



Agricultural Marketing Service

U.S. DEPARTMENT OF AGRICULTURE

AWARD YEARS 2021 AND PRIOR

This annual Performance Progress Report (PPR) must illustrate the progress made toward the completion of your project. If this project is completed at the time of the annual PPR submission, the project report should be marked as final. Please note character limits (abbreviated "char.") throughout.

PROJECT INFORMATION

Project Title (250 char.)	Enhancing Economic Return on Pulses Through Cultivar Selection and Ingredient Production
Organization Name (250 char.)	South Dakota State University
Project Start Date	09/30/2020
Project End Date	09/29/2023

ORGANIZATION POINT OF CONTACT

Full Name	Clifford Hall
Phone Number	605-688-6233
Email Address	clifford.hall@sdstate.edu

BACKGROUND INFORMATION

PROJECT PROGRESS

Please provide the total percentage of work completed on the project.	100
Is this a final report? Please select the box to the right if the answer is "yes".	☐

PROJECT BACKGROUND (REQUIRED FOR FINAL REPORTS)

Provide enough information for the reader to understand the importance or context of the project and any key findings. This section may draw from the background and justification contained in the accepted project plan. As the project has been completed, write this section in past tense. If this is an annual report, please skip this section. (1200 char.)

The project focus was to identify cultivars grown in South Dakota that have the greatest protein composition and have functional characteristics suitable as food ingredients. The research is important because the protein and starch compositions of peas grown in South Dakota was established and showed compositional differences among cultivars. Cultivar composition analysis was targeted since food ingredient manufacturers pay a premium for high protein peas. The highest protein contents were approximately 27% for the striker cultivar. Nette 2010 had the highest starch concentration. The specialty crop producer of pea will benefit by knowing what cultivar will most likely return a premium and thereby enhance the economic return for the producer. In addition, life cycle assessment of agricultural production has gained traction within the last decade. Ingredient and food manufacturers look for ways to utilize the whole commodity as a means to create a positive life cycle assessment. Thus, we demonstrated several uses of the starch fraction, which is considered a byproduct of protein isolation,

in puddings and yogurt.

OBJECTIVE(S) (REQUIRED)

Please provide the approved project's objectives from the accepted project plan. Use the boxes to indicate if the objective is in progress, has been completed, or is not (and will not be) completed. At the final report, if "no" is selected for any of the listed objectives, you must expand upon this in the Challenges and Developments Section. Additional objectives may be added as needed.

+	#	Objective (2,000 char.)	Objective Completed?
-	1	To validate the relationship between protein content and cultivar through production of pulses at different growing locations.	Yes
-	2	To demonstrate the versatility of pea starch using model laboratory functionality tests and through development of food items not commonly associated with pea.	Yes
-	3	To develop visual and written materials representing a farm-to-table basis for further development of peas as a specialty crop.	Yes
-	4	To present a seminar to specialty crop growers and food ingredient manufacturers on characteristics of pulses such as pea that will provide enhanced economic return and have a positive impact on sustainability.	Yes

OUTCOMES

Please only report on the outcomes and indicators that are selected and approved for this project. Use the check boxes to indicate which outcomes and indicators are selected. Select the "N/A" box for any indicators that are not applicable.

1. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH INCREASED SALES

☐

2. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH INCREASED CONSUMPTION

☒

Please provide the total number of children and youth reached and select the applicable indicators for this reporting period.

Indicators	Value	N/A
1. Total number of children and youth		☒
1.a. Of the total number in 1, enter the number of children and youth that gained knowledge about eating more specialty crops		☒
1.b. Of the total number in 1, enter the number of children and youth that reported an intention to eat more specialty crops		☒
1.c. Of the total number in 1, enter the number of children and youth that reported eating more specialty crops		☒

Please provide the total number of adults reached and select the applicable indicators for this reporting period.

Indicators	Value	N/A
2. Total number of adults reached		☒

Indicators	Value	N/A
2.a. Of the total number in 2, enter the number of adults that gained knowledge about eating more specialty crops		☒
2.b. Of the total number in 2, enter the number of adults that reported an intention to eat more specialty crops		☒
2.c. Of the total number in 2, enter the number of adults that reported eating more specialty crops		☒

Please provide the number of new and improved technologies and processes to enhance the nutritional value and consumer acceptance of specialty crops (excluding patents) for this reporting period.

