LEGACY

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Amaranth Certified as Gluten-free

The Jefferson Institute in Missouri recently commisioned the American Baking Institute to conduct research on amaranth utilization in baking. The American Baking Institute is a large, not-for-profit research center located in Manhatten, Kansas, where they regularly conduct research for clients from across the U.S. As part of this project, the American Baking Institute provided the Jefferson Institute with a letter certifying that amaranth is gluten-free. This is significant documentation of a fact well-known in the amaranth community, yet the source of some confusion in consumer circles. Some web sites have incorrectly listed amaranth as containing gluten. Staff of the Jefferson Institute believe this has occured because many amaranth retail products contain wheat flour, which would cause a reaction in gluten-intolerant individuals (celiacs). The market for gluten-free products is sizeable and growing, so amaranth workers should continue to spread the word about amaranth as a gluten-free source of baking flour. A copy of the gluten-free certification letter is provided on page 11 of this newsletter.

Summary of Amaranth Institute Business Meeting

At the conference, a business meeting was held of the Amaranth Institute, which serves as a non-profit organization to share information on amaranth, including publication of this newsletter. In business action, Byron Sleugh was elected for a two-year term as the new Amaranth Institute president, replacing David Brenner. Rob Myers continues as secretary-treasurer. New board members elected were Burton Johnson, Roman Millan, and Jim Behling, joining Arris Sigle, Alan Weber, and Byron Sleugh on the board. The next meeting was tentatively scheduled for August, 2005, at Western Kentucky University, Bowling Green, Kentucky.

2003 Amaranth Institute Meeting Speakers and Topics

The following individuals gave presentations at the Amaranth Institute meeting held in Ames, Iowa, on August 15 and 16. Some of these speakers provided summaries of their presentations, which are also included in the newsletter. The conference was organized by David Brenner of the USDA-ARS North Central Plant Introduction Station, affiliated with Iowa State University.

Tom Ehrhardt, Albert Lea Seed House, Minnesota, "Amaranth Grain Price Fluctuations"

Rob Myers, Jefferson Institute, Columbia, Missouri, "Opportunities for Marketing Amaranth to the Baking Industry"

Danik M. Martirosyan, D&A, T&E, Inc., Dallas, Texas, "Pharmacological Properties of *Amaranthus*"

Byron Sleugh, Western Kentucky University, "Agronomic Evaluation and Animal Acceptability of 'DB 98246' a Forage Amaranth"

Susan Walters-Flood, Nu-World Amaranth, Naperville, Illinois, "Amaranth Retail Product Development"

Ido Simon (co-author Itama Harel), Bacto Sil. Ltd, Tel-Aviv, Israel, "The Effects of Salinity on Germination and Growth of Different Species of *Amaranthus* in Controlled Culture"

Michael D. K. Owen, Iowa State University, "Weed Management in *Amaranthus* Species and Herbicide Resistance"

Ramon Leon, Iowa State University, "Complex Seed Dormancy Control in a Weedy Amaranth"

Charles Block, USDA-ARS, NCRPIS, Ames, Iowa, "Disease Resistance Evaluations in Amaranths"

Davidson Mwangi, Grain Amaranth Consultant. Kenya, Africa, "Amaranth as a Promising Crop for Food, Nutrition, Healing, and Poverty Eradication in Africa"

Ciro Valdes-Lozano, Universidad Autonoma de Nuevo Leon, Mexico, and **Gabriel Alejandre-Iturbide**, CIIDIR Unidad Durango, Instituto Politecnico Nacional, "Objectives and Breeding Approaches for Grain Amaranth in Mexico"

David Baltensperger, University of Nebraska, "Amaranth Cultivar Improvement in the High Plains"

The following poster was also presented during the meeting:
Jesús García-Pereyra (Facultad de Agronomía, División de Estudios de Posgrado, Universidad Autónoma de Nuevo León, (FAUANL), (Agricultural Science Doctorate Student) México) "Agronomic Performance of Amaranth Cultivars in North Mexico"

The conference attendees also attended a field tour of Iowa State University research plots and greenhouses, hearing about research on weedy amaranth species by Mike Owens and Ian Zelaya. They toured a starch utilization lab project, hosted by Susan Duvick, and visited the USDA-ARS North Central Plant Introduction Station, where they toured a field demonstration of many different amaranth germplasm lines curated by David Brenner, and learned more about the plant curation program from Charlie Block and Larry Lockhart.

