fargo, ND. Dr. Al Schneider and Dr. Patricia Rayas-Duarte (NDSU) are doing an excellent job of planning a program, focusing on utilization and marketing amaranth, and including presentations by farmers and agronomists. Some recent research findings may be of great interest to amaranthologists.

The purpose of this organization is to facilitate communication among farmers, marketers and researchers towards the development of amaranth as a viable crop and product option. Our organization is small, but it often amazes me what a dedicated group of people can accomplish when they put their minds to it. We welcome your involvement!

AMARANTH AND THE CURRENTS OF HISTORY

I have been thinking a lot lately about the historical context of new-crop development. Occasionally I am reminded by our resident pundit, and former Amaranth Institute president, Dr. Jim Lehmann, of the importance of interactions between human culture and agricultural crop species. Crops are truly artifacts of human history. Asking questions related to the coevolution of plant species (e.g. Why was amaranth so important to the religion of the Aztecs?; When and how did amaranth make the journey to the old world?; or, What was the evolutionary significance of antioxidants in amaranth oils?), might enable us to discover its value today, and

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Notices

BARRIER BREAKING AMARANTH MEETING

The sixth annual Amaranth Institute meeting will be held in Fargo, North Dakota, August 21 to 22, 1992. The title is "Breaking Barriers in Amaranth Production and Utilization." It will be sponsored by North Dakota State University (NDSU) and the Amaranth Institute. The program will feature speakers from many states talking about new products and production. The meeting sessions will be in Loftsgard Hall on the North Dakota State University campus. We will also have a tour of research plantings.

The pre-registration is \$35, or \$45 at the meeting

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GRAS STATUS FOR GRAIN AMARANTH

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The Amaranth Institute petitioned the Food and Drug Administration (FDA) for amaranth grain to be recognized as GRAS (Generally Regarded as Safe). Because grain amaranth was not commonly used as a food in the United States prior to January 1, 1958, the FDA must establish if it is GRAS. Legally, foods are judged on the basis of whether or not there are known detrimental effects and safety hazards. For the past five years, the Amaranth Institute has received ambiguous statements from the FDA concerning these matters. Apples and wheat, for example, don't need GRAS status because they were common U.S. foods in 1958, but crops like quinoa and amaranth, which are becoming more popular, fall into an untested territory. Ironically, grain amaranth has been documented as one of the United States' oldest crops and was consumed in the desert Southwest prior to nationhood.

Foods can enter the food supply without FDA approval if the supplier has evidence of the food's safety and properly qualified experts consider the food safe. Because of this situation, some observers have questioned the need to instigate a GRAS petition. After some deliberation, the Amaranth Institute decided that the petition would serve a dual purpose: i) meet the legal requirements for commercialization and industrialization, and ii) establish a baseline of research and development documentation within key government agencies. The latter goal, we believe, could smooth the grain's introduction into international commerce and facilitate domestic seed and grain processing standards. Another motivation for the GRAS petition was the perceived caution by industry in approaching amaranth foods, protein, and starch. Apparently the controversy about psyllium from India as a food ingredient or as a laxative created misperceptions of crops such as amaranth or quinoa.

On Monday, January 3, 1992, a legal notice, on behalf of the Amaranth Institute, was filed in the Federal Register. The notice

documented a petition to consider amaranth grain as a direct human food ingredient with GRAS status (Docket No. 91G-0452, Petition GRASP 1G0372). A thirty-page petition, supported by over 80 scientific papers and proceedings, was filed. The review period for the petition is currently open while the Amaranth Institute prepares an abbreviated environmental assessment or claim for categorical exclusion from FDA's environmental requirement 21 CFR Part 25. The environmental assessment statement will include these topics:

1. Grain amaranths and their wild allies history as an integral part of North America's ecosystems.
2. Grain amaranths and their wild allies' impact on soil residues, mineralization, microfauna, and microflora.
3. Predicted impact of processing grain amaranth with regard to by-products and wastes.

**GENERALLY
REGARDED
AS SAFE**

AMARANTH AND THE CURRENTS OF HISTORY
(Continued from p. 1)

increase its adaptation to our culture.

History is full of twists and turns; it is serendipitous, quirky, and essentially unpredictable. Sometimes the most unpredictable events can be the most important (witness the dramatic end of the Soviet state). Each of us can think of examples in our own lives. The unpredictable historical impact of agricultural crops has been brought to our attention this year with the quincentennial of the Columbus voyage, as we contemplate the tremendous exchange of crops, livestock, and diseases, (and of course people), which accompanied the leap across the big puddle. The "Seeds of Change" exhibit, which I visited at the Smithsonian Institute earlier this year, does an excellent job of describing the importance of this biological exchange (amaranth was featured in some of the

very early illustrated texts from the 1500s). This exchange should remind us of the impact of new crop introduction. Ask yourself this: "what would the Africans do without peanuts, the Indians do without chilies, the Irish or Poles do without potatoes, the Italians do without tomatoes, or the whole world do without maize?" All of these species were (only a short time ago, historically) new crops from the Americas (as is amaranth).

Each of these species found an important role in the culture of the society to which they were transported, and filled an important need or niche not previously met by an "old" crop. For example, historians of the potato note that not only did this energy-rich tuber provide a high-yielding food source, but stores of potatoes in the field could not be as easily raided as granaries by invading armies. Potatoes became an important crop because of a convergence of ecological, cultural and historical factors. Crops such as amaranth (which also made the same trip), became only curiosities in Europe, largely because those cultures did not discover ways to easily incorporate the crop into their diet; the grains of amaranth were too small to be easily ground by primitive flour mills. Initial mistrust may have also played a role, as it did with the tomato.

