

Industrial Uses of North Dakota Crops

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Three years ago the May-June 1988 issue of *North Dakota Farm Research* contained a guest column by D'Appolonia entitled "A Renewed Need for Utilization Research." The same issue contained a research review article by D'Appolonia, Hettiarachchy and Khan entitled "Agricultural Processing and Utilization Research." This review article presented utilization type research that had been conducted in the Department of Cereal Science and Food Technology. Since that time, utilization research on alternate crops and on existing crops grown in this area has shown positive growth at North Dakota State University. At the same time, research has been undertaken on production of alternative crops.

Much of this expanded effort has been made available as a result of specific cooperative agreements between the USDA's Cooperative State Research Service and the Agricultural Experiment Station. The research in many instances has been interdisciplinary in nature and has involved departments both within and outside the College of Agriculture and Agricultural Experiment Station. In this article we would like to highlight the utilization and production research that is currently in progress. A directory of faculty involved in these two areas is presented at the end of this article.

UTILIZATION RESEARCH

The major goal of the utilization research is to develop, introduce and commercialize new products to further diversify North Dakota agriculture and to establish new uses for alternate crops and by-products of existing crops. As will be indicated in this article, numerous research areas are currently in progress to meet this goal. The new Industrial Agriculture and Communications Center scheduled for completion in December of 1992 will provide the needed space to make this goal become a reality. The third floor of this structure will include value-added food and non-food laboratories as well as extrusion, oilseed, food protein, bioprocessing and biotechnology facilities.

Crambe

Industrial research on crambe oil has been under way in the polymers and coatings and chemistry departments on campus. One of the major objectives in this research is to prepare esters, polyester resins and other precursors from erucic acid or its derivatives, such as brassylic acid, for usage in lubricants, nylon-13, perfumery materials and coatings

and elastomers. In the polymers and coatings department three types of coating material have been synthesized from brassylic acid. Samples of these coating materials were sent out for industrial evaluation with favorable results being reported. Within the chemistry department the program is directed to developing optimum procedures for preparing useful derivatives of erucic, brassylic and perlargoniac acids which are derived from crambe oil. These derivatives have a wide area of application. Researchers are also investigating methods for the conversion of erucic acid to brassylic and perlargoniac acid by nonozonolytic techniques.

The crambe research just mentioned becomes even more important when one considers the successful grow-out of crambe by 38 North Dakota farmers in 1990. The crop harvested, approximately 1,500 tons, was processed by National Sun Industries into 500 tons of oil, 850 tons of meal and 150 tons of hulls. Coordination was undertaken by the High Erucic Acid Development Consortium of universities and government (HEADE). The oil was marketed to Calgene Chemical and the meal to Foxley Cattle Company.

Sunflower

A major project involving the purple-hulled sunflower is the development of a natural red food colorant. This project is interdisciplinary in nature and involves cereal science and food technology, food and nutrition, crop and weed sciences, agricultural engineering and agricultural economics.

Researchers working on this project are involved in several different areas, including:

- Characterizing the anthocyanin pigments of a purple-hulled genotype grown in different environments.
- Characterizing the anthocyanin pigments of sunflower hybrids formed by crossing a purple-hulled genotype with non-purple inbred sunflower lines.
- Studying the pigment profiles and quantification by high performance liquid chromatography.
- Extracting, characterizing and stabilizing the anthocyanins from sunflower hulls.
- Determining the market potential of the anthocyanins as a red food colorant for the industry.
- Studying the economic feasibility of processing a natural red food colorant from purple-hulled sunflower in North Dakota.
- Scaling-up the extraction and stabilization at the bench level followed by pilot plant evaluation.

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There is a need for the development of a natural red food colorant due to the delisting of particular synthetic red colorants. The interdisciplinary effort in this project to date indicates a high potential for commercialization of a natural red dye in the next two to three years. Private sector involvement and confidentiality agreements are being explored.