Titles and Summaries of Presentations at the Amaranth Institute Meeting August 14 and 15, 2003 Ames, Iowa Amaranth Farming and Technology Transfer

David Baltensperger (University of Nebraska)
Amaranth Cultivar Improvement in the High Plains

Breeding for improved grain yield performance is the primary focus of breeding efforts at the University of Nebraska Panhandle Research and Extension Center. Traits identified with major importance include shatter resistance, lygus resistance, seed size and lodging resistance. Efforts utilizing enhanced germplasm collections from the USDA/ARS and crosses with locally adapted types are the main strategies. A population breeding effort has been conducted for several years utilizing this collection as the backbone along with Plainsman. In the past three years these populations, one selected under rainfed conditions and one selected under irrigated conditions, have yielded very well. The selection has continued along with the testing this year. In addition several promising lines have been evaluated.

This year we have the opportunity to select for disease resistance as the pythium susceptible check was severely injured early in the season and additional lines are now showing symptoms.

David M. Brenner (Iowa State University, Plant Introduction)
Amaranth Demonstration and Plant Breeding Field

The amaranth breeding and demonstration field has three parts. (1)The demonstration planting includes 45 accessions of grain vegetable and ornamental types. (2)The *Amaranthus* tricolor plantings include entries with varying resistance to the Phomopsis amaranthicola disease. Some of these are from new crosses to develop disease resistant vegetable lines. (3)A segregating planting of F3 generation grain amaranth lines is spaced widely for selection of short lodging-resistant types. These segregating grain lines are derived from either African vegetable or 'Elephant Head' germplasm.

David M. Brenner and Larry Lockhart (Iowa State University, Plant Introduction)
<u>*Seed Cleaning and Storage Facilities at the North Central Regional Plant Introduction Station*</u>

The walk-in cooler for germplasm distribution seed lots is kept at 4 degrees centigrade and 30% relative humidity. The *Amaranthus* seed lots are in pint jars. We have 3,327 accessions of *Amaranthus* germplasm, 91% of the accessions are available for distribution. Amaranth seed samples are sent to approximately 40 recipients per year. Our seed regenerations are now performed in plastic greenhouse tents. The seed are dried, hand-threshed by rubbing, and then cleaned in air column separators "blowers". A belt thresher is used for large seed lots.

Susan Duvick (USDA-ARS, NCRPIS, Ames, Iowa)
<u>*Amaranth Grain Quality Trait Measurements*</u>

Near infrared reflectance spectrometry (NIRS) uses light to nondestructively analyze seeds for grain quality traits. The reflected light spectra are matched with reference data to generate calibration equations. Expanding the calibration and reference file increases the NIRS' capacity to measure additional traits. Currently, the USDA-ARS Quality Traits Laboratory in Ames, Iowa has added a small seed sample cell to the NIRS and is collecting spectral and reference data on amaranth seed. This data will be used to measure moisture, protein, oil, starch and seed coat color.

