Department of Agriculture, Trade and Consumer Protection
Division of Agricultural Development
Agricultural Development & Diversification Program (ADD)
Grant Project Final Report

Contract Number**: 22046**

Grant Project Title: Testing the Methionine Content of Corn Hybrids for Organic Poultry Producers

Amount of Funding Awarded: $20,000

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Please use the following questions as a guide for writing your grant project final report. In your final report, please answer each question as it relates to your grant project.

What was the original intent of the grant? The major objective was to develop a reliable NIR calibration for methionine. This was integrated with other objectives that included a) comparing the yields and other agronomic characteristics of high methionine corn hybrids b) determining the methionine content of their grain; c) evaluating and selecting varieties to increase their methionine content; d) providing grain from the trials to Organic Valley Coop for feeding trials to assess the value of *fl2* and hard endosperm hybrids to chickens; and e) disseminating information back to all relevant partners in the work.

What did you want to accomplish with the grant? In this project we intended to improve our methods for routinely measuring methionine in grain, increase the methionine content of our varieties, test hybrids between these varieties for their agronomic characteristics and methionine content, provide seed for feeding trials by Organic Valley Coop, and disseminate information on our results to our clientele and to the public.

How was it expected to benefit Wisconsin Agriculture? According to USDA/ERS figures, organic layer and egg production in the Nation tripled between 2000 and 2003 and quadrupled since then. Almost 40% of that production was located in Wisconsin, Iowa, and Minnesota. Major organic poultry and egg companies in Wisconsin include Farmers Organic Foods, Organic Valley/Organic Prairie, Egg Innovations, and Chino Valley Producers. Methionine is the first limiting amino acid for poultry health and egg production and this need is met in feeds based on corn and soybeans by supplementing with synthetic DL methionine. Corn is the major component of chicken feed. It contains approximately 0.21% methionine, but we have bred lines of corn that have methionine contents ranging between 0.25 and 0.39% and higher contents of lysine and cysteine as well. This improvement in amino acid composition is highly pertinent for organic poultry producers as USDA may not allow them to feed synthetic methionine after October, 2008. Though organic poultry production and especially egg production is a fast growing enterprise for Wisconsin farmers it is threatened by looming regulations on the use of synthetic methionine. It is possible to avoid that problem if we can breed and release high methionine corn hybrids that have competitive agronomic characteristics. We are developing

competitive, high methionine hybrids that will provide profit opportunities for institutions, seed companies, poultry feeders, and farmers. Key to bringing this work forward is developing a method for quickly and cheaply testing the methionine content of the grain. The centerpiece of our work with DATCP has been developing an Near Infra Red Spectroscopy (NIRS) calibration for methionine. This test appears to be valid for testing methionine from many kinds of corn. It has the potential to be widely used to test corn grain for methionine by breeders, grain handlers, and feed formulators.

What makes this project work important or significant? It is clear that without synthetic methionine the organic poultry industry could be crippled, with reduced yields, health and humane handling issues, and questionable profitability. The opportunity to grow high methionine corn represents a significant financial opportunity for organic producers. If Wisconsin farmers have competitive corn hybrids with high methionine in their grain, the growth rate in the organic poultry industry should be prolonged, bringing more $ to local production. The project should enable us to better understand the tradeoffs involved, including any potential yield penalties associated with growing high methionine hybrids rather than conventional hybrids. Organic Valley has done considerable research on the impact of having to buy and import expensive sources of natural methionine and none of them seem to be as profitable and viable as growing corn with high methionine.

What steps did you take to reach your goal?

What worked? The NIRS calibration worked and the breeding nurseries worked. However, it proved difficult or impossible to plant yield trials.

What challenges did you face? Seed hybrids made in Chile and seedstocks multiplied in Hawaii arrived late in May or in June. Though we had prepared to plant yield nurseries in various places in Iowa and Wisconsin, the sites for planting were too waterlogged when we wanted to plant them. Spring conditions forced us to prioritize plantings to high ground, to focus our efforts on the breeding nurseries, and to drop planting of our yield trials.

What would you do differently? Had we been earlier in getting seed ready we probably would have lost many field plantings due to waterlogged or flooded conditions. Our process of selecting and getting seed ready is intense and it was a major effort on the part of our team to prepare seed in time. We are striving to streamline the process and to make it easier but there is a lot of handwork and human hours involved in identifying and processing the best ears. We are very happy for the great work done by ISU grain lab. However, due to other issues at the lab we received the methionine calibration on the 8th of May. This development was behind schedule. It slowed down our ability to get seed packets ready to plant because we needed an updated calibration in order to turn the spectra we had gathered into information on amino acid composition.

What were you able to accomplish?

What are the results from this project?