Such was not the case in the introduction of amaranth to India. I made a trip to India last summer which took me from the foothills of the Himalayas to the Deccan Plateau and the coastal rain-forest (a journey made centuries ago by our crop amaranth). I was fascinated to learn that not only was amaranth grown by farmers at the highest habitable regions of the Himalayas, but it's grown in arid regions of the plains and throughout the subcontinent. Amaranth assumes special significance because it is eaten during religious fast days (when pulses and grains are banned). At other times it is eaten as a leafy vegetable or popped as a candy, "chikki". Unlike Europe, and because of particular cultural factors, the new-world amaranths found a place in India. It is widely adapted and reasonably high yielding. Amaranth is cited in ancient religious texts (perhaps holdovers from earlier Asian amaranth forms?), and has many Indian names. It is hypothesized that amaranth found its way to Surat and South India via Portuguese traders, and eventually made its way to the Himalayas.

I do not mean to imply that amaranth occupies large acreage there (it does not), but it is grown, and one can find amaranth leaves in the market and amaranth candies are sold on the trains. In the subcontinent, amaranth is still very much an underutilized crop. There, as here, tradition dictates eating habits, and amaranth is not widely utilized in daily diets. The Indian market is huge; Indian scientists and entrepreneurs would benefit from cooperating (as we can here) to develop detailed information about amaranths agronomy, nutritional value, and new products.

Some of this seems to be developing. I visited with Dr. G.L. Bansal, a plant physiologist at Himachel Pradesh Agricultural University (Palampur, H.P.), who is beginning a project to study the physiology of amaranth (starting 1992, for 3 years), funded by the USDA. His proposed work on growth analysis and photosynthetic efficiency in grain and vegetable amaranths will develop new knowledge as to the relative physiological efficiency of

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amaranth lines in their region. He is also working on a "multiple-use" model for amaranth: harvesting the leaves for food or fodder, and later harvesting the grain. Germplasm exploration is also important. Dr. Bansal and I visited Dr. Joshi, a plant collector, who has trekked the mountains to discover the true riches of the Himalayas: the many diverse types of plants of this region. He has published a valuable record of his experiences with amaranth germplasm (Grain Amaranths: The future food crop. by B.D. Joshi and R.S. Rana, National Bureau of Plant Genetic Resources, Reg. Stn. Phagli, Shimla 171004, India, 1991), which contains much useful information. I was also able to visit many excellent scientists in New Delhi, Hyderabad, and Bangalore, and there is some activity on amaranth at each of these locations, and several varieties have been released. A number of researchers in India have been working on amaranth for decades, especially the geneticists M. Pal and R.M. Pandey in north India, and Dr. Kulkarni, food scientist in Bombay. There is certainly a core of expertise in India which may bode well for the future of amaranth in the subcontinent.

But the positive attributes of amaranth grain will remain academic unless we develop products or applications which consumers like and will be widely accepted. There's the rub: finding the special qualities, or roles amaranth plays, that are unique to any culture (it is my belief that there are several unique, and underexploited, characteristics of amaranth). Mrs. Bansal, a nutritional professional at Palampur, was quite inventive in producing many different dishes of amaranth, including a pancake made with chickpea, spinach-like preparations of the greens, and a cereal made from the popped grain with cardamom (quite delicious!). More of this type of imaginative thinking is required to incorporate amaranth in the diet.

We should not underestimate the potential worldwide value of amaranth as a crop. By the turn of the next century, India's population is likely to exceed 1 billion, a distinction that China has already attained. Amaranth's drought resistance, high growth rate, and high protein and energy content of the seed, and potential for multiple use, may enable a future role for this crop in helping to feed future populations. With research and experimentation, amaranth could be readily incorporated into flours, chapaties, cereal products and other commonly used foods to increase quality. I recently met with Richard Grimshaw, a scientist at the World Bank in Washington, D.C. who reported on the developing use of amaranth (especially as a forage) in many parts of China.

Norman Borlaug, one of agronomy's few claims to a Nobel Prize, in a speech last week at the University of Minnesota not only raised the specter of the "population monster," but emphasized the importance of interdisciplinary cooperation in agricultural development. The human factor is important, and we should heed his advice in our efforts with amaranth. Whether in the private or public sector, we should cultivate a culture of ethics and cooperation (do these words seem missing from our current public vocabulary?), free exchange of ideas and information (and seeds) across the boundaries of self interest, and seek to enhance creativity across many disciplines and professions. We have much to learn from each other. This is the inspiration behind the Amaranth Institute, which seeks to bring together farmers, food technologists, entrepreneurs, agronomists, and many others to sit down and discuss each "blind-

man's view" of the elephant amaranth which we each "see" differently. If we are lucky, we may have an important part to play in the continuing history of amaranth.

...Amaranth's drought resistance, high growth rate, and high protein and energy content of the seed, and potential for multiple use, may enable a future role for this crop... to feed future populations.

WHAT THE HECK IS A TARNISHED PLANT BUG?

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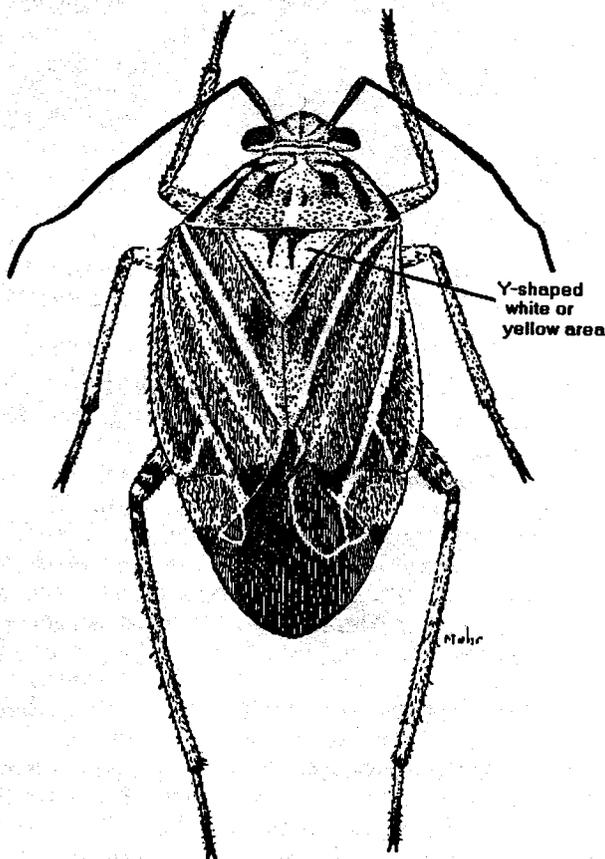
For the past few years, you have heard me say that the most consistent pest we find on amaranth plants is the lygus bug. I felt it was time to take a closer look at this "critter" and provide you with some basic information.