Ramon G. Leon and Michael D. K. Owen (Iowa State University)
<u>*Complex Seed Dormancy Control in a Weedy Amaranth*</u>

Amaranthus tuberculatus (Moq.) J.D. Sauer. (synonymous A. rudis J.D. Sauer.) is a common and problematic weed in corn and soybean fields in the Midwest Region of the United States. Herbicide resistance to important herbicides such as ALS and PPO inhibitors, and glyphosate, and variable emergence timing during the cropping season are two important characteristics that have contributed to the success of *A. tuberculatus* as a weed. We studied how the transition from dormancy to germination of *A. tuberculatus* seeds is controlled by environmental factors. Several experiments demonstrated that the dormancy level of the seeds was dramatically reduced by exposure to chilling (4 C and wet conditions). Chilling did not alleviate dormancy completely but made the seeds more sensitive to other environmental signals such as light exposure and temperature fluctuation that are responsible for completely alleviating dormancy and inducing germination. Non-chilled seeds showed limited germination regardless the quality of the light at which they were exposed. On the other hand, the germination of chilled seeds was promoted after exposure to red light and inhibited after exposure to far red light showing that *A. tuberculatus* seeds are photosensitive. The inhibitory effect of far red light on chilled seeds was overcome by heat shocking the seeds suggesting that temperature fluctuation played an important role in dormancy alleviation. Further studies showed that temperature fluctuation was more effective than constant temperatures to alleviate seed dormancy. There was a positive correlation between the amplitude of the fluctuation (difference between the maximum and minimum daily temperatures) and the increase in germination. In addition, it was demonstrated that the optimum germination temperature was inversely related to the amplitude of the fluctuation. Recent results indicated that there is intraspecific genetic variability for seed dormancy control. An *A. tuberculatus* population collected in Everly, Iowa showed no response to chilling. Therefore, it is possible that different *A. tuberculatus* populations have evolved different mechanism for controlling seed dormancy. These differences could be the product of differences in the selection pressure exerted by different agricultural practices. Our actual knowledge of *A. tuberculatus* seed dormancy regulation indicates that the seed dormancy of this species is highly specialized and dependent on environmental cues to generate germination events when the conditions are most suitable for successful seedling establishment.

Danik M. Martirosyan (D&A Inc., Richardson TX)
Pharmacological Properties of Amaranthus

During the present research work, we were able to show that amaranth is a good source of bioflavonoids (rutin) and ceratinoids. We also established that amaranth extracts have a diuretic and anti fungicidal properties.

Our experimental data demonstrate that *Amaranth cruentus* and *Amaranth lividus* provide high concentrations of rutin. From the pharmacological point of view, rutin is vital to increase the strength of the capillaries (blood vessels) and to regulate their permeability.

It was confirmed that extracts of amaranth have diuretic properties. Extracts from Amaranth increase diures of experimental animals an average of 50%, which means that amaranth can be used as a natural diuretic agent for the treatment of certain diseases, connected with the intestines.

Davidson Mwangi (Grain Amaranth Consultant. Kenya, Africa)
Amaranth as a Promising Crop for Food, Nutrition, Healing, and Poverty Eradication in Africa

In Kenya, Uganda and Zimbabwe, grain amaranth is not just a foods fortifier, but a necessity. A reward achieved through 20 years of research including 18 years of my work with amaranth. Its acceptability 5% 1985 and circa 100% 2001 in porridge and 50% -100% in traditional foods. Amaranth is displacing sorghum, fingermillet and pearlmillet.

In Kenya housewives discovered that toasted grain amaranth flour replaces cooking oil added when preparing chapati dough.

Grain amaranth has successfully been used in the management of HIV/AIDS, diabetes, migraines, marasmus, kwashiorkor etc.

Grain amaranth market price stands highest among cereals, thus creating jobs.

Michael D. K. Owen (Iowa State University)
Weed Management in Amaranthus species and Herbicide Resistance

Common waterhemp (*Amaranthus tuberculatus*) has become within the last decade, a major weed problem in the Midwest United States. The reasons that this indigenous weed has risen to economic prominence are several and include changes in herbicide use patterns, changes in crop production practices, and changes in tillage patterns. However, the ability for common waterhemp to evolve resistance to a number of herbicide mechanisms of action has contributed significantly to the difficulties growers are experiencing in weed management. Common waterhemp populations have evolved resistance to ALS inhibitor herbicides, PSII herbicides, and EPSPS inhibitors. Some biotypes have evolved multiple resistance. The ability to evolve herbicide resistance represents an interesting opportunity to improve weed management in domestic Amaranthus.