Antioxidant Research

The overall objective is to develop and commercialize natural antioxidant extracts from selected northern grown crops. The active antioxidant components will be separated and identified and the effectiveness of extracts exhibiting the highest antioxidant activity in selected lipid based food systems will be tested. Involvement with the private sector will be pursued.

Antioxidants are required in a number of food products to prevent oxidative rancidity and thereby increase the shelf-life of the product. Currently there are a limited number of synthetic antioxidants which are used in various food applications. There is considerable interest today in developing natural as opposed to synthetic antioxidants. The potential for such natural additives exists in extracts from various agricultural crops and by-products of crops grown in North Dakota.

Extraction and Characterization of Pectin from Sunflower Head Residues

The objectives of this effort are to isolate and characterize the physico-chemical properties of pectin from sunflower head residues. Functional properties studied included viscosity, water-holding capacity and gelling capacity. The effect of pH, soluble solid (sucrose) content, and calcium concentration on the characteristics of jellies made with sunflower pectin is being investigated. Research data to date indicate that the gelling property of pectin from sunflower head residues is very promising for industrial applications.

Flax

Work with flax is currently concentrated in two areas:

- The efficacy of crushed flaxseed (as a source of omega-3 fatty acids) to alter blood lipids when incorporated into a bakery product is being studied. In addition, bleeding time, blood pressure and plasma levels of thiocyanates and B6 are being followed.
- The stability of α -linolenic acid in ground flax and in products containing ground flax is under investigation.

The positive nutritional implications associated with the use of flax in the diet have received considerable attention in recent months. Research conducted at NDSU should answer questions related to this phenomenon.

Barley

Considerable interest has been expressed recently in the food use of barley. Some of this interest is because of a carbohydrate material found in barley called beta-glucans which has nutritional implications. The major carbohydrate found in barley is the starch component. The physicochemical characteristics of starch from different barleys should provide useful information related to utilization.

Work is currently centered in two areas:

- **Beta-Glucan Research**

The objectives of this research are to extract, purify and study the chemical, physical and flow properties of

β -glucans from barley. The effect of modification of the β -glucans on functionality will be studied and their performance in a food system assessed.

- **Alternative Uses for Barley**

In this effort the variability of starch composition in genetically diverse modern barley lines will be assessed and its functionality will be compared to other starches in food and non-food uses.

Extrusion Research

This project involves use of high temperature short time extrusion on fractions derived from dry edible beans in the development of snack type products. Also, the effects of high temperature extrusion on the nutritional and anti nutritional factors of dry edible beans and their fractions have been studied.

Interest has been expressed in the marketing of a nutritious edible bean snack food by a private company and plans are underway to fully develop this concept.

Dry Bean Utilization Research

The objectives here are to study the effect of selected storage conditions on the food quality characteristics of navy and pinto beans. The effects of storage on fatty acid composition and cell wall components of beans are being studied. Isolation and characterization of the lectins from beans is also underway.

Information derived from the storage studies on beans could greatly expand their utilization in that a better quality bean could be marketed. Industry has expressed interest in the research since a higher quality bean food product would result.

Utilization of Amaranth, Buckwheat and Lupins

The functional properties of amaranth flours including raw, extruded, popped and sprouted will be investigated as will the starch, protein and oil for industrial uses. Utilization research on buckwheat and lupins will be initiated.

Foam Fractionation of Water-Borne Polymers Based on Natural Products — A Route to Improved Water-Borne Alkyds Based on Linseed and Sunflower Oils

Research efforts here will include:

- Establish suitable test procedures for measuring "foaminess" and other surface properties of w/r resins.
- Examine the effect of co-solvent and neutralizer on "foaminess" and other surface properties of commercially available w/r resins and especially synthesized model compounds.
- Separate the high-foaming fractions of the investigated systems using foam fractionation techniques.
- Synthesize model w/r alkyd resins based on natural oils and examine the relationship between synthesis variables and "foaminess" and other surface properties of the products.

These projects are at various points of completion and several have been underway for over two years. Several new projects have been funded and work will be initiated beginning July 1, 1991, with emphasis on industrial applications.

