

## **Final Progress Report**

**Project Title:                   Development of New Extra Virgin Unrefined Vegetable and Fruit Seed Oils for Food and Nutraceutical Markets**

**Contractor Name:   Badger Oil Company**

**WDATCP Contract No.                   15105**

**Project Leader:                   Bruce Davis and Mark Mueller**

**Progress Report for Period July 1, 2000 to September 31, 2001,**

### **Field Trials**

Four potential new oil seed crops were field tested and evaluated in the summer of 2000 by the University of Wisconsin, Department of Agronomy under the leadership of Thomas Osborn, PhD. The field trials were undertaken at the Arlington and Sturgeon Bay research stations. See Appendix A for further discussion and photos of UW Field trials.

A brief summary is as follows:

**Meadowfoam** This was the third year's attempt at growing meadow foam and although this years attempt was the most successful, this crop is probably not well suited to Wisconsin growing conditions

**Borage** Grew very well at each location. Harvesting is somewhat problematical as the seed develops and matures over a long period of time.

**Black Caraway** Grew quite well at Arlington with an expected yield of nearly 700 pounds per acre. The plant needs warm soil conditions so it better suited to lighter soils.

**Evening Primrose** The seed did not germinate, it was later determined the seed was sterile. The seed is not readily available and was provided a Canadian company.

Using seeds from the crop grown in 2000. a Black Caraway field trial was conducted again in 2001 by the UW Agronomy Department at the Arlington Agricultural Research Station focusing on chemical weed control since this seems to be the most problematic factor in commercial growing of black caraway. Eight different herbicides were used in the trials with two of them showing good potential. See Exhibit for full report of UW field trial.

Badger Oil oversaw field trials for the following on a plot of ground in the Spooner area for the following:

**Styrian Pumpkin** This is a hull less type high oil seed pumpkin originating from Austria where it is extensively grown for a gourmet type food oil. Roasted hull less seeds are also excellent as

a snack food. A trial of 40 ft by 150 ft in 2000 had good initial germination and growth, but crop suffered severe deer damage. In 2001 a deer protection fence was installed. Planting occurred on May 24 and pumpkins reached maturity by August 31. The field had 100 pounds /acre of nitrogen applied after seeding. Weeding was undertaken in June and early July. The yield was good and the pumpkins appeared to be free of blight or other problems.

**Coriander** Initial germination and growth was good, but the crop suffered severe deer damage. An additional small planting of 4 ft by 10 ft was made in the spring of 2001.

**Seabuckthorn** Suffered deer damage, but the perennial plants survived. This plant should be well suited for Wisconsin growing conditions. An additional planting was made in spring of 2001

**Mullein** This is a wild biennial weed which grows prevalently throughout Wisconsin. A field of 75 ft by 75 ft was developed from wild seeding. Seed was harvested in early September and after cleaning was pressed into oil, having an approximate recovery rate of 30%. Samples have been provided to several nutraceutical firms. The oil from the weed has skin care applications and has medicinal health benefits as well.

Continuation of field trials are planned for the summer of 2002 and will include continuation of Seaberry, Black Caraway, Coriander, Styrian pumpkin, Meadowfoam and Mullein. .

### **New Oil and Meal Extract Development**

Oil was successfully produced from the black caraway seed produced in Wisconsin and supplied to a nutraceutical company, TNC International. The commercial customer indicated that the aroma and color of the Wisconsin product was superior to the seed which the customer was importing from the Middle East. The customer indicated strong interest in purchasing Wisconsin grown black caraway with a current market in excess of 100,000 pounds annually. Black Caraway is a powerful antioxidant with both food and non food product applications. It has considerable future potential.

The following new oil and meal extract products were produced:

- Onion Oil, can be used as a food ingredient and for aroma
- Mullein Oil, this a common weed in Wisconsin, the oil has medicinal value and skin care applications
- Corn Germ Oil, corn germ is byproduct of ethanol production. Oil was successfully produced from this by product for a company called Energenetics, Inc.
- Carrot Seed Oil, very high in beta carotene, good potential for skin care product, used in tanning lotions
- Tomato Seed Oil, can be used as food oil, seeds from processors are readily available
- Lupine Oil, good flavored cooking and baking oil, yield was lower than expected
- Fenugreek Oil, high valued nutraceutical and used as a food flavoring agent

- Milk Thistle Oil, a common weed, contains an antioxidant, silybum marium, which is effective in treating various liver disorders, high valued nutraceutical, used extensively in Europe as a pharmaceutical
- Squash Oil, a sweetening tasting oil having potential as food oil, seeds available from processors
- Blueberry Oil, very high in antioxidants, good potential as a nutraceutical
- Black Raspberry Oil, very high in antioxidants and ellagic acid, a cancer fighting phytochemical
- Marion Berry Oil, oil has similar characteristics to raspberry oil.