Ido Simon and Itama Harel (Bacto Sil. Ltd, Tel-Aviv, Israel)
The Effects of Salinity on Germination and Growth of Different Species of Amaranths in Controlled Culture

Fifteen varieties of five species of *Amaranthus* were examined for their abilities to germinate in varying levels of salinity, with and without modified Hoagland's buffer solution. Increase of salt concentrations, reduced germination in all accessions studied. This study determined the optimal and the limitation, of salt concentration with and without buffer, on these materials with respect to germination and growth. We were interested in the protective effects, of the buffer, on the ability of Amaranth to tolerate high salt concentration.

Amaranthus seeds were germinated and grown in NaCl solutions, with or without buffer, in two salt concentrations of 3,000 and 4,000 mg NaCl/liter. Most of the varieties, could resist the high salt concentration, and there was a protective effect of the buffer on all the amaranth studied, weakening the trauma of high salt on the seeds. Some varieties, like the *A. hypochondriacus* (cu. Don Pedro Argentina), were very sensitive to the salt concentration - whereas other like the *A. cruentus* (Amont, USA), could resist well the high salt concentration.

To compare germination in the laboratory study with field growth, we did a field study with one amaranth. We found that one can grow, *A. hypochondriacus* x *A. hybridus* (var K-432), well with 1,800 mg NaCl/Liter, and get similar grain yields, compared to fields that are irrigated with fresh water. This information is very important, for growing amaranth on desert land, with high salt concentration in the limited and costly water supply.

Carlos Spehar (Embrapa Cerrados, Brazil)
Spontaneous Hybridization Between A. cruentus cv. BRS Alegria and A. viridis

Natural crosses among grain amaranth species can occur based on the morphological characteristics of the flower, genomic similarity and flowering coincidence for pollen flow. Brenner et al. (2000), reported that cultivated and wild species possess similar genomic structure to allow interspecific crosses, with pairing at meiosis, producing viable hybrid seeds.

The genus *Amaranthus* is wide spread throughout the world. In Brazil, the weed species *A. viridis*, *A. retroflexus*, *A. blitum*, *A. spinosus*, *A. hybridus ssp. paniculatus* , *A. hybridus ssp. patulus*, associated with agricultural expansion in the Brazilian Savannah, have been described; hybridization between *A. viridis* and *A. blitum*, has been reported (Coons, 1981). The genome analysis shows that grain amaranth is alotetraploid where the basic numbers are common to some species (Brenner et al., 2000). The fertile hybrids raise the question whether morphologically distinct species, should be treated as such or classified as ecotypes.

Grain amaranth has a recent history in Brazilian agriculture. BRS Alegria is the first cultivar released to farmers. It belongs to *Amaranthus cruentus* species (Spehar et al., 2003). In commercial seed and grain production, some of the prevailing weeds and BRS Alegria grow together. Developmental phases do not coincide. Gradual emergence, however, may allow plants to match flowering, ensuring pollen exchange. Due to limitations in machinery, great seed losses occur, such that spontaneous plants may grow. Crosses between cultivated and weed species may become a problem and an opportunity. The aim of this research is to identify inter-specific crosses to use them in breeding of grain amaranth and to define conditions for seed and grain production

In seed multiplication, at the Savannah Research Centre Experiment Station, a relatively high frequency of weed amaranth has been detected. Based on morphological characters: green, branched inflorescence, spotted leaves, it has, tentatively, been classified as *A. viridis* (Spehar et al., 2002).

Plants with rose coloring, were identified visually in the field, they have lax panicles and similar height to BRS Alegria, but possess black seeds. They were measured and seeds were harvested from individual plants, for comparisons of seed size, germination and hypocotyl color ten days after emergence. At maturity the plants of weed types were smaller than the cultivated BRS Alegria, but not as short to fit description. It is speculated that these result from *A. viridis* x *A. retroflexus* hybridization, based on morphological similarities. Identification of the species involved is a problem to be resolved.