Indicators	Value	N/A
3. Number of new and improved technologies and processes	3	☐

Please provide the number of new specialty crops and/or specialty crop products introduced to consumers this reporting period.

Indicators	Value	N/A
4. Number of new specialty crops and/or specialty crop products	2	☐

3. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH INCREASED ACCESS AND AWARENESS ☐

4. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH GREATER CAPACITY OF SUSTAINABLE PRACTICES OF SPECIALTY CROP PRODUCTION RESULTING IN INCREASED YIELD, REDUCED INPUTS, INCREASED EFFICIENCY, INCREASED ECONOMIC RETURN, AND/OR CONSERVATION OF RESOURCES ☒

Please provide the numbers of plant/seed releases (e.g., cultivars, drought-tolerant plants, organic, enhanced nutritional composition, etc.) for this reporting period.

Indicators	Value	N/A
1. Number of plant/seed releases		☒

Please select the applicable indicators and provide data for the adoption of best practices and technologies resulting in increased yields, reduced inputs, increased efficiency, increased economic return, and conservation of resources for this reporting period.

Indicators	Value	N/A
2.a. Number of growers/producers indicating adoption of recommended practices	2	☐
2.b. Number of growers/producers reporting reduction in pesticides, fertilizers, water used/acres		☒
2.c. Number of producers reporting increased dollar returns per acre or reduced costs per acre		☒
2.d. Number of acres in conservation tillage or acres in other best management practices		☒

Please provide the total number of adults reached and select the applicable indicators for this reporting period.

Indicators	Value	N/A
3. Number of habitat acres established and maintained for the mutual benefit of pollinators and specialty crops		☒

5. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH MORE SUSTAINABLE, DIVERSE, AND RESILIENT SPECIALTY CROP SYSTEMS ☐

6. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH INCREASING THE NUMBER OF VIABLE TECHNOLOGIES TO IMPROVE FOOD SAFETY ☐

7. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH INCREASED UNDERSTANDING OF THREATS TO FOOD SAFETY FROM MICROBIAL AND CHEMICAL SOURCES ☐

8. ENHANCE THE COMPETITIVENESS OF SPECIALTY CROPS THROUGH ENHANCING OR IMPROVING THE ECONOMY AS A RESULT OF SPECIALTY CROP DEVELOPMENT ☐

ADDITIONAL APPROVED OUTCOME (IF APPLICABLE) ☐

OUTCOME REMARKS (REQUIRED)

Please explain any quantifiable results, along with an update on their progress and data collection efforts for each of the outcomes and indicators selected in the accepted project plan. It is understood that the results may not yet be final at the time that this report is submitted; however, please provide an update on progress to date. If you do not have any data on the indicator(s) listed above, you must explain why in this section. (2,000 char.)

Outcome 2, indicators 3 and 4: We have optimized the starch isolation process. Under the dehulling-fractionation approach, 6 times less water was used compared to using the whole or dehulled pea flour as the starting materials. This aspect of the project led to the creation of one isolation technology. The pea starch from the developed approach was further purified using supercritical fluid extraction using ethanol modifier (SFE-E) and ethanol (EtOH) extraction to remove color and flavor. Both SFE-E and EtOH extraction processes produced similar starch ingredients. In contrast, the pre-gelatinized starch had significantly different properties. The application of the different starches in food products was also demonstrated. Thus, the goal to produce two starch ingredients and two product applications was accomplished. Project success was defined as 30% of the ingredient manufacturers completing a webinar survey indicating that they will adopt the technology for producing starch ingredients. A survey was provided to participants after the webinar. The response rate was low (5% of the 41 reviews of the webinar). Responses indicated adoption of the technology and pea starch utilization.

Outcome 4. An increased economic return includes incentives for protein composition greater than 23%. Before a benefit can be gained, we must first know which pea cultivars will provide producers a premium. Peas with the highest protein were identified in this research. The 10-25 cents/bu premium some ingredient manufacturers pay can signify an increased economic return. As a result, at \$0.25/bu premiums, an additional \$2.00 to \$7.25 per acre can be gained by the producer for meeting the 23% protein based on the protein percentage and bushel per acre yield. Thus, recommendations regarding pea cultivar must include production data and protein percentage for best returns to producers. However, the low response rate for the survey indicated 2 producers adopting targeted cultivars.