NIRS Test. Over a two year period of funding from DATCP and others the Iowa State University Grain Testing Lab (Charles Hurburgh, director) finished two cycles of developing a Near Infra-Red Spectroscopy-based calibration based on the wet chemistry and spectral analysis of 200 samples of corn from our program. Many samples of corn from our test plots were sent to the lab, scanned with NIRS technology and spectra were collected. 200 samples of the most spectrally diverse samples were then sent to University of Missouri testing lab for HPLC analysis of grain for its amino acid content. The Grain Testing Lab then developed a NIRS calibration for testing for relevant amino acids (lysine, methionine, and cysteine/cystine). We applied the calibration to the spectra we had gathered at MFAI on approximately 4,000 samples to identify plants with a high methionine content. Those plants were packeted and planted in nurseries in May and June of this year, demonstrating the use of the method for breeding.

Many companies have attempted to calibrate amino acids in corn but have failed due to the inherent correlation between protein content and constituent amino acids. Fortunately, we had a unique data set composed of corn that produces high methionine in many different ways and this allowed us to break the inherent correlation between protein content and the relevant amino acids lysine and methionine, but not for cysteine/cystine. The correlation coefficients for protein with the amino acids lysine, methionine, and cysteine/cystine were 0.39, 0.54, and 0.80. The NIR calibration predicted lysine, methionine, and cysteine/cystine with correlation coefficients of 0.84, 0.75, and 0.78. The calibration was vastly improved over correlation with protein for predicting the lysine and methionine content of corn grain. This calibration is useful as a breeding tool and may allow us to test samples for companies as they develop their use of high methionine corn.

Breeding: Corn has different ways to make protein with enhanced quality. We assembled corn with these genetic systems and have been breeding with them. They include:

- Enhanced contents of high methionine *delta* zein storage proteins (hard endosperm, *dzr1* gene).
- Decreased contents of *alpha* zein and increased proteins with more methionine and tryptophan (*floury-2* gene).
- High oil corn (hard endosperm, large embryo size).

Our present breeding objectives focus on developing inbreds/populations that when made into hybrids have: 1) reliably high methionine content in the grain and proven ability to satisfy the needs of poultry; 2) reliable, high standing ability, high yields of grain, and quick dry-down of grain; 3) adequate disease and insect resistance; 4) vigorous and leafy growth with superior ability to compete with weeds, thereby adapting them for seed production under organic conditions. Weeds are presently a major problem in growing organic seed because inbreds lack vigor and do not compete well with weeds. We refer to this ideal combination of characteristics as our *organic ideotype*.

Our strategy involves breeding to this ideotype by crossing complementary lines and selecting their offspring through 3 cycles of inbreeding coupled with evaluating test crosses with these lines. The best lines are to be used per se or recombined to produce narrow populations with good vigor to use as seed stocks.

The lines from our breeding program that were identified by the NIRS calibration to be high in methionine were planted out in several nurseries in East Troy and in Ames, Iowa or in blanket plantings (isolations for seed increase). Thousands of plants were self pollinated in the small plot nurseries (5 to 7 from each 18 foot row) and crosses were also made between our cultivars and inbreds with higher methionine contents from companies that have been released after 18 years of protection by the Plant Variety Protection Act.

Together with USDA, we are implementing the systematic evaluation of our breeding lines within the nurseries using artificial disease and insect infestation. High methionine lines were inoculated with 2nd generation European Corn Borers and 12 different foliar and stalk diseases in Ames. In East Troy, they were inoculated with stalk diseases. We were able to screen those lines and make selections of plants with the least disease. At the present time we are still selecting in our nurseries for those plants. However, it is clear that some cultivars possess multiple pest and disease resistance.

Yield Trials with Hybrids: Due to wet conditions in both Wisconsin and Iowa we were not able to plant our hybrids in yield trials. However, we did send corn to Minnesota (U of MN, Lamberton Station) and we are presently waiting for data.

Feeding Trials: Organic Valley did not do feeding trials, but Practical Farmers of Iowa has done one trial with broilers using *fl2* corn and is doing another with hard endosperm high methionine corn. We do not yet have data on the trials.

A theoretical evaluation of diets for layers based simply on amino acid composition and NRC values for the needs of pullets and layers suggested the following:

- Without synthetic methionine, feeding floury-2 corn instead of normal corn would allow farmers to halve their use of soybean meal and cut costs of feed per hen by 13%.
- Feeding floury-2 corn would be more profitable until the cost of floury-2 exceeded that of normal corn by more than 20%.

Include any analysis of data collected or materials developed through project work
At the present time we are still gathering data on corn from our nurseries and we have not yet received data from our yield trials in Minnesota. Attached are data sets on NIRS calibration and from HPLC wet chemistry analysis of samples as well as a methionine fact sheet explaining high methionine corn and summarizing our analyses.