First, let's begin with its name. There are more than a million species of insects crawling over this planet. Taxonomists have developed a system for naming these species. All the insects are combined into a big class called **Insecta**. This group is then subdivided into **orders**. The order **Hemiptera** contains the "true" bugs. Orders are then split into **families**. Lygus bugs are in the family **Miridae**. The families are further split into **genera** and the genera are divided into **species**. We use a general name of "lygus bugs" because they are found in the genus **Lygus**, which contains about 34 species in North America. The most common lygus bug we see on amaranth is the tarnished plant bug (TPB). Its unique scientific name is **Lygus lineolaris**. A common lygus bug on amaranth in our western states is called the "pale legume bug", **Lygus elisus**.

Now let's look at some basic biology. The main reason that lygus bugs are pests is that they are all plant feeders. They are known to feed on over 300 host plant species. The bugs possess piercing-sucking mouth parts especially designed for feeding on plant sap. Some lygus bugs also have a toxic substance in their saliva which causes additional kinds of damage. For example, after the bugs feed, leaves may be deformed, black spots (dead areas) may be evident, and growing points damaged, causing the plants to grow into weird shapes or not grow at all. The main problems we see in amaranth are shriveled seed and broken ends of smaller branches. We've already shown that TPB will greatly reduce seed yield of amaranth when

insect populations are higher than a dozen per head (Olson and Wilson, 1990). In fact, cage tests have dramatically shown that seed can be reduced by over 90% if high populations of TPB are not controlled (Wilson and Olson, 1992 [In press]).

The TPB adult is about 1/4 in long and has a flattened shape. It is yellowish-brown with variable amounts of brown or black mottling on the body. A good



TARNISHED PLANT BUG

Fig. 1

identifying character is the Y-shaped yellow or white mark on its back (we call this area the scutellum). Figure 1 illustrates the location of this Y-shaped area (see Borror et al., 1989, for additional information).

The TPB adult is able to survive our cold winters by hibernating in protected areas. In the spring, the adults mate and eggs are laid on several different plant species. The eggs, which take about a week to hatch, are elongated (see Fig. 2) and are inserted into plant tissue so that the tip is visible (see Fig. 3). When the exposed ends of the eggs are observed (usually under magnification), they resemble a tiny football on the plant surface.

The TPB can go through 2 or 3 life cycles during the growing season. Populations of TPB can vary considerably from year to year. When amaranth plants are available, they prefer to lay their eggs on the heads but will use leaves as their second choice (Wilson and Olson, 1990). Amaranth is a good host plant for TPB because it produces considerable succulent growth needed by the tiny TPB nymphs after they hatch.

The nymphs (immature stage) begin life as tiny green bugs and as they grow larger they begin to develop the characteristic color patterns mentioned earlier. The TPB nymphs have five growth stages called instars. Each instar lasts about 5 days giving the TPB a life cycle interval of 3 to 4 weeks. Figure 2 shows the last growth stage before they become adults. When adulthood is reached, the process repeats itself: the adults mate, lay eggs, and their nymphs grow to adults of the next generation.

Amaranth growers who wish to control the TPB have a serious problem because there are no insecticides registered for controlling lygus bugs on amaranth. Most of the chemical companies are not willing to spend the money to develop pesticides for "minor" crops. Fairfield American Corporation has a chemical called 'Pyrenone Crop Spray' that can be used on amaranth because its active ingredients are safe enough to be exempt from tolerances. However, we don't know if this compound effectively controls lygus bugs.

I am currently looking at plants (e.g., alfalfa, mustard) that are more attractive to TPB than is amaranth. If TPB would feed on these "trap crops" grown around or near amaranth fields, this might help reduce the lygus numbers in the fields and, ultimately, reduce the seed loss. The TPB is here to stay so let's learn to recognize it and if necessary, control it. Good luck!

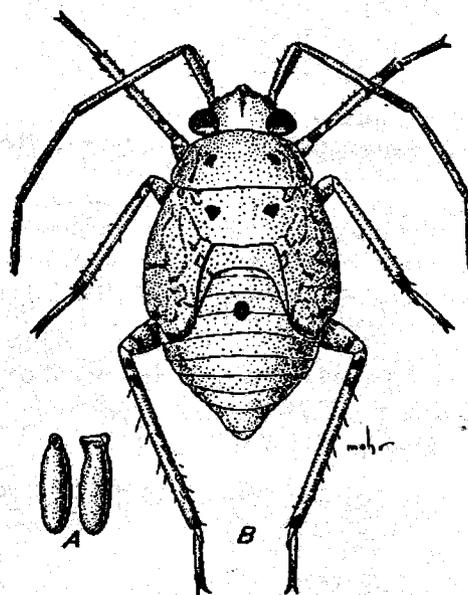
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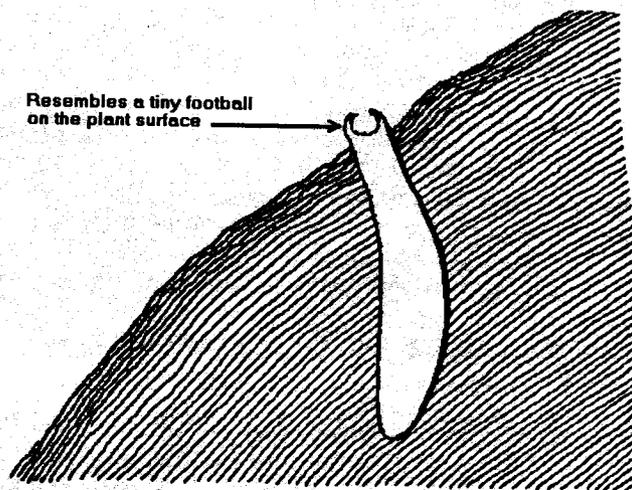
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TARNISHED PLANT BUG A-EGG.
B-5TH STAGE NYMPH
Fig. 2

...cage tests have dramatically shown that seed can be reduced by over 90% if high populations of tarnished plant bug (TPB) are not controlled...