NARRATIVE

ACCOMPLISHMENTS (REQUIRED)

If this is an annual report, list your accomplishments for this reporting period. If this is a final report, your accomplishments should be cumulative and include all accomplishments previously reported on and updated to include activities conducted this past reporting period. Indicate how these accomplishments associated with each of your project's objective(s), outcome(s), and/or indicator(s). This listing should identify your project's partners and their contributions. Additional accomplishments can be added as needed.

+	#	Accomplishment (1,200 char.)	Related to (Objective/ Outcome)
---	---	------------------------------	------------------------------------

-	1	The protein, starch, and amylose contents of 182 pea samples were evaluated. The data supports significant compositional differences among the cultivars. The data will allow producers and ingredient manufacturers to select cultivars that meet their requirements. For example, higher protein cultivars may be more advantageous for growers as ingredient manufacturers of protein ingredients pay a premium for high protein peas. The data also supports that experimental lines match or exceed protein and starch composition of commercial cultivars. This is valuable information as the need for new cultivars exists and those that can deliver higher protein will bring greater returns to the grower.	The data obtained is relevant to Objective 1 and Outcome 4, Indicator 2. Specifically, quality indicators (protein and starch) of both spring and winter peas were determined. These data coupled with agronomic data will provide invaluable insight for producers choosing the best cultivars to plant with targeted composition.
-	2	Under this objective, we treated isolated pea starch to remove flavor. An advisor to the pulse quality lab recommended that we use an approach suited for the ingredient manufacturing industry. Therefore, the process of starch isolation was evaluated first followed by methods to remove flavor. We evaluated different isolation techniques to determine an improved method that was more suitable for the food industry than a laboratory research approach. This research supports an efficient isolation technique that utilizes a dehulling step prior to an alkaline extraction step. The result of this work was a significant reduction in the need for repeated chemical washing steps during the purification process of starch isolation.	Objective 2. To demonstrate the versatility of pea starch using model laboratory functionality tests and through development of food items not commonly associated with pea. This research activity allowed use to answer two questions. First, can we develop extraction protocols that yield more starch than traditional approaches. Second, can we improve color and flavor of raw starch isolates without major changes in total starch content. This information was important for Outcome 2, indicator 3.
-	3	Functional properties of isolated and purified starches were completed. Samples that were dehulled prior to starch isolation produced raw starch samples that had higher pasting properties compared to samples that were not dehulled before extraction. Second, samples that passed a 100-mesh sieve had higher peak viscosities than other samples. This supports the isolation process impacted raw starch properties. Furthermore, the method used for purification of raw starch impacts functionality. The differences in functional and pasting properties observed specifically in the SFE-E purified starch likely are due to complex changes in the starch. While water holding capacity and oil holding capacities were different, the differences were small. However, the pasting properties of the SFE-E purified raw starch were significantly different. In contrast, the properties of the raw starch and EtOH extracted starch were comparable for the functionality test. This data supports that the ethanol extraction to remove color and flavor did not significantly impact functional and pasting properties. This is important if a product developer needs starch that has similar properties to raw pea starch.	Object 2. The properties of the pea starch isolated from dehulled peas followed by SFE-E and EtOH extraction was completed. This research activity allowed us to answer the question does the preparation of purified starch impact functional properties compared to raw starch. Addressing functionality questions can provide food manufacturers with answers regarding functionality of the starch and potential applications. This information was important for Outcome 2, indicators 3 and 4.