What conclusions can you make based on project work the analysis of collected data? 1) The NIRS calibration is promising; 2) High methionine corn exists in many different cultivars of different genetic background; 3) These high methionine corns provide the basis of cultivars and hybrids.

What do you plan to do in the future as a result of this project? Recently, a consortium of organic poultry companies called the Methionine Task Force (which includes Organic Valley) petitioned the NOSB for continued use of synthetic methionine. Allowance was made by the NOSB for two additional years of continued use until October, 2010. However, the NOSB appears adamant that an alternative be found quickly. It has requested continuous reports from the MTF at every meeting on progress towards achieving the goal of becoming independent from using the synthetic source. We intend to help the MTF to develop the corn and provide information to the NOSB. The MTF has funded the production of hybrid seed in Chile and the production of seed stocks in Hawaii.

A price incentive, track record, and monitoring system for high methionine corn needs to be established or it will not be grown. Grain yield, agronomic characteristics, and price will determine the risk that farmers will take in growing high methionine corn and thereby whether high methionine corn will be a competitive option. Yield reductions and subsequent increases in price associated with the production of high methionine corn will directly affect the willingness of companies to contract for high methionine grain or feed. On the other hand, high grain prices will probably cause organic poultry farmers to have a greater interest in growing their own corn.

We have inbreds that have promise for producing hybrids at the 90% yield level with similar agronomic traits to conventional hybrids (see attachment). However, these are generally in the 108 to 110 day relative maturity category and we actively breeding earlier hybrids to fit our region. Several inbreds can be immediately multiplied as they have potential for filling the forthcoming need, but we are running a longer-term breeding program to meet the long-term objectives. Multiple stresses associated with disease, weeds, insect, and climate fluctuations are a reality for organic corn crops and screening for multiple pests and diseases is important.

In the future we will continue our breeding program to develop cultivars of high methionine corn that will adequately meet the present and future needs of agriculture. If we can find funding we will plant and grow the best, high methionine cultivars in trials in Wisconsin and Minnesota thereby continuing the process of providing high methionine corn to farmers. We have prepared seed of several different

hybrids for testing including seed grown in Chile last winter and new hybrids made this last summer. This seed might be sent or given to farmers and companies in 2009 with the agreement that they would plant and tend it, and help to assess yields and agronomic characteristics on plots. We will analyze grain for its methionine content using NIRS technology that we developed. We also would like to promote the project and its results at various organic farmer meetings, including the Organic Valley Egg Pool and provide information to the MTF for the NOSB meetings.

A quick, cheap, and reliable test for methionine in corn grain is essential for helping grain handlers, grain elevator operators, and feeders to establish value of corn crops grown by farmers. Working together with the ISU Value Added Program and the Grain Quality Lab we have developed a Near Infra Red Spectroscopy (NIRS) test for rapidly and cheaply assessing the relevant amino acids in corn samples. Our approach has proven fruitful. Many companies have attempted to calibrate amino acids in corn but have failed due to the inherent correlation between protein content and constituent amino acids. Fortunately, we had a unique data set composed of corn breeding lines that produces high methionine in many different ways and this allowed us to break the inherent correlation between protein content and the relevant amino acids lysine and methionine. The calibration was vastly improved over correlation with protein for predicting the lysine and methionine content of corn grain.

This reliability of the calibration should allow us to test samples for companies as they develop uses for high methionine corn. The calibration and use of the ISU machine is greatly helping us to breed corn with enhanced methionine contents. Their use will allow us to identify breeding lines and hybrids that reliably produce high levels of methionine.

Though our present version of the calibration is a good start it needs to be updated and strengthened in coming years by repeatedly measuring grain samples grown in different sites and years. All NIRS tests increase in its value with subsequent years of testing and require regular validation.

What information or additional resources are needed to commercially develop this enterprise? Though we have made progress in developing high methionine corn we have need for further work to clarify and establish the role of high methionine corn. These include: a) further testing and refining the NIRS calibration and making it stronger; b) further testing of presently available high methionine cultivars and hybrids for level and reliability of their agronomic traits and methionine content; c) further work to gain acceptance by industry and farmers for high methionine corn cultivars, establishing price, testing guidelines, and contracts for production; d) further work to assist companies or universities with feeding trials.

It is crucial that feeding trials are done to clarify the reduction possible in soybean meal inputs under conditions where no sysnthetic methionine is fed.

For further perfecting the calibration we need two more years of data with 100 sample lots and smaller lots of 50 samples in following years. We envision that after the technique is established, routine updating and testing of the calibration will take place with help of industry cooperators.

How should the agricultural industry use the results from your grant project? Because the ban is such a critical issue it is important to provide the MTF and the NOSB with information on the progress we are making with high methionine corn. Poultry companies need to consider our results and to invest in purchasing high methionine corn from farmers for feeding trials with our corn. Organic poultry producers need to consider using our corn to replace synthetic methionine.