LYGUS BUG EGG EMBEDDED IN PLANT TISSUE
Fig. 3

ANTI-NUTRITIONAL FACTORS IN AMARANTH GRAIN

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Amaranths have long been consumed as cereals, vegetables and forages. There are conflicting reports as to whether they possess any significant toxic or anti-nutritional factors which would limit their usage (Saunders and Becker, 1984). For example, Singhal and Kularni (1988) assert that "anti-nutritive factors...in grain amaranths are unlikely to present any nutritional hazard," while Pond et al. (1989) found anti-nutrients in one line of A. cruentus L. that interfered with growth of rats.

Possible anti-nutritional factors in grain, vegetable and feral amaranths include: saponins and phenolics (Cheeke and Bronson, 1980; Banerji, 1980; Kohda et al., 1991), tannins (Afolabi et al., 1981; Imeri, 1985; Lorenz and Wright, 1984), phytic acid (Pedersen et al., 1987a; Lorenz and Wright, 1984), protease inhibitors (Pedersen et al., 1987; Correa et al., 1986; Fung and Lewis, 1991), oxalates (Hill and Prabdu, 1982; Marshall et al., 1967; Osweiler et al., 1969), nitrates (Arguoudis et al., 1985), polyphenols (Correa et al., 1986), and phytohemagglutinins (lectins) (Pardoe et al., 1970; Bird, 1954; Calderon de la Barca et al., 1985; Zenteno et al., 1985; Zenteno and Ochoa, 1988). Some of these factors, such as oxalates and nitrates, are more often associated with vegetable and forage applications (Saunders and Becker, 1981). Those anti-nutritional factors most pertinent to the amaranth grain will be discussed in greater detail.

TANNINS. Tannins are known to "lower digestibility, reduce mineral bioavailability, [cause] possible carcinogenic effects, lower palatability, and lower growth rates in animals" (Lorenz and Wright, 1984; Hosney et al., 1981; Price et al., 1980). Afolabi et al. (1981) found poor growth or protein efficiency ratio in rats, which they attributed to a "high" tannin content (0.25%) in Amaranthus caudatus L. This species is the main Andean grain amaranth. Becker et al. (1981) studied the tannin content of 10 amaranth grains and found tannic acid ranging from 0.08% to 0.42% in amaranths while proso millet, wheat and triticale had levels of 0.20%, 0.17% and 0.19%, respectively. Ramos and Engleman (1980) investigated the location and developmental deposition of tannins in A. hypochondriacus L. seeds and found them in the testa or epispem of both brown and black varieties. Pal et al. (1990) confirmed that for A. hybridus, tannin deposition occurs in epidermal cells of the ovule's outer integument, while for A. hypochondriacus, tannins were lacking in that outer covering.

Lorenz and Wright (1984) studied phytate and tannin levels in four A. cruentus, two A. hypochondriacus, one A. hybridus, and one A. hybridus X A. hypochondriacus line. Similar to the Ramos and Engleman (1980) report, they concluded that dark amaranth varieties contained the highest tannin contents. Dehulling the amaranth seed decreased the tannin content. They concluded that the

tannin levels in amaranth (0.043-0.116% catechin equivalent) were small in comparison with sorghum and millet" (Lorenz and Wright, 1984).

Pond et al. (1991), while studying effects of heating on amaranth varieties, found that dark seeds of commercial varieties had greater ash and neutral detergent fiber. Comparing light and dark seeds of two commercial varieties, they found that heat treatments were more important factors in animal growth than the seed coat color. An earlier study with cooked amaranth (A. caudatus L.) flour (Imeri et al., 1987) suggested that the small tannin content in this grain disappeared after 30 minutes of cooking in water (autoclaved at 15 lb. pressure for 0-30 minutes).

There appears to be no substantive research on the tannin levels in wild relatives of amaranth, especially those species which may be harvested in Midwestern fields, e.g., A. rudis Sauer, A. tuberculatus (Moq.) Sauer, and A. retroflexus L. The crop improvement associations of Wisconsin, Montana, Kansas, Colorado, Minnesota, South Dakota, Illinois, and Nebraska (Campbell, personal communication, 1989) developed tentative seed certification guidelines, including seed standards for objectionable and noxious weeds.

Dark amaranth seed coat colors are simply inherited, qualitative traits (Y/y, Br/br) (Kulakow et al., 1985). As such, planting true-breeding amaranths with light seed coats will perpetuate the recessive trait. Dark seed coats are often indicative of segregating and outcrossing populations or "wild types." In Mexico, India, and Peru, countries where amaranths have been traditionally consumed, a small percentage of dark seeds is often seen. Primitive varieties or landraces often have from 20% to 30% dark seed coats, as I observed in random seed lots in 1987 at the U.S.D.A. genebank, North Central Regional Plant Introduction Station, Ames, IA. Further, it is possible to sieve out most wild amaranth seeds because they are typically 1/18th to 1/23th inch in diameter, whereas grain amaranth seeds are typically 1/15th to 1/18th inch in diameter.

Overall, dark, tannin-rich seeds of amaranths seem to be more of a cosmetic rather than a nutritional concern. Standards for the proportion of dark seeds desirable or tolerable could be developed as increased processing occurs. Preliminary work in the People's Republic of China has shown that the dark seed coat color [brown and black pigments] could be used as a coloring for cola drinks and soy sauce. Incidentally, the latter application won two product awards at 1988 Chinese food and science exhibitions (Yue, 1991, personal communication).

LECTINS. Lectins are widely present in the food legumes and cereals. Commonly called phytohemagglutinins because they clump red blood cells, they can constitute up to 10% of the total protein in some types of beans (Gupta, 1987). Researchers speculate that plant lectins might act as fungal protectants, as bacterial antibodies, and as factors in plant development and differentiation. If humans or animals consume lectins in high amounts, there can be disruption of nutrient absorption in the intestine, decrease

of digestive enzyme activity, and in extreme cases, death (Gupta, 1987).