The seed size, measured in ten individual plants, showed that in hybrid plants the seeds are bigger than in the weed type but smaller than in cultivated BRS Alegria.

The implications of this finding are: i) gene introgression – in the many years of association with agricultural activity in the savannah, some favorable adaptive genes may have accumulated, like aluminum and drought stress tolerances; ii) care in seed production - to avoid field contamination by hybrid plants with undesirable weed characteristics; iii) prevention approach - stimulating farmers to monitor weed amaranth frequency in a field before using it for grain amaranth production.

Ciro Valdes-Lozano (Universidad Autonoma de Nuevo Leon, Mexico) and Gabriel Alejandre-Iturbide (CIIDIR Unidad Durango, Instituto Politecnico Nacional)

Objectives and Breeding Approaches for Grain Amaranth in Mexico

Since amaranth domestication in Mexico, and in spite of its prohibition by the Catholic Church, *Amaranthus hypochondriacus* and *A. cruentus* have survived as a small scale grain crop species. Amaranth is a potential crop for new production areas, and both species have high genotypic variability to apply breeding methodologies to develop cultivars that could fit and succeed in the new production environments. This work presents the available amaranth genotypic variability and its actual geographic distribution in Mexico, its present use by Mexican breeders and the objectives and possible amaranth breeding approaches in the developing of new and better amaranth cultivars.

PHARMACOLOGICAL PROPERTIES OF AMARANTH

Martirosyan D.M.*, Kadoshnikov S.I., Borsukov P.A., Kadoshnikova I.G., Agababyan E.Y., Kamalyan N.S., Mnatsakanyan V.A.

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Our group has worked on several contributions to the amaranth field, concerning the investigation of amaranth dye (1), amaranth oil (2), amaranth as a nutritional supplement for the modern diet (3), amaranth as a source of forage (4) amaranth and quinoa as a source of functional foods (5). We also developed the technology of extracting oil from amaranth seeds with hexane. Furthermore, we established the amaranth seed oils' physical and chemical properties (*A. cruentus*, *A. caudatus*, *A. speciose*, and *A. montegazianus*) and confirmed that amaranth oil affects the ion channels in human red blood cells, making the membranes more stable to the stress (2). It was shown that amaranth content biological active component that can be involved in the regulation of ion transport through cellular membranes.

We felt, it is important to find out the chemical composition of amaranth in the different parts of amaranth. During the present work, chemical composition of amaranth was studied and some pharmacological properties of extracts from amaranth were also verified.

RESULTS AND DISCUSSION

First, we provided extraction of plants with methyl alcohol and then we dried up methyl extracts (Table 1).

Table 1. The amount of dry methyl extracts from the different parts of amaranth.

No.	Species	Dry Extracts in %
1	*A. cruentus* (sp 1), green parts	17.7
2	*A. cruentus* (sp 1), roots	11.1
3	*A. cruentus* (sp 2), green parts	14.9
4	*A. cruentus* (sp 2), roots	17.3
5	*A. hypochondriacus* (sp 1), green parts	18.3
6	*A. hypochondriacus* (sp 1), roots	13.5
7	*A. hypochondriacus* (sp 2), green parts	15.8
8	*A. hypochondriacus* (sp 2), roots	11.5
9	*A. hypochondriacus* (sp 3), green parts	11.2
10	*A. hypochondriacus* (sp 3), roots	12.7

Investigation of the effects of extractions to the Mg-ATP-az activities of actomiozine of white rats myocardium showed that extracts from different parts of amaranth inhibited the Mg- ATP-az activities of actomiozine in vitro and shrink of the Mg-ATP-az peptides in the solution. The same effects of leaf extracts was much more effective than extracts from roots. It was found 5 picks of absorptions (255-8, 263-5, 272-55, 285-8 and 310-30 nm). It means that amaranth contains pharmacological active component that could be very significant factor in the creating a new medicines for cardiological diseases treatment. To find out which chemical component can be responsible for these actions (inhibitions of Mg-ATP-az *in vitro* and shrink of this peptides in the solution) further it was investigated the chemical composition of amaranth in the different parts of plant. We determined the content of flavanoids, iridiods, saponins, and amino acids in plants in Table 2.