Tomato, squash, blueberry, black raspberry and marion berry are by products of food processing lines.

## **Product Testing**

Antioxidants Samples of the blueberry oil, strawberry oil tomato oil, hemp oil, carrot oil and black raspberry oil were sent to Brunswick Laboratories of Waltham Massachusetts for antioxidant analysis. Brunswick lab is the only private lab with the capability to test for Total Antioxidants according to the ORAC procedure developed by the USDA ARS Human Nutrition and Aging laboratory at Tufts University. As a comparison, “off the shelf” extra virgin cold press olive oils were also tested using the same antioxidant procedure. The Blueberry Oil was found to have 3X times the level of antioxidants as Olive Oil, while Strawberry Oil, Tomato Oil and Black Raspberry Oil, 2X times the level as olive oil and hemp oil was comparable to olive oil. See Appendix B for lab reports

Sterols were analyzed by Covance Laboratories of Madison for Cranberry Oil, Raspberry Oil, Black Caraway Oil, Carrot Seed Oil and Saw Palmetto Oil. See lab reports, Appendix C. Cholesterol was found to be very low (less than 1mg /100 G) in the fruit oils.

Vitamin E, including a breakdown of four Tocopherals and four Tocotrienols were analyzed by Covance Laboratory for meal extracts of Black Caraway, Black raspberry and Grape Meal. See Lab Report from Covance Laboratory Appendix D. Tocopherals and Tocotrienols were also analyzed for Cranberry Oil, Blackberry Oil, Black Caraway Oil and Raspberry Oil.

Ellagic Acid and Pycnogenol, two powerful antioxidants which have reported characteristics of inhibiting growth of cancer cells were analyzed in the meals and oils of raspberry, strawberry and grape. These are water soluble substances and concentrations of these substances are considerably higher in the meal extract than in the fruits of these plants. They were not present in the oils. See Appendix E for lab report.

A continuing relationship has been developed with Brunswick Labs and the Children’s Nutrition Center in Arkansas . Dr. Ronald Prior, the scientist who developed the ORAC assay has expressed an interest in developing a CRADA (Cooperative Research and Development Agreement) with Badger Oil focused on several issues including; identification of the phytochemicals acting as antioxidants in the various fruit and vegetable oils, the cell absorption

efficiency for antioxidants from the cold press fruit and vegetable oils, and the potential for these antioxidants to act as cancer cell inhibitors and to act for antitumor activity. See Appendix F for Scope of Work by Dr. Ronald Prior.

With a letter of support from Dr. Ronald Prior, an application was prepared to the USDA SBIR program for \$80,000 to fund analytical work on more than forty different extra cold press oils and meal extracts with an aim of finding the best applications for oils and extracts in food, medicinal and industrial applications. The laboratory work would be conducted by Dr. Lucy Yu of the School of Food and Nutrition at Colorado State University, Fort Collins Colorado. Dr. Ashok Patel of Centre Manufacturing has agreed to be the principal researcher on the project.

## **Market Research, Testing and Strategies**

Contract Manufacturing New customer accounts have been developed with the following:

Eclectic Institute, a nutraceutical company in Oregon for the production of Milk Thistle Oil and Meal. Milk Thistle contains a powerful antioxidant, Silibum Marium, and is widely used in Europe and Asia for treatment of a variety of liver disorders.

A-CAM, an aroma therapy network in Florida. This company has been purchasing grape seed oil, carrot seed oil, hemp oil, almond oil and sesame oil.

Centre Manufacturing, LLC. a cosmetics and skin care manufacturing company. The company is interested in carrot seed oil as well as other oils.