-	4	The formulation development using raw and purified (SFE-E and EtOH) pea starch completed the activities of objective two. The focus of this formulation development was the application of various pea starches in the creation of pudding and yogurt products. These two products are unique as pea starch application in puddings and yogurt have not been reported. In addition, sugar cookies and base formula for the chocolate beverage has been developed. Based on the firmness, syneresis, and sensory data, the EtOH treated starch would be the recommended version of pea starch, evaluated in this research, to use in a pudding application while both the EtOH and SFE-E treated starches would be the recommended versions of pea starch, evaluated in this research, to use in a yogurt application. For beverages that need slight viscosity enhancement, but not gelling characteristics, a recommendation is that the formula developed using pre-gelatinized pea starch is best for the beverage. Cookies made with EtOH and SFE-E treated starches were not substantially different and thus either starch would be acceptable for use in cookies.	Objective 2 and Outcome 2, indicator 4. The focus in this product development was to create puddings and yogurts using SFE-E and EtOH treated pea starch. In addition, pre-gelatinized pea starch was also assessed in pudding formulations. This research activity allowed us to develop two products (pudding and yogurt) using the SFE-E and EtOH treated pea starches developed during this research.
-	5	Under objective 3, a technical bulletin entitled "Composition and Functionality of Peas Grown in South Dakota" was developed. This bulletin provided information on the visual images of the pea cultivars/varieties that were investigated, images of pudding and yogurt, and functional properties. Data tables were also provided in the bulletin along with text highlighting major findings. Overall, the technical bulletin provides a more in-depth discussion of the data than presented in this final report.	Objective 3. To develop visual and written materials representing a farm-to-table basis for further development of peas as a specialty crop.
-	6	This research was presented at two producer orient meetings and 1 scientific meeting. The project also yielded two webinars. The producers orient meetings had approximately 30 individuals in attendance in each presentation (60 total). The scientific meeting involved a graduate student presenting his work on pea starch. Approximately 25 individuals spoke with my student while an additional 35 took paper copies of the available poster presentation. The starch webinar was a live event and 83 individuals had registered for the event. However, by the end of the funding period, 41 had watched live or reviewed the recording. The protein webinar was placed online line as a prerecorded webinar in late August and has been reviewed eleven times.	Objective 4. To present a seminar to specialty crop growers and food ingredient manufacturers on characteristics of pulses such as pea that will provide enhanced economic return and have a positive impact on sustainability.

CHALLENGES AND DEVELOPMENTS (REQUIRED)

Provide any challenges to the completion of your project or any positive developments outside of the project's original intent that you experienced during this reporting period. Also, provide the corrective actions you took to address these issues. If you did not attain an approved objective, outcome(s), and/or indicator(s), provide an explanation in the Corrective Actions column. For developments, you may put "N/A" under Corrective Actions. Additional challenges/developments may be added as needed.

+	#	Challenge or Development (1,200 char.)	Corrective Action
---	---	--	-------------------

-	1	The addition of activities related to pre-gelatinized starch was based on the advice from an ingredient manufacturing company.	We conducted only a few activities involving pre-gelatinized starch. The activity to create and assess pregelatinized pea starch is an entire research project. Thus, the targeting of pudding applications was appropriate since commercial pudding products contain pre-gelatinized starch. The outcome of pre-gelatinized starch assessment was that it was better suited for a nutritional beverage that requires viscosity enhancement compared to a gel formation.
-	2	Starch isolation was another area of research that was added to the project. Like pregelatinized starch activity, the decision to develop a new approach to starch isolation from peas was based on discussions with an ingredient manufacturer to evaluate a commercial starch isolation approach rather than a laboratory isolation technique.	In this activity we evaluated the process of converting whole pea to an isolated starch. The starch obtained was subjected to purification processes that were originally proposed. Thus, the main difference between the revised activity and the original proposal was the revised method used an isolation approach relevant to ingredient manufacturers.
-	3	A challenge encountered dealt with the survey response. The survey response to questions after the webinar was less than 5%.	The webinar was completed within the last three months of the project end date. Thus, it was not possible to collect additional survey information.

UPCOMING ACTIVITIES (REQUIRED FOR ANNUAL REPORTS)

Provide a description of the activities that you are planning to complete during the next reporting period. Additional activities can be added as needed. Please note, if this is a final report there should be no upcoming activities associated with the project, and this section should be left blank.

+	#	Activity (600 char.)	Anticipated Completion
-			

-			
---	--	--	--

LESSON LEARNED (REQUIRED FOR FINAL REPORTS)

The recipient or subrecipient is required to provide recommendations or advice that others may use to improve their performance in implementing similar projects. If this is an annual report, please skip this section. (1200 char.)

The most significant lesson learned was that the approach to collecting survey data needs to be changed. Webinars are effective in reaching those that cannot make a physical location for a meeting. In hindsight, we should have presented the webinars through several venues to broaden the audience attending the events. Also, a follow up communication with those attendees should have been done within a few days of the webinar completion. The last recommendation would be to reach out to the US Dry Pea and Lentil Trade Associate as a possible venue to present the composition and functionality data. My recent attendance at their annual meeting is the basis for this recommendation where I spoke with individuals about general pulse quality and functionality not related to this project.