Lectins may be the thermolabile factors alluded to in many amaranth feeding studies (Bressani, 1983; Bressani et al., 1987b; Tillam and Waldroup, 1987; Takken and Connor, 1985; Connor et al., 1980; Calderon de la Barca et al., 1985). For instance, Calderon de la Barca et al. (1985) found that heating A. leucocarpus L. lectin for 3 min. at 100° C. irreversibly destroyed its agglutinating activity. They also found a higher protein efficiency ratio (P.E.R.) with whole seed meal than with lectin-extracted seed meal. Because thermolabile factors have been identified in various A. species, e.g. A. edulis (Connor et al., 1980), and A. cruentus (Koeppel and Rupnow, 1988; Bressani et al., 1987a,b), A. caudatus (Pardoe et al., 1970), A. spp. (Arora et al., 1987), it is likely that an array of lectins or multiple forms of a lectin may be present (Lis and Sharon, 1981). All of the aforementioned species are closely related and may share a common progenitor, A. hybridus. To ascertain the amount of immunologically-related lectins, Koeppel and Rupnow (1988) tested the three grain species plus A. hybridus, and the weed A. retroflexus and found that with the exception of A. caudatus, all species of widely divergent origins had similar lectin concentrations. The authors also found that heating A. cruentus lectin at 70° C. for 5 min. destroyed 90% of its activity and the lectin agglutinated all common human blood types as well as erythrocytes of rabbit, sheep, and steer. Bressani et al. (1987a,b) does not concur with the view that nutritionally significant lectins are the thermolabile factor in amaranths.

Certain amaranth lectins may have medical uses; for instance, University of Michigan researchers have found that amaranthin [not the pigment but a proteinaceous lectin] will stain colon cancer and pre-malignant tumors in the human colon (Rinderle et al., 1989; Anonymous, 1989). This technique could potentially supplement colonoscopy in detection of the second leading cancer killer in the U.S. (Boland et al., 1991). In another medical application, Zenteno et al. (1985) found that A. leucocarpus lectin stimulated cell division in both bone marrow and total spleen cells.

PHYTATES. Phytic acid (myo-inositol hexaphosphoric acid) is present at varying levels in amaranths: Amaranthus caudatus 1.1%-1.8% phytic acid, (Pedersen et al., 1987); A. cruentus [A. paniculatus] 0.5-0.6; A. edulis [a form of A. caudatus] 2.2%; A. hypochondriacus 0.5%-0.6%, (Singhal and Kulkarni, 1988). These levels, for the most part, are typical of the conventional cereals. On the negative side, phytates may limit bioavailability of minerals in the diet, while there may be numerous positive effects and uses, e.g., antioxidant effects, anti-carcinogenic effects, and a commercial source of chelating agents (Reddy et al., 1989).

Both phytate (the mono- to dodeca-anion of phytic acid) and dietary fiber may modify mineral absorption and/or form insoluble complexes with the minerals (Cowan et al.,

Comparing light and dark seeds of two commercial varieties, they found that heat treatments were more important factors in animal growth than the seed coat color (Pond et al., 1990).

1966; Sayers et al., 1974). In humans, though, the effect of phytate on Ca absorption may be temporary due to a stimulation of phytase activity in the intestine (Walker, 1951; Cruickshank et al., 1945). Another effect, competitive antagonism of minerals, is possible in high mineral grains such as amaranth. For instance, Pedersen et al. (1987) found a low availability of zinc (Zn) in test rats maintained on certain popped, flaked, and toasted amaranth products with high phytate/Zn ratios. Whether a copper and Zn antagonism or an interaction of amaranth fiber and phytate is possible has not been adequately studied.

Only some hints of the chemistry of amaranth phytates exist: Saunders and Becker (1984) asserted that "the high Ca and Mg levels in amaranth suggested that phytic acid occurs as the insoluble divalent cation salt in the seed." Using scanning electron microscopy, Irving and Becker (1985) examined A. cruentus seed and found phytin inclusions amidst proteinaceous bodies in the seed's embryo."

PROTEASE INHIBITORS. Small levels of heat-sensitive trypsin and chymotrypsin inhibitors are present in A. caudatus grain (Pedersen et al., 1987). Likewise, Correa et al. (1986) found low levels of trypsin inhibitors in A. gangeticus [tricolor], A. anclancalius, and A. hypochondriacus. They found the latter grain species had inhibitor levels of 8000 trypsin inhibitor units (TIG) per gram of sample, whereas raw soybeans levels typically range from 15,000 to 110,000 TIG/g. For more extensive reviews of nitrates, saponins, oxalates, and phenolics in amaranths, researchers are referred to Saunders and Becker (1984), Singhal and Kulkarni (1988), and Teutonico and Knorr (1985).

Thermal processing appears to be the most satisfactory method of reducing any effects of grain amaranth's anti-nutrients (Garcia et al., 1987; Bressani, 1989; Pedersen et al., 1990). Throughout history thermal processing of amaranth has been practiced, but the same could be said for many indigenous foods. Alternatively, heating might have broken the hard seed coat or made the amaranth-based foods more palatable. Early Spanish records, such as the 'Ramirex Codex,' indicate that Aztec rituals included the blending of milled amaranth seed with toasted maize and honey to construct dough figures (Sauer, 1950). Thermal processing via popping has long been used to prepare Mexican "alegría" and in India "laddoos" (Erwin, 1934; National Research Council, 1984). Some

Mexicans, using an unusual grain technology, go one step further and stone-mill the popped amaranth into flour (Early, 1979). Termed "pinole," the popped, milled flour ranks second to alegria in household processing. South Americans continue to pop and roast *A. caudatus* grains (Early, 1988). Finally, the indigenous Seri Indians of Sonora, Mexico, collect wild amaranths and then toast, grind and prepare them as a gruel (Felger and Moser, 1976). All in all, thermal processing is a well-entrenched cultural practice which probably reduces some anti-nutrients.