PRODUCTION RESEARCH

Evaluation of alternative crops and alternative methods of producing new and traditional crops are the central objectives of the production research team. Alternative crops are needed to complement and diversify crop rotations. Often crops with favorable markets are grown nearly continuously which, over time, results in increasing costs of production due to mounting disease, weed and insect adaptation. Thus, the alternative crops of most interest are not only those which appear to have a promising market, but also which possess characteristics needed in crop rotation. Crambe, for example, has demonstrated a high level of resistance to flea beetles, a troublesome insect among most crucifers. Leguminous and perennial crops would also be advantageous additions to most North Dakota cropping systems.

New production methods are also of interest as a means of increasing the efficiency of water and nutrient use and diversifying the cropping system. Growing several crops simultaneously can have a broad impact on the agroecosystem, often changing the makeup of most pest populations. Such systems are being studied in North Dakota to hopefully discover crop combinations which are both economically viable and exhibit a reduced dependency on pesticides and fertilizers. Such systems might also provide a low risk means of introducing a new crop when grown in combination with a traditional crop.

Projects currently sponsored in part by the joint USDA/CSRS and Agricultural Experiment Station follow. These and other on-going projects of similar objectives across the university will hopefully contribute to a more resourceful and diverse agriculture for North Dakota.

New Crop Development

Evaluation of a wide range of alternative crops is being conducted across the state. Classes of crops include the oilseeds (crambe, mustard, rapeseed, canola, safflower, sunflower, camelina and several undomesticated species), grain legumes (lupins, faba bean, field pea, lentils, chickpeas and fenugreek) and other crops such as buckwheat, amaranth, the millets, coriander, emmer, winter and spring triticale, canary seed and traditional crop derivatives such as hard white spring wheat, waxy hulless barley and malting barley low in dimethyl sulfide precursors. In most cases both the production potential and the quality of the commodities are evaluated with a special emphasis on market potential in both food and non-food end uses.

Other species being evaluated as potential crops include harvesting perennial grasses, flax and sunflower as seed crops. Also, irrigated potato, onion and carrot production methods are again being evaluated.

Along with the introduction of new crops, refinement of the production methods among the most promising crops are being conducted. Amaranth planting dates, rates and row widths are being evaluated. Soil fertility requirements of crambe are being documented. Crambe's insect resistance mechanisms are being isolated, not only to better understand crambe's success, but also to explore the possibility to transfer similar defense strategies to other cruciferous oilseeds such as canola and rapeseed.

Alternative Production Methods

Study has only just begun on the potential of multiple cropping and other alternative production schemes for North Dakota crops. While several crop combinations have been observed (wheat/flax, wheat/lentils, crambe/rape-

seed, corn/dry beans, sorghum/dry beans, canola/field peas, flax/lentils, wheat/field peas, soybean/flax, wheat/soybean) only a few have been more thoroughly investigated for their influence on pests and nutrient cycling. Production schemes such as inter, relay and strip cropping are now being observed in field-scale trials where the integration of the complexity of the crops themselves, pests, soil erosion and machinery requirements can be viewed together. Such demonstration and evaluation is critical before broad recommendations and farmer adoption will occur.

In summary, the evaluation of new alternative uses, crops and production methods is a necessary role of North Dakota State University. As stated in the National Research Council's recent report on alternative agriculture, "Today's alternative farming practices could become tomorrow's conventional practices, with significant benefits for farmers, the economy and the environment."

The following is a directory of faculty currently involved in the production and utilization of Alternate and Existing Crops at North Dakota State University being funded by a USDA/CSRS grant. It does not include those faculty initiating projects in July 1991.