Table 2. Chemical composition of amaranth in different parts of the plant.

Species	Organ of Plant	Flavanoids	Iridiods	Saponins	Amino Acids	Alkaloids
A.cruentus (sp 1)	over ground	+ +	-	+ +	+	-
A.cruentus (sp 1)	roots	+	-	+	+	-
A.cruentus (sp 2)	over ground	+ +	-	+ +	+ +	-
A.cruentus (sp 2)	roots	+	-	+ +	+ +	-
A.hypochon. (sp 1)	over ground	+ +	-	+ +	+	-
A.hypochon. (sp 1)	roots	+	-	+	+ +	-
A.hypochon. (sp 2)	over ground	+ +	-	+ +	+	-
A.hypochon. (sp 2)	roots	+ +	-	+ +	+	-
A.hypochon. (sp 2)	over ground	+ +	-	+ +	+ +	-
A.hypochon. (sp 2)	roots	+	-	+	+	-

- not a numerous amount
+ a little
++ large amount
+++ huge amount

Our research confirmed that there was not a numerous amount of iridoids and alkaloids in this particular plant yet flavanoids, saponins, and amino acids are plentiful in its green parts. Because flavanoids are now known to be essential to health our further investigations have focused to the determination of most available flavanoids among variety species of amaranth in ontogenesis. Further experiments were provided only with leaves of amaranth, because it contains the main amount of bioflavanoids.

Some experts believe that bioflavanoids maintain capillaries, inhibit clot formation, and protect against heart disease. It is well known that bioflavanoids act as an antioxidant and prevent the cellular damage caused by free radicals. They enhance the action of vitamin C and help prevent cancer. Currently, at least three flavanoids (rutin, hesperidin and quercetin) are under study for medical uses. Rutin, is being studied for treating glaucoma and retinal bleeding in diabetics as well as for reducing tissue damage from radiation exposure. Hesperidin is being considered for treating bleeding abnormalities (6). Quercetin has shown promise as an anticancer compound (7). It is well known that flavanoids possess wide spectrums of biological activity. From the therapeutical point of view, the most important are their antioxidant properties. From the pharmacological point of view, inhibition of cyclooxygenase and lipoxygenases as well as scavenging of superoxide anions seems to be essential. They are also antithrombotic owing to their ability to scavenge superoxide anions (8). Bioflavonoids such as qercetin, rutin, and hesperidin are vital in their ability to increase the strength of the capillaries (blood vessels) and to regulate their permeability. Doctors Donegan and Thomas (9) noted in the American Journal of Ophthalmology that 75 percent of cases of capillary leakage can be restored to normal by using 500 milligrams a day of rutin and that universally improves capillary strength, stops the progression of retinopathy, and benefits diabetics in general. Rutin is a very important remunerative and age-retarding bioflavanoid, as circulation problems and cardiovascular disorders are at the base of many aging processes (10).

It was important to find out the amount of rutin in different types of amaranths. We provided quantitative analyses of rutin by high-pressure gas chromatography. We determined the amount of rutin in different stages of growth of plants: vegetation, budding, blossoming and fruitage. The result of this part of investigation provided on Table 3.

Table 3. The contents of rutin (%) in ontogenesis.