CONTINUATION AND DISSEMINATION OF RESULTS (REQUIRED FOR FINAL REPORTS)

Describe your plans for continuing the project (sustainability; capacity building) and/or disseminating the project results. If this is an annual report, please skip this section. (1200 char.)

The results collected during the research activities led to the creation of two webinars on protein and starch utilization. In addition, a technical bulletin was developed. These outputs were not scientifically intensive and thus we will continue to disseminate the information to the scientific community. The amount of data collected will allow for the creation of two manuscripts to be submitted to scientific organizations. The manuscripts will include protein and starch composition for the Journal of Food Composition and physical and functional properties and product utilization to the Cereal Chemistry journal.

PROJECT BENEFICIARIES (REQUIRED FOR FINAL REPORTS)

Provide the number of project beneficiaries. If this is an annual report, please skip this section. (12 char.)

5,000

FEDERAL PROJECT EXPENDITURE

EXPENDITURE (REQUIRED)

You must respond to at least one cost category. Please note, the subtotal and total rows include formulas to auto-calculate totals. The approved budget should come from the accepted project plan or any approved budget amendments.

Cost Category	Amount Approved in Budget	Actual Federal Expenditures (Federal Funds Only)
Personnel	\$52,098.00	\$52,233.36
Fringe Benefits	\$4,040.00	\$3,838.99
Travel	\$0.00	\$0.00

Equipment	\$0.00	\$0.00
Supplies	\$7,770.30	\$7,454.94
Contractual	\$13,000.00	\$3,060.00
Other	\$7,868.00	\$9,385.57
Direct Costs Sub-Total	\$84,776.30	\$75,972.86
Indirect Costs	\$7,221.70	\$6,554.61
Project Expenditure Total Federal Costs	\$91,998.00	\$82,527.47

DISCUSSION OF EXPENDITURES (REQUIRED)

For 1st Annual Reports, if total project expenditures is less than 30 percent, and for 2nd Annual Reports, if total project expenditures is less than 60 percent, include a statement explaining how the grant funds will be expended and project activities completed as planned by the end date on the grant agreement. Any state approved budget amendments should be included here; Include the line item that the funds are coming from and going to and when the state approved the budget amendment. (1,200 char.)

In general, expenditures for most budget categories were met except for the contractual. The original contractual agreement was for the sending of a newsletter and publication of the technical bulletin. While the SD Pulse Crop Council originally planned a newsletter, pay for travel to Ag Horizons, and technical bulletin. A change in personnel from the time of approval to year 1 the original lead from the SD Pulse Crop Council left. Thus, timing of the new hire meant we were into the grant period and were unable to send out newsletters. The SD Pulse Crop Council did arrange a publisher of the Technical Bulletin. However, the PI created the document. Thus, the only contractual need was for the webinar development.

PROGRAM INCOME (IF APPLICABLE)

If program income was earned on the project, grant recipients are required to report on the source, amount, and how funds were expended. Program income is gross income --earned by a recipient or subrecipient under a grant --directly generated by the grant-supported activity or earned only because of the grant agreement during the grant period of performance. Program income includes, but is not limited to, income from fees for services performed; the sale of commodities or items fabricated under an award (this includes items sold at cost if the cost of producing the item was funded in whole or partially with grant funds); registration fees for conferences, etc.

+	Source/Nature of Program Income (100 char.)	Amount Approved in Budget	Actual Amount Earned
-		\$0.00	\$0.00

USE OF PROGRAM INCOME (IF APPLICABLE)

Describe how the earned program income was used to further the objectives of this project during the performance period. Any income generated must be reinvested back into the project and not set aside or reserved for future expenses after the grant ends. (1,200 char.)

PPR ATTACHMENTS DESCRIPTION (IF APPLICABLE)

Grantors will rely on the data that is submitted in this form when they report to congress. However, if you think additional documents are necessary to support PPR, please attach then and provide a document name and description of document below.

+	Document Name	Document Description
-	Webinar Link	https://www.northern-crops.com/past-webinar-videos/cliff-hall-pea-starch-webinar-june-15-2023
-	Technical Bulletin	Technical bulletin on the composition and functionality evaluations completed in this research. The data reported is targeted at producers and ingredient manufacturers.