- Dr. Patrick Carr — Carrington Research Extension Center. 652-2951. Multiple cropping evaluation, soil enhancement of alternative crops and cropping practices, evaluation of undomesticated crops.
- Dr. Larry Cihacek — Soil Science. 237-8572. Development of soil fertility recommendations for crambe.
- Dr. Jerry Frankowiak — Crop and Weed Sciences. 237-8142. Breeding of special end-use barley varieties.
- Dr. John Gardner — Carrington Research Extension Center. 652-2951. New crop development of perennials, multiple cropping evaluation.
- Bryan Hanson — Langdon Research Center. 256-2582. New crop evaluation and insect management strategies of canola, crambe and rapeseed.
- Dr. Rich Horsley — Crop and Weed Sciences. 237-8142. Breeding of special end-use barley varieties.
- Dr. David Klinkebiel — Carrington Research Extension Center. 652-2951. Irrigated vegetable crop production, multiple cropping evaluation.
- Dr. George Pomonis — USDA/ARS. 239-1292. Isolation of biochemical deterrents in crambe to flea beetles.
- Neil Riveland — Williston Research Center. 774-4315. Alternative oilseed evaluation for western North Dakota including safflower, crambe, mustard and rapeseed.
- Blaine Schatz — Carrington Research Extension Center. 652-2951. New crop development of grain legumes, oilseeds and grains, multiple cropping evaluation.
- Dr. Al Schneiter — Crop and Weed Sciences. 237-8895. New crop development of amaranth, crambe and rapeseed.
- Dr. Mike Weiss — Entomology. 237-7924. Insect resistance mechanisms of cruciferous oilseeds, study of multiple cropping strategies on insect ecology.
- Dr. Patricia Berglund — Food and Nutrition Department. 237-7843. Alternative Uses for Barley - Starch.
- Dr. Gordon Bierwagen — Polymers and Coatings Department. 237-8294. Improved Water-Borne Alkyd Polymers from Linseed and Sunflower Oils.

- Dr. Philip Boudjouk — Chemistry Department. 237-8601. Chemical Conversion of Crambe Oil Derivatives to Oils, Waxes, Perfumery Materials and Nylons.
- Dr. Sam Chang — Food and Nutrition and Cereal Science and Food Technology Departments. 237-7485. Extraction and Characterization of Pectin from Sunflower Head Residues, Dry Bean Utilization Research.
- Dr. Holly Dieken — Food and Nutrition Department. 237-7475. Flax as a Potential Source of Omega-3 Oils in Human Nutrition.
- Dr. Patricia Rayas-Duarte — Cereal Science and Food Technology Department. 237-8092. Utilization of Amaranth, Buckwheat and Lupins.
- Dr. David Gabrielson — Microbiology and Veterinary Science Department. 237-7842. Microbial Conversion of Triglycerides to Free Fatty Acids.
- Dr. James Hanzel — Crop and Weed Sciences Department. 237-8160. Natural Red Colorants from Purple-Hulled Sunflower - Agronomic Studies.
- Dr. Navam Hettiarachchy — Cereal Science and Food Technology Department, 237-8218. Natural Red Colorants from Purple-Hulled Sunflower-Quantification, Stability and Production Application; Natural Antioxidants from Northern Grown Crops for Food Use. Storage Stability of α -Linolenic Acid in Flax. Quantification of Quality Components of Alternative Oilseeds.
- Dr. Edna Holm — Food and Nutrition Department, 237-7486. Natural Red Colorants from Purple-Hulled Sunflower - Anthocyanin Characterization; Alternative Uses for Barley -Starch.
- Dr. Khalil Khan — Cereal Science and Food Technology Department. 237-7729. Extrusion of Dry Edible Beans and Component Fractions for New Products.
- Dr. James Lindley — Agricultural Engineering Department. 237-7273. Natural Red Colorants from Purple-Hulled Sunflower Bench Scale Up Process.
- Dr. Paul Schwarz — Cereal Science and Food Technology Department. 237-7732. Barley Beta-Glucans-Properties and Uses.
- Dr. Mukund Sibi — Chemistry Department. 237-8251. Chemical Conversion of Crambe Oil Derivatives to Oils, Waxes, Perfumery Materials and Nylons.
- Dr. Dennis Wiesenborn — Agricultural Engineering and Cereal Science and Food Technology Departments. 237-7277. Natural Red Colorants from Purple-Hulled Sunflower - Bench Scale Up Process.