Proposal for “Grow Iowa Values Fund” Grant Program
Naturally Controlled Gelatinization of Corn Starch

PI: David Grewell, Agricultural and Biosystem Engineering, Iowa State University,
dgrewell@iastate.edu

Company Partners
($5,000 cash, $25,000 in-kind):

Grain Processing Corporation
$5,000 cash, $20,000 in-kind
Muscatine, IA
Perminus Mungara
(perminus_mungara@grainprocessing.com)

Emerson Electric Corporation
$5,000 in-kind
Danbury, CT
Jon Piasecki
(Jon.Piasecki@emerson.com)

Has this or a similar proposal been submitted in previous years to the GIVF competition?
NO

EXECUTIVE SUMMARY
The main thrust of the proposed work is to characterize, demonstrate, and scale-up the use of high
powered ultrasonics to partially and controllably gelatinize corn starch for an application. Grain
Processing Corporation (GPC), in collaboration with Dr. Grewell's laboratory, has produced bench-
scale data that show ultrasonics can be used to partially gelatinize corn starch. This new processing
method would allow GPC to market a new product with estimated annual sales of $10 million. This
is based on the fact that this product would be made without the use of aggressive chemistries and
sold as a “natural” product. In recent years, there has been a push by consumers for food or food
ingredients made without use of synthetic chemicals. These foods or ingredients with the “natural”
label have been the fastest growing product segment in the food industry with an estimated annual
growth of 20%. These pre-cooked starches are used in food products such as gravies, soups, fruit
pie fillings, puddings, dressings, dips, and pizza toppings, among others.

Annual production is estimated to be 15 million lb/year, requiring 20 continuous flow ultrasonic
systems from Emerson Electric Co. (EMR). The combined sales of the new starch and ultrasonic
systems represent a multi-million dollar sales increase in the state of Iowa. In this project, ISU
researchers will work closely with GPC to optimize processing conditions. In more detail, ISU will
treat samples at various conditions and GPC will characterize the effects giving ISU researchers
direct and immediate feedback. Based on optimized conditions, ISU, GPC and EMR will work
together to design and implement this technology into GPC’s production facilities.

It is important to note that the PI has been successful with previous commercialization projects,
including projects with Creative Composites (Ankeny IA-letter attached) and SoyWorks (IL).
Technical Objectives

This work will develop, demonstrate, and scale-up a novel, efficient technology for partially and controllably gelatinizing No. 2 yellow dent corn starch for food applications. In recent years, there has been a push by consumers for food or food ingredients made without use of synthetic chemicals. These foods or ingredients with the “natural” label have been the fastest growing product segment in the food industry with estimated annual growth of 20%. Natural instant starch (pre-cooked) is one such example of an important food ingredient. Instant starch is a cold water thickening starch that has many applications in food processing. These pre-cooked starches are used in food products such as gravies, soups, fruit pie fillings, puddings, dressings, dips, and pizza toppings, among others. In these applications, instant starch is preferred over conventional cooked starch because it delivers more stable products and increases efficiency during food processing.

Currently, methods for producing instant starches either involve use of harsh chemicals or energy intensive processes. For instance, in some methods native starch is modified with synthetic chemicals, such as propylene oxide, in order lower viscosity and achieve lower gelatinization temperatures. Other conventional methods for producing instant starches, such as extrusion and drum drying, are energy intensive. The proposed method will allow for convenient partial gelatinization of corn starch without application of harsh chemicals and using low energy intensity. This chemical-free method will allow the subsequently made product to be marketed as “natural.”

Researchers at GPC and Iowa State University (ISU) have shown that partial bulk (not limited to surface gelatinization) gelatinization is possible with high ultrasonic fields in a liquid medium (water). The work has been demonstrated with both batch and continuous flow systems. The partially gelatinized starch does not build viscosity and remains a pumpable fluid at room temperature. In addition, this product has the potential of being turned into a “natural” instant starch. Based on the existing market size, GPC projects $10 million of new annual sales for this Iowa-based company.

Ultrasound is sound waves at a frequency above the normal hearing range of humans (> 15-20 kHz). When the ultrasound wave propagates in a medium such as a liquid or slurry, it produces cavitation [1,2] and acoustic streaming [3]. The cavitation generates powerful hydro-mechanical shear forces in the bulk liquid [4], which disintegrates nearby particles by extreme shear forces. The main benefit of streaming in corn slurry processing is mixing, which facilitates the uniform distribution of ultrasound energy within the slurry mass, convection of the liquid, and dissipation of any heating that occurs.

