Reduction in Egg Roll Temperature

BY SCOTT SINK WITH BENJAMIN CHEN AND JEFF MICHALSKI

Kahiki Foods Inc. manufactures Asian-style frozen foods. In 2008, Kahiki produced more than 5 million egg rolls. Of the company's product assortments, egg rolls took the longest time to ready for shipping because the temperature of the cooked egg rolls was too high and variable after initial freezing. To address the issue, Kahiki had inserted a second freeze step, but this created large amounts of work in process (WIP) and required significant additional material handling. Now faced with a waste issue, Kahiki focused a DMAIC project on improving the process capability of the first freeze step, post frying. A cross-functional team, led by an industrial engineering student and Green Belt candidate from the integrated systems engineering department at The Ohio State University, successfully applied Lean Six Sigma to the egg roll temperature problem.
**DEFINE**

Prior to starting the DMAIC project, the team created a scoping document to operationally define the defect that was occurring. The United States Department of Agriculture (USDA) requires that all frozen foods be below 40 degrees Fahrenheit before they are packaged. According to historical data (before October 2008), egg roll temperatures in the original baseline process (freeze-to-post-spiral-freeze) ranged in the 40s and 50s.

In order to see the value-added and non-value-added activities of the process, the entire egg roll production value stream was mapped and initial measurements obtained. After firing, the egg rolls move into a spiral freezer, which has a conveyor belt that spirals the product in a z-patterns. As the egg rolls travel, fans circulate supercooled nitrogen to ensure full exposure to all sides of the egg rolls.

After the egg rolls exit the spiral freezer, they are placed in