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

Contract Number: **21035**

Grant Project Title: **Improving the Competitive Advantage of Wisconsin Cheese Makers through the Development of In-line Monitoring of Moisture**

Amount of Funding Awarded: **$14,000**

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Report Submitted on: **October 14, 2009**

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1. What is the intent of the Grant?

The objective of this grant was to use new technology to monitor and control the moisture level in mozzarella during the production process where the cheese exits the cooker. Once a correlation was developed between the in-process moisture level and finished product moisture level additional moisture would be injected into the cheese using controls to target a specific final moisture level.

A successful outcome of this grant project would benefit Wisconsin Agriculture in a very specialized area: mozzarella cheese manufacturers. The in-line moisture monitoring capabilities will give producers a competitive advantage to increase their yield and maintain product consistency without compromising the unique functionality characteristics of mozzarella cheese.

A project of this nature supplies the mozzarella cheese manufacturer with the knowledge and confidence to make small adjustments to their art of making cheese that can significantly improve their bottom line without detracting from product quality.

2. What steps did you take to reach your goal?

A number of steps were taken to achieve our goal with this project; first and foremost ESE aligned itself with a number of experts within the industry. ESE strived to not only have the best hardware and intelligence working together, but also felt this type of project required an open-minded, progressive-thinking plant to host the trials. Trega Foods, in Luxemburg, WI was selected for the plant trials and Johnson Industries was engaged to provide the moisture injection part of the solution.

The first step to implementing this grant project was to collect baseline data that benchmarked the current process configuration without any modifications. Once the benchmark data was collected

and analyzed the team worked together to identify success criteria, which was defined as a reduction in the finished product moisture StDev by 0.07 for the Whole Milk and Part Skim Mozzarella recipes respectively.

Hardware installation included positioning ESE's patent pending Q5I in-line analytical instrument at the immediate discharge of the cooker. The Q5 uses Near Infrared technology to monitor the moisture in the molten cheese as it exits the cooker. A calibration was developed to capture process variation, seasonal milk changes, and moisture levels for both recipes individually. Several validations were conducted to verify the Q5 was accurately reflecting the moisture level of the molten cheese when compared to the lab reference method.

Once the Q5 was successfully calibrated the next step was to install Johnson Industries moisture injection system that included a four port injection halo designed to stream warm water into the molten cheese. An encoder was also installed to monitor the speed of the cheese as it entered into the molder. A control program was designed to use the Q5 moisture reading and encoder speed output to determine the water injection rate.

Five individual water injection trials were conducted to see how the addition of warm water to the molten cheese impacted the functionality of the cheese. The Center for Dairy Research in Madison, WI conducted a variety of functionality tests and concluded that there were no significant differences between the cheese that was treated with warm water compared to the control cheese.

However, the plant was seeing an additional amount of liquid expelled from the cheese at the molder and had concerns that the water injected into the cheese at the exit of the cooker was purging out in the molder. Further research pointed to the cheese molecular structure at this point in the process and its inability to retain additional water without some type of binding agent.

Additional trials were conducted injecting various levels of salt solution ranging from saturated 26% concentration wt/wt down to 18%. With the addition of the salt to the injection brine, the amount of dry salt added to the curd on the table was reduced. The reduction of dry salting on the table improved the consistency of the cheese moisture as it exited the cooker.

During the process there were several challenges encountered. One of the first hurdles that emerged was the amount of space available to install the control panel that housed the Q5I components. As with many dairy plants, extra real estate is difficult to find; fortunately, the Q5 is designed to be versatile and was easily modified to fit within the customer's needs.

The second issue identified and overcome dealt with the speed of the cheese as it flowed through the system. Depending on the rate that the cheese exited the cooker affected the sample collection times further on in the process. By using the speed from the encoder wheel a matrix was developed as to when to correctly collect samples from the Rotary Molder Chiller.

Third issue, the plant recipe requirements changed and prevented it from running the same product mix as was run during the benchmarking period. This caused considerable delays. Once customer requirements dictated the need to run those products, testing continued.

The fourth issue dealt with the encoder and halo injection system requiring several adjustments to obtain the optimum production environment. Several changes were also made to accommodate operator requests for ease of cleaning and handling of the equipment.

What to do differently:

A. ESE had to engineer the optimum location for the equipment and it took several attempts due to the limited working area, taking into consideration all operator activities.
B. The customer's recipe requirements changed, causing delays in calibration. Better anticipate recipe changes that may come into play and develop contingency plans.
C. New personnel became involved with the project without the previous understanding of the value of the project. The sense of urgency was not as strong as it later became.
D. Defining the functionality tests earlier in the process would have avoided delays.

3. What were you able to accomplish?
The objective of the project was to improve the consistency of the moisture in the cheese and reduce the standard deviation (StDev). Once an improvement in product consistency can be identified then an opportunity is presented to modify moisture the set point. Below is the Benchmark data that was collected before any modifications were made to the process. Using the benchmark data, the group defined success criteria listed below. The last set of data presented shows data relative to the water only trials where the StDev was improved, but no significant improvement was noted for Average Moisture.

Process Control Statistics

	Benchmark Data		
Product	StDev	Samples	Ave Moisture
Low Moisture Whole Milk	1.00	2413	46.78
Low Moisture Part Skim	0.94	1884	47.98

	Success Criteria
Product	StDev
Low Moisture Whole Milk	0.93
Low Moisture Part Skim	0.87

	Trial Data		
Product	StDev	Samples	Ave Moisture
Low Moisture Whole Milk	0.857	126	46.7
Low Moisture Part Skim	0.864	165	48.5

The trials where the salt brine was injected resulted in finished cheese with very comparable composition to that of control cheese with no injection of any kind. The only drawback of adding salt brine to the molten cheese after the cooker is that some pocketing appeared in the cheese.

Unfortunately attempts to increase the amount of moisture injected and retained in the cheese after the cooker were unsuccessful.

4. What conclusions can you make based on project work the analysis of collected data?
   Using the data collected it can be concluded that warm water and warm salt brine can be injected into molten cheese with limited improvements to the finished product. Improvement in standard deviation would improve the consistency of product. However, we were not able to raise the level of moisture retained, the average moisture level.

5. What do you plan to do in the future as a result of this project?
   As a result of this project ESE plans to continue market this technology to other areas within food processing, where benefits from monitoring and controlling moisture, fat, protein, and/or solids of their products inline bring much faster returns on investment.

6. What information or additional resources are needed to commercially develop this enterprise?
   Additional resources needed to commercially develop this enterprise include more extensive research and development into the methodology of being able to raise the moisture content of mozzarella cheese. This project has data to prove the technology can monitor moisture inline, but being able to raise the moisture in the process still needs further development.

7. How should the agricultural industry use the results from your grant project?
   The agriculture industry should use the results from this grant project to understand that production processes can be monitored, but that more work is needed on the production processes needed to actually adjust and optimize the product by increasing yield through moisture adjustment without harming the product functionality.