Ultrasonication has been applied widely in various biological and chemical processes. The use of high-powered ultrasound has been used to enhance starch-protein separation in a wet-milling operation. Ebringerová et al. [5] used ultrasound to aid in the extraction of active xylan and heteroxylan from corn cobs and corn hulls, respectively. Wood et al. [6] studied the effects of ultrasonic treatment on ethanol fermentation from mixed office paper. The authors demonstrated that sonication of recycled paper increased ethanol production by as much as 20%. In addition, Dr. Grewell’s laboratory has shown that starch granules for both no. 2 yellow dent and sugary-2 corn can be gelatinized at room temperature [7].

In order to employ this technology commercially, characterization and optimization are needed, including tool design and parameters. The goal of this project is to work with GPC and EMR to realize this technology’s potential by optimizing and characterizing the technology, performing continuous flow studies (scale-up) and implementing the technology in GPC production facilities. Once the process is optimized, the PI and key personnel from EMR will assist GPC with full-scale equipment design, selection, and setup. This will occur through communications as well as plant visits to selected plant locations. It is important to note that EMR offers a commercially available ultrasonic system that has standard piping flanges for attachment. This assures that existing GPC
facilities can be retrofitted with ultrasonic systems. In addition, these systems have been proven in other industries, such as the municipal waste treatment industry.

**Scope of Work**

The work will be divided into three tasks: 1) optimization of bench-scale systems, 2) scale-up and continuous flow characterization, and 3) commercialization of the technology. These tasks are detailed below:

**TASK 1: Bench-scale Optimization of Controlled Gelatinization of Corn Starch**

In the initial phase, preliminary results from GPC and ISU will be further characterized to develop empirical models between processing parameters, such as energy density and amplitude to gelatinization. The degree of gelatinization will be characterized with cross polarization microscopy and thermal analysis methods, such as differential scanning calorimetry (DSC). GPC will conduct the characterization studies. Samples will be shipped to GPC (overnight) for studies and GPC will provide the results directly to ISU.

**TASK 2: Scale-up of Controlled Gelatinization of Corn Starch**

In order to gain insight into the scale-up, tests will be conducted in a continuous flow sonication chamber. A single and multiple donut horn system with a 3.0 kW (per horn), 20 kHz power supply will be employed. The reaction mixture will be pumped at various pressures and flow rates (1, 5, 7, 10, and 15 gallon/min). The parameters to be studied include:

- Amplitude: A (5 levels) 0, 3, 6, 9, and 12 µm\(_{\text{pp}}\)
- Pressure: P (5 levels) 5, 20, 40, 60, and 80 psi
- Flow rate: Q (5 levels) 1, 5, 7, 10, and 15 gallon/min

Again, GPC will characterize the effects of the ultrasonic treatment and give ISU direct feedback.

**TASK 3: Commercialization of Controlled Gelatinization of Corn Starch**

Once the optimum conditions are identified, the PI and key personnel from EMR will work with GPC to design a full-scale demonstration plant. This will occur through communications and consultations as well as production plant visits. The PI and key personnel will make at least 2 trips to a plant within the United States for 3 days/visit. In addition, EMR will assist with these installations at their own expenses.

**Materials**

GPC will supply all required feedstocks, including starch, for the entire duration of the project.

**Characterization**

GPC will characterize the processed feedstocks and provide direct feedback to the PI on the processes, modeling, and optimization. This will include, but not be limited to, differential scanning calorimetric (DSC), polarized optical microscopy and spray drying results.

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Commercialization Plan

The commercial objective of this work is to develop a new product for a medium-sized Iowa-based company (GPC) with a global reach. The new processing method developed uses ultrasonics to partially gelatinize corn starch and allows GPC to market a new product with estimated annual sales of $10 million (GPC estimate). This is based on the fact that this product would be made without the use of aggressive chemistries and would be sold as a “natural” product.