Species	Vegetation	Budding	Blossoming	Fruitage
A. paniculatus	0.70	1.16	2.15	-
A. cruentus (127)	0.20	0.62	1.42	0.04
A. cruentus (218)	0.72	1.04	2.39	-
A. cruentus (23)	0.09	0.12	0.76	0.48
A. montegazeanus	0.30	0.53	1.12	-
A. caudatus (271)	-	-	0.98	-
A. cruentus (276)	1.98	-	-	-
A. paniculatus (k-61)	-	-	3.10	-
A. boliveyskiy	-	-	0.24	-
Spinach	-	0.10	0.16	-

The most amount of rutin in our case was among the *A. paniculatus* and *A. cruentus*. You can see that rutin is mostly produced in the stage of blossoming. This was the reason that further investigations were provided mostly in the stage of blossoming. The amount of rutin in different kind of amaranth in the stage of blossoming provided in the Table 4.

Table 4. The contents of rutin (%) in different kind of amaranth (stage blossoming).

Species	Harvest (ton/ha)	Index of leaf yield	Dry material in %	Rutin in %
A. paniculatus	48.9	0.3	20.0	2.2
A. cruentus (127)	42.3	0.3	18.4	1.4
A. cruentus (218)	53.6	0.3	14.9	2.4
A. cruentus (23)	32.9	0.4	19.4	0.8
A. montegazeanus	104.1	0.1	15.7	1.1
A. caudatus (271)	12.9	0.4	13.8	1.0
A. cruentus (276)	29.6	0.3	13.1	2.0
A. paniculatus (k-61)	28.3	0.3	15.8	3.1
A. boliveyskiy	103.5	0.3	14.2	0.2
Spinach	8.0	0.3	13.7	0.2
A. cruentus (Mexic)	754.0	0.3	18.0	1.1
A. cruentus (k-78)	214.0	0.2	13.9	0.5
A. species (k-388)	347.0	0.3	17.4	1.2
A. panicul (Hurasaho)	200.0	0.5	14.1	1.4
A. species (Spartak)	321.0	0.6	13.4	1.4
A. hypochon (Azteca)	529.0	0.3	13.0	1.9

Table 4 shows that the most perspective species of amaranths are *Amaranth poniculatus* and *Amaranth cruentus*.

According to a harvest of different kinds of amaranths, we calculated that in 1 ha, you could receive an estimate of 60 kg of rutin. Our results confirm that amaranth is a good source of rutin with low cost.

Usually, rutin is extracted from fruits of the Fava D'Anta tree (Dimorphandra). These trees are native to the vast savanna areas in northeast of Brazil. There are considerable amounts of rutin in buckwheat also. But to compare harvest from 1 ha amaranth (48 ton / hectare in our case, in China fresh green leaf and stem yields were 30-45 ton/ha, (11) and buckwheat (1.5-2.5 ton/hectare), we made a conclusion that amaranth is more likely natural source for rutin. Ruhn and other amaranth constituents may help stimulate amaranth commercialization.

CONCLUSIONS

1. There are not a numerous amount of iridoids and alkaloids in the amaranth, yet flavanoids, saponins, and amino acids are plentiful in its green parts.
2. Extracts from amaranth contain pharmacological active components that can be involved in the regulation of Mg- ATP-az activities in cells.
3. It was found that *amaranth paniculatus* and *amaranth cruentus* are a good source for flavanoids, especially for rutin, which are mostly produced in the stage of blossoming.

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October 6,2003

Brian Strouts
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Dear Brian Strouts,,

Below are the results of the quantitative gluten allergen testing done on the sample of Amaranth Flour (Thomas Jefferson Agriculture Institute project 03-5-291) you submitted:

Sample	Results
Amaranth Flour	ND

Note: ND = Not detected. Level of detection = 20 ppm.

An invoice for this test will follow in a few days. If you have any questions, please contact me at (785) 537-4750 extension 156 or by e-mail at bglaser@aibonline.org. Thank you for allowing us to serve you.

Sincerely,

Bryan Glaser
Supervisor, General Laboratories

Note: The analytical results pertain only to the submitted sample and may not be construed as an endorsement of the sampling method employed.

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