The following are prospective customers, where Badger Oil has done test runs and provided production yield data and samples for customers testing:

Energenetics. Inc. Corn Germ Oil  
ABSIM, Inc. Argane Oil  
AA Haji Food Oil, Sesame Oil

## Proprietary Product Development

**Skin Care and Wound Healing Cosmeceutical Products** A collaborative venture has been created involving Dr. Edward Sachowitz a plastic surgeon and Centre Manufacturing LLC, a small cosmetic company. A new company is envisioned with these partners that will develop high end skin care and wound healing products using fruit and herb oils and meal extracts. A skin care product has been developed from black caraway and an exfoliating cleanser has been made from raspberry meal and grape meal. These three products are now in early test market stage.

**Pharmaceutical Products** Lab data on the antioxidant values and phytochemical values in the fruit and herb oils and meal extracts have been supplied to a cancer research group at the University of Minnesota. Based on the data supplied by Badger Oil, the group is interested in

combining natural sources of powerful antioxidants with its proprietary biotherapy treatment for liver cancer. A research proposal has been designed and the work is planned to be started in early 2002. Black caraway oil and meal extract and milk thistle oil and meal extract will be tested along with several other high antioxidant oils. The work is intended to lead to filing of a patent.

**Animalceuticals** Product samples of grape and black caraway meal extract have been supplied to Agroin, GBK International, a firm developing natural phytochemical products for the animal industry with the intended purpose of improving animal health and growth. The company plans to undertake several swine and poultry trials later in 2001 to determine if the animal immune system can be strengthened with the antioxidants and thereby reduce the usage of antibiotics.

During the course of this past year Badger Oil Company has converted 4000 square feet of industrial space into food grade space which has met DATCP requirements. The pilot plant has now been converted into production space, with seed cleaning and drying capabilities, seed tempering, storage, material transfer, pumps and filter equipment, mixing tanks and two presses set up to run on a continuous basis. See Appendix G.

### **Bio Fuel, Natural Diesel (NADI)**

This is the third year of a three year field demonstration with Kurin Powers of Lyndon Station, and FABCO of Madison using the NADI fuel in a Caterpillar tractor, the Challenger 35. The NADI fuel is a patented fuel using cold press vegetable oil with additives. The NADI fuel can be run at 100% strength or as a blend with petroleum based diesel. The technical specifications of the NADI fuel were reviewed by Caterpillar and found to meet their requirements.

Four hundred gallons of NADI fuel will be produced in 2001 for use in the tractor for field work during spring, summer and fall by Kurin Powers. The NADI fuel is a blend of canola oil, sunflower oil produced by Badger Oil and soybean oil produced by SOYCO of Adams Friendship. Kurin Powers consistently observed more power using the biofuel versus petroleum based diesel, saying he could plow one gear higher. After the third year, FABCO will break down the engine and measure for wear.

LaCrosse Diesel Service, Inc. This is a large regional diesel engine maintenance and rebuilding business. The company and Badger Oil have undertaken initial tests demonstrating fuel consumption and power using the NADI as an engine lubricant.

Horsepower was measured using a high capacity hydraulic dynamometer at La Crosse Diesel's facility in LaCrosse Wisconsin. Blends of mineral based No. 2 diesel and NADI were used to fuel a test stand 6.2 liter diesel engine. All tests were run at 2,800 rpm. Blends with .35%, .78%, 2.34%, 4% and 10% NADI were tested and horsepower output measured. The addition of NADI improved horsepower even at small ratios below 1%, but showed no increase after 10%. A 10% addition of NADI increased horsepower 12%. See graph in Appendix. The results of the test stand power tests confirm the field experience of Kurin Powers of increased horsepower. Increased horsepower is explained at least partially by improved internal engine lubricity using the bio fuel.

Mileage tests (fuel consumption) were also conducted with La Crosse Diesel Service. Tests were conducted using a Borrough's Vacuum Filled Mileage Tester and a Mercedes 300TDT 1987 Stationwagon. Blends of 5%, 10%, 50% and 100% NADI with Number 2 mineral diesel were tested. Mileage increases were experienced with NADI blends up to 50%.

Badger Oil and La Crosse Diesel plan additional tests in 2002 including additional mileage testing and emission testing.

Based on the tests, La Crosse Diesel Service, Inc has expressed interest in being distributor of NADI. It sees a market for NADI as a fuel additive. Samples have been provided to it's customers with positive feedback. A formal business relationship is expected to be developed in 2002.

A distribution agreement is also being developed with a firm, Neotrics Fuels of British Columbia. The company is interested in being a distributor of lubricant additives and NADI for western Canada.