Because preliminary data at ISU has demonstrated that 15 gal/min of corn starch slurry can be treated with a single ultrasonic system; therefore, the projected annual sales of 15 million lbs with an assumed 30% wt. total solids, would require 20 units. This generates a new market for EMR. With an estimated cost of $10,000/ultrasonic unit, the GPC’s payback period on the investment will be less than 12 months. New sales of 15 million lbs of starch annually equates to new utilization of approximately 370,000 bushels of corn annually. The corn has a value of about $1.4 million/year at today’s price of $3.95/bushel and creates a new market for Iowa corn producers.

Project Deliverables
1. Develop a novel method, with accurate control, to partially gelatinize corn starch.
2. Commercialize resulting novel processing technologies and increase sales.

Budget

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<th>Category</th>
<th>Requested amount</th>
<th>ISU Cost Share</th>
<th>GPC</th>
<th>EMR</th>
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Budget Justification

Salaries and Wages:
Principal Investigator: 50% salary support for one month during the summer. Postdoctoral Research Associate: Hired for 12 months (50%) at a cost of $21,828.

Benefits: Fringe benefits are estimated as 27.2% and 23% of salary for the PI and the postdoctoral research associate, respectively.

Materials and Supplies: All materials and chemistries will be provided by GPC. The project will be charged $500 for overnight shipping of materials.

Travel: Trips to visit collaborating companies will be charged to the project at a cost of $3,000. All travel by corporate sponsors will be paid directly by the companies.

Cost Share: Attached are selected letters of support detailing the industrial contribution. Cash cost share includes: $5,000 from GPC. In-kind cost share includes: $5,000 from EMR, $20,000 from GPC, and $6,078 from ISU as one month of cost share for one month of salary for the PI. These in-kind cost share amounts will be used for technical support, chemicals, and feedstocks (namely starch), product development, and commercialization of the proposed products.

Schedule This project will have a total duration of approximately 12 months as detailed below:

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<thead>
<tr>
<th>Task</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
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<tbody>
<tr>
<td>1) Bench-scale Optimization</td>
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<td>2) Continuous Flow Optimization</td>
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<td>3) Production Demonstration</td>
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May 27, 2009

David Grewell, PhD
Agricultural and Biosystem Engineering
100 Davidson Hall
Iowa State University
Ames, IA 50011
515-294-2036
FAX 515-294-2255

Dear Dr. Grewell,

On behalf of Grain Processing Corporation, We are highly supportive of the Grow Iowa Values Fund proposal by Dr. Grewell entitled “Natural Controlled Gelatinization of Corn Starch.”

Grain Processing Corporation (GPC) is a major supplier of carbohydrate ingredients for the food industry and sees the tremendous economic potential of supplying “Natural” line of starches. The consumer-driven natural line of food ingredients is the fastest growing throughout the world and GPC is well placed to become a major player in this field by developing high quality products that GPC is known for.

In the last few months, GPC had an opportunity to work in your lab and use ultrasonication equipment to test the concept of controllably gelatinizing native starch to a level that is amenable to post treatment processing. This preliminary work showed tremendous potential for being adaptable and scalable for industrial production of partially gelatinized starches. However, the work also revealed a need for process optimization and product characterization. These results will give GPC a better position in an industrial set-up. GPC is fully committed to working with you to realize successful industrial adaptation of this processing method. GPC agrees to support with $5,000 in cash and $20,000 of in-kind support in terms of technician and laboratory support.

Additionally, successful development of natural instant starches resulting from this unique technique has ability to generate over $10M/year in sales to this Iowa based company.

ISU and GIVF will be instrumental in helping develop this processing method. Also, a successful commercial launch of a product resulting from this technique fulfills the mandate of GIVF. This proposal is an excellent example of how academic-industrial collaborations can be leveraged with State Funds in order to create novel methods or new products that benefit the State of Iowa. In addition, this project will help satisfy the consumer need for “naturally” processed food ingredients.

GPC looks forward to the opportunity of working with you.

Sincerely,

Frank Barresi, PhD, Senior VP, Research & Development

Perminas Mungara, PhD, Research Scientist, Research & Development
May 31, 2009

Dr. David Grewell  
Agricultural and Bio-Systems Engineering  
Iowa State University  
100 Davidson Hall  
Ames, IA 50011-3232

Subject: Letter of support for the project on “Bio-fuels Unit Operations Course Development”

Dear Dr. Grewell,

It is my great pleasure to participate in “Naturally Controlled Gelatinization of Corn Starch” for Grow Iowa Value Funds. As you know Branson Ultrasonics is a division of Emerson Electric which has great interest in developing technologies relating to sonochemistry and in particular to the food processing industry. We feel that this is a large market opportunity for Emerson’s core technologies and help us remain competitive in a struggling economy.