Amaranth's anti-nutrients should be further studied to

reap the crop's full nutritive value. Because variability exists in amaranths' tannins, lectins, phytates, etc., future studies of anti-nutritional factors should clearly identify the species, origin, and variety. I recommend studies to assess the relative importance of moisture, heat, and duration of heat and their impact on anti-nutrients. For instance, Pond et al. (1991) found that moist heat treatments were superior to dry heat in negating anti-nutrients and/or in increasing the nutritive value. Time-honored and modern methods of thermal processing—popping, roasting, extruding (Breene, 1991), or boiling (Singhal and Kulkarni, 1988)—are recommended to lessen or negate the effects of anti-nutrients.

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A GROWER'S NOTEBOOK

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Puffing up their feathers as well as their amaranth lies well within the right of American Amaranth's Ed Hubbard and product developer Terry Guanella, both of Briceyn, MN. According to the January 18, 1992, issue of the New York Times the pair received US patent 5,069,923 for "a method of popping the seeds without rupturing the embryo that contains the vitamin E." Hats off gentlemen! Your puffing invention and process discovery advances not only your own but all of our work and possibilities with amaranths.

Keep the air flow and seed size up might be the catch phrase to remember for growers cleaning their own re-selections for planting in the 1992 season. This winter, having our sights set on a bulk amaranth sale to a regional seed company, my partner and I fanned 70 pounds of combine run, plot seed to 50 net pounds of seed for sale. According to plan, all immatures and smalls went "over the top." Our germination rate? One hundred percent in two separate checks. That's the kind of information I want customers...and now you to have.

I disagree with some research that suggests nitrogen (N) is the limiting nutrient in amaranth grain yields, or at least the only one. Experience and lots of experiments and observation suggest to me the mega-nutrient in amaranth vigor, growth and yield is available calcium (Ca). In fact N levels over 100# have consistently led to lodging in our standard lines (5.5 - 7 feet) if severe fall weather hits. Nitrogen excesses, when they exist, seem to grow my amaranth back toward the ground! This happens while 60-80 pounds of available N and 300-500 pounds per acre fine grade kiln dust or calcite lime, 80-99 screen, in row have stimulated 1200-1800 pound yields for us within an organic rotation including amaranth. Perhaps it is the N/Ca relationship and interaction our soil scientists should consider for further study.

A bargaining checklist for growers who might sign contracts this year could include some or all of the following items for that kitchen table or phone conversation with the buyer:

*Try to create a pickup pool, a network of growers within a section or township who agree to have so many acres of grain ready for bulk pickup the same day. Next, use the "convenience" and cost-savings of that pickup to bargain price upward so you're sharing the rewards of proximity with your buyer.

*Make every effort to clean your combine-run grain. You'll save yourself, I promise you. Your buyer, in his right mind, will thank you too. Hold back random samples of your cleaned material and keep records of relative weights of your gleaned and waste material. Net weights paid for by your contractor should come close to your own

We farmers, in our enthusiasm to grow a new crop, sometimes forget to be hard-headed business people.

calculations. Of course you must allow him some final room for food-grade cleaning...say 2-3% additional waste if you're really giving him #1 seed, not sending him down the road with trash and pigweed seeds galore. Sometimes, in their enthusiasm and hurry, food grade grain processors push more product over top and sides of fanning mills and gravity separators than they really should. You need not pay the price of that fury.

*No other American producer but a farmer would think of bankrolling a wholesaler in his "manufacturing industry." Insist on the complete payment for your crop at pickup, less a fair estimate of waste, with final give or take to be completed later. We farmers, in our enthusiasm to grow a new crop, sometimes forget to be hard-headed business people. Being amaranth industry lenders is probably unwise for any of us given cash flow problems most of us on farms have these days.

*Require your contract buyer to be bonded. Many states have laws requiring this and some state Agriculture departments have administrative rules with the practical force of law. Though not airtight, bonding is one insurance policy against payment default.

May sun and rain come to all your fields...and at the right time.

--Mike's background: Wisconsin grower since 1981, direct marketer of certified organic amaranth products, covers sustainable agriculture and environmental issues for farm publications, wrote **From the Ground UP**, a book of interviews with Wisconsin's sustainable farmers now entering a second printing.

AMARANTH PRODUCT DEVELOPMENT IN KENYA

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Dr. Mwangi and his colleague Dr. V. K. Gupta (Univ. of Nairobi) have some breakthroughs in grain amaranth product development. Kenya does not have a tradition of using amaranth grain. Consumers in Kenya are responding positively to three kinds of amaranth flour packaged in polyethylene bags: a toasted flour that improves the sweetness and texture of chapati bread, a non-fermented porridge flour fed to babies and made into porridge for adults, and a fermented and dried flour for a special local kind of porridge. The amaranth flour is valued for fermenting more rapidly than flour from other grains. Dr. Mwangi also markets puffed amaranth seeds used for bread garnish or mixed with cooked rice.

As a result of this work amaranth has been "gazetted" as a crop in Kenya: the Kenya Gazette July 19, 1991 supplement no. 45, Legislative Supplement no. 35, Legal Notice number 287, Seeds and Plant Varieties Regulations.

MARKETING THE GOLDEN GRAIN

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"Amaranth...shows promising potential as a global resource by supplying nutritious grains, as well as tasty leafy vegetables..." (Saunders and Becker, 1984)

"...dry milling of amaranth grain can yield a 25% germ fraction containing 42% protein, far superior in composition to any dry-milled fraction from other grains." (Saunders, 1985)

"Amaranth seems to be an effective source of protein to combine with cereal grains (especially sorghum, wheat and maize)." (Pedersen et al., 1987)

"Whole amaranth significantly lowered serum cholesterol levels compared to the controls...the results suggest that dietary amaranth should lower serum cholesterol in humans..." (Danz and Lupton, 1988)

One would think the world would beat a path to sources of amaranth, given the valuable characteristics ascribed to this "golden grain of the Aztecs." However, the statement made by Teutonico & Knorr (1985): "The main challenge for R & D is to incorporate amaranth into existing food formulations to modify their functional and nutritional quality, as well as to create entirely new products..." is still true. And we could add - the next challenge is getting these products into mainstream markets.

The first efforts of American Amaranth, Inc. (AAI) to profit from the development of amaranth grain sources was the resale of the grain itself, but this was never intended to be a principal marketing focus. The emphasis was to be "adding value" to the grain, thus multiplying volume and profit opportunity. The process of adding value meant pioneering in a third field (after agricultural and genetic development). The third major challenge for Edward Hubbard and the small AAI team was food technology, developing specific products using amaranth. This required venturing into marketing, to determine who was the customer and what was the need.

While various recipes for breads, snacks, cereals were being investigated, Edward ran the gamut of marketing. He determined that the popcorn snack sold by Nutri/System, a weight loss program, was an inferior product, so he created a caramel-coated popcorn using amaranth bits, thus providing the

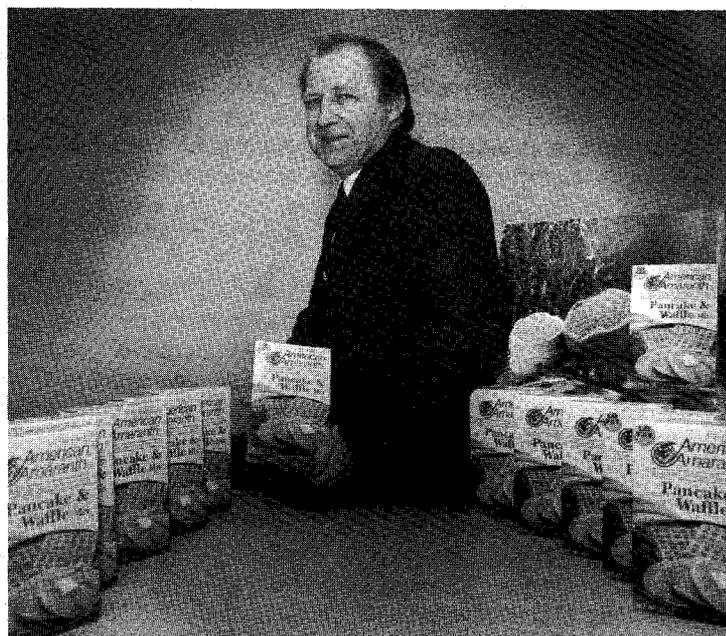


Figure 1. Ed Hubbard, founder of American Amaranth, Inc., poses with one of his company's products, a pancake and waffle mix, at the company's suburban Minneapolis office.

benefit of extra nutrition with good taste. A sales presentation to Nutri/System in New York was successful and AAI had its first major value-added product out in the marketplace. Unfortunately, because of the fickle nature of the weight loss business, the caramel popcorn product was phased out. Contacts with Nutri/System remain, however, and current product development may soon recover this high-potential customer.

Another value-added product was developed early in AAI history, by using the nutrition and unique taste of amaranth in a wheat-based pancake mix. The mix was packed in a cylindrical, 40 ounce container and given the name "Post Rock," calling forth the heritage of the Post Rock Country in the central Kansas Plains. The mix had a delightful flavor and was a hit with every one who tried it. Efforts to obtain broad distribution were limited and sales of this first "consumer" product remained with only a small but loyal group. With the establishment of the "Development Office" in Minnetonka last year, a broader marketing strategy was adopted, embracing various potential food product categories - cereals, snacks, breads, pasta and pancake mix. A new 20 ounce carton was designed for the pancake mix. The objective wasn't only to provide a more competitive product for the grocery shelf, but also to be a front runner, carrying the American Amaranth name and its unique nutritional characteristics, including the "Ring of Life™." The "Ring of Life™" concept communicates the fact that the high level of natural nutrients in amaranth are "protected," in a ring shaped embryo. If processed appropriately, the ring embryo maintains its nutrients, unlike other grains whose nutritional value is highly diminished during processing.

(Continued on p. 12)

The marketing efforts for American Amaranth Pancake & Waffle Mix are focused on the broadest distribution readily available. Regional "Specialty Distributors" have been contacted with a marketing/promotional program to introduce the Pancake & Waffle Mix to the network of major grocery stores that each distributor reaches. Distribution is established throughout nine Upper Midwest states, with four states immediately to the East soon to be added. Distributors covering the New England states, as well as NY, NJ, and PA, have been contacted and show interest.

The distribution contacts described above are a potential network for other products as they become ready for market. Efforts also continue to provide some food marketers with amaranth-based products to use within their own brand-name structure.

Most grocery product marketing efforts require large outlays of development and marketing funds. These brands "pay their way" into the market, and they don't always succeed. The route AAI is taking is to maximize the unique characteristics of amaranth and dramatize the benefits that can accrue to individual customers and other marketing companies. These basic marketing efforts are beginning to compound and awareness and interest in our products are increasing. The marketing action called for in the 80's by a large group of the nutritionally-aware is now being accomplished.

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...The "Ring of Life™" concept communicates the fact the the high level of natural nutrients in amaranth are "protected," in a ring-shaped embryo...

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THE PLAINSMAN STORY

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The variety "Plainsman" is one of the most successful grain Amaranth cultivars in North America. It has desirable short stalks compared to older varieties; however it is taller than newer varieties. For comparing varieties the Amaranth Grain Production Guide (Weber et al., 1990) is the best source of agronomic information.

Plainsman is a product of modern crop breeding developed by the Rodale Research Center (RRC) in Pennsylvania, USA. Its parents originated with traditional farmers in Pakistan and Mexico. Ms. Laura Feine Dudley at RRC crossed Amaranth accessions from those two countries in a greenhouse in the fall of 1977. Before and after making the cross, desirable crop

types were selected for several generations. In 1977 Ms. Dudley had 184 accessions of international Amaranth germplasm at her disposal as breeding stock (Weber and Reider, 1989). By comparison, in 1992 approximately 4,000 accessions are available to breeders from various germplasm banks in the United States and internationally.

The Pakistani germplasm was collected in 1960 in the Chitral valley of Pakistan. This region has a very dry summer, and agricultural plantings are irrigated with snow-melt water that runs off the surrounding mountains. The seed was collected in a garden in the town of Mastuj. The collector, J. R. Harlan, was an "agricultural explorer" on a five day horse back expedition for the United States Department of Agriculture (USDA). He brought the seed to the Plant Introduction Office of the USDA in Maryland where it was assigned the Plant Introduction (PI) number PI 274275. Harlan's seed was maintained only in Taiwan, China at the Asian Vegetable Research Development Center. Then in 1977, a sample was sent to the RRC.

In June of 1977 the Mexican germplasm (RRC 362) was collected from Don Camilo Jimenez, who popped

amaranth grain in the village of Tuyehualco, Federal District of Mexico. Daniel Early, of Central Oregon Community College in Bend, Oregon, collected the seeds. During a recent phone conversation Dr. Early was surprised that Camilo's Amaranth has become so important. Early recalled that Don Camilo was very pleased to share seed with US growers. Early has maintained contact, since 1977 with Don Camilo. Dr. Early told me that the Camilo Jimenez family has prospered, and that their son has an engineering degree. In the years since the Camilo's seed was collected, cultivated Amaranths in Mexico have rebounded from the brink of extinction, and Amaranth is now popular with Mexican consumers and growers.

In 1985 Plainsman left the RRC plant breeding station under the name "K343." The seeds were distributed through a seed company. When the seed company no longer carried it, individuals saved their own seeds for several years. The Amaranth Grain Production Guide (Weber et al., 1990) lists people that sell Amaranth seed. Plainsman is the new name for "K343." David Baltensperger (1991) at the University of Nebraska is promoting Plainsman, and distributing foundation seed.

Distinctive characteristics of Plainsman plants include faint red patches on juvenile green leaves, red roots, green stems, and red seed heads. The stems have desirable ability to remain erect after frost and until harvest.

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EDITORS UPDATE

VITAMIN E IN AMARANTH-- A NEW EXTRACTION PROCESS

A recent patent application has been published that outlines a process for extraction of medicinally-useful vitamin E isomers from amaranth and a host of plant products, including rice bran. The application states that the novel process recovers high yields of tocopherols from plant materials, including cereals, grains and grain oils.

The patent, International Publication No. WO 91/17985, was filed on May 23, 1991 by Pentad Foods International, Ltd. Among the inventors included was Dr. Asaf A. Qureshi, USDA Barley-Malt Lab, Madison, WI, who originally was one of the discoverers of cholesterol-lowering alpha-tocotrienol (a rare form of vitamin E) in barley oil.

...[Dr. Dan] Early recalled that Dan Camilo was very pleased to share seed with U.S. growers...

THE AMARANTH INSTITUTE- A GRASS-ROOTS ORGANIZATION

"We have not inherited the Earth from our parents, we have borrowed it from our children."¹

From its beginnings in 1986 the Amaranth Institute has prospered as an organization of growers, marketers, and researchers of the crop amaranth. We have no granite buildings, national check-offs, or showy literature. Rather, the Institute represents a grass-roots group of people who believe that improvements in our society start with individuals like you and me. We believe that through cooperative efforts amaranth will contribute significantly to the food, forage, and environmental needs of our generation and generations to come.

WHAT WE DO:

- Sponsor annual meetings for growers, marketers, and researchers, which have been held in IA, CO, KS, NE, and MN and which will be held in Fargo, ND on August 21 and 22, 1992.
- Petition the Food and Drug Administration for GRAS (Generally Regarded as Safe) status and the use of amaranth as a human food.
- Develop national grain standards for use by state certifying agencies, processors, and international commerce.
- Coordinate variety evaluation of improved amaranth lines in different states and distribute the data to members.
- Publish an annual, copyrighted newsletter called **Legacy**, which contains in-depth scientific reviews, production information, and new findings.

The Amaranth Institute is a 501(c)3 organization approved by the IRS as an educational and scientific non-profit organization. Your contributions are tax deductible. *The Institute pays no salaries. All mailings and office duties are by volunteers. All dues are used for publications, mailings, meetings, and public inquiries.*

We invite you to join us in bringing amaranth, one of the most nutritious and diverse crops of the New World, into domestic and international commerce.

¹ Quote from the International Union for the Conservation of Nature.

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(includes supper). Student registration is free (without supper). Rooms are available at a nearby Holiday Inn, call 701-282-2700 for reservations.

For further information, and registration packets, contact Dr. Patricia Rayas-Duarte, Cereal Science and Food Technology, North Dakota State University, Fargo, ND 58105-5728, phone 701-237-8092, fax 701-237-7723.

INTERNATIONAL AMARANTH ORGANIZATION

Peter Kulakow is the contact person in the United States for an emerging organization that started at the First International Amaranth Congress last summer in Mexico. Contact him at The Land Institute, 2440 E. Water Well Rd., Salina, Kansas 67401, phone 913-823-5376.

NEW BUMPER STICKER FOR MEMBERS:

AMARANTH IS COMING...

PUBLICATIONS FOR SALE

- 1990 Proceedings of the Fourth National Amaranth Symposium, 200 pp.
- 1990 Amaranth Grain Production Guide, 36 pp.
- 1988 *Legacy*, Vol. 1, (includes review of amaranth carbohydrates)
- 1989 *Legacy*, Vol. 2, (includes review of amaranth proteins)
- 1990 *Legacy*, Vol. 3, (includes review of amaranth pigments and seed shattering)
- 1991 *Legacy*, Vol. 4, (includes review of amaranth lipids and release of the variety "Plainsman")

The first copy of the Amaranth Grain Production Guide and of all volumes of *Legacy* are available without charge to members. The Proceedings is discounted to members. Write to the Amaranth Institute for current prices.

AMARANTH INSTITUTE MEMBERSHIP

The 1992 member's dues are: \$30. For members with addresses outside the United States of America the dues are \$40 individual, including individuals at institutes, \$50 for institutions, and \$60 for private companies.

Legacy is edited by David Brenner and Todd Vens, USDA/ARS North Central Regional Plant Introduction Station, Iowa State University, Ames, Iowa 50011. Manuscripts and information for publication in *Legacy* are welcome. The layout of *Legacy* is done by Jim Lehmann, American Amaranth, Inc.