Branson will happily provide technical support during installation and equipment design/selection up to $5,000. With success of the research, Branson would like to help commercialize this growing market.

I strongly support the proposed research under “Naturally Controlled Gelatinization of Corn Starch”. If you need any further information, please feel free to contact me.

Yours Sincerely,

[Signature]

Peter J. Keleb  
Director of Advanced Engineering  
Branson Ultrasonics
June 1, 2009

Dr. David Grewell
Agricultural and Bio-Systems Engineering
Iowa State University
100 Davidson Hall
Ames, IA 50011-3232

Subject: Letter of support

To Whom It May Concern,

As you know we were part of an ongoing GIFV project and are very encouraged by the results of this work and are currently testing commercial designs for future products. Dr. Grewell has been very helpful in formulation development, testing and product design. He and his group are always very responsive and willing to respond at a moments notice. They have supplied us invaluable information on our current product as well as the new proto-types allowing us to make engineering and marketing plans regarding product design. These new designs will give us a competitive edge relative to our competitors’ products. Dr. Grewell’s team has lead us through these new formulations and designs and it has been a great pleasure working with them.

Please feel free to contact me directly for any further details.

Yours, Sincerely,

Aron Fleischmann
PI Name: David Grewell

Project Title: Naturally Controlled Gelatinization of Corn Starch

College Ranking _1 of 6_

Recommendation: Fund _X__ Fund if Possible ___ Do Not Fund ___

SECTION I: TECHNICAL MERIT (60% of recommendation)

5

Considerations:
• What is the scientific merit of the proposed project?
• Is the project technically feasible to accomplish in the listed time frame?
• Does the budget seem reasonable?
• Does the PI/team of researchers have the qualifications necessary to carry out the work?

Justification:
High scientific importance with a highly qualified team of researchers. Modest and appropriate budget for a 1-yr project

SECTION II: BROADER IMPACTS (30% of recommendation)

5

Considerations:
• What is the probability that this project could be used to leverage future funding from non-ISU sources?
• What is the potential to increase ISU’s research capabilities or capacity?
• What is the potential to enhance learning opportunities for students?

Justification:
Very strong industry connection. Clear leveraging of industry-sponsored research. Unclear connection with graduate students.

SECTION III: COMMERCIAL POTENTIAL (10% of recommendation)

5

Considerations:
• What is the likelihood that new intellectual property will be generated?
• What is the likelihood of eventual commercial success?

Justification:
High likelihood of new IP and eventual commercial success.
Proposal Number: FY10-26

PI Name: David Grewell

Project Title: Naturally Controlled Gelatinization of Corn Starch

Commercial Recommendation: Fund

Commercial Potential:

1) Will this project lead to a new Iowa business/company, or increase the sales/profitability of a recently started Iowa company?

   Yes

   Please comment on the above:
   Increased sales potential through new product development based on process

2) Will this project increase the sales or profitability of an existing Iowa business/company?

   Yes - Grain Processing Corporation

   What is the probability of commercial success:

   Preliminary data is promising. Industry partner is well established company with means to successfully introduce new products to market.

Grain Processing Corporation, Muscatine, estimated new annual sales of $10 million.

3) Are competitors identified, is the advantage of the proposed technology clear.

   Yes/No

   Please comment on the above:

   “Natural” aspect of this product would be selling point, opening new markets.

No competitors are identified. The advantage is to partially gelatinize corn starch with the use of ultrasonics. This opens up a new natural product line to market nationally.

4) Is there a clear strategy for entry to the market, start up or existing Iowa business/company.

   Yes

   The entry into the market with a new product line would be rather quick after full testing.

5) Please make any other comments related to the commercial potential of this proposal:

   This reviewer appreciated the modest budget requested for the project. Considering the predicted market of $10M new annual sales, it would be nice to see higher cash investment by industry partner.

   Intellectual Property Evaluation
1. Have any current ISURF invention disclosures been identified as background IP?  No

2. Does this project have the potential to generate new intellectual property?  No
   (please explain)

3. Based on your current knowledge, without having the opportunity to receive input from the principle investigator or to conduct a market or technology assessment, what will be the barriers to commercializing this technology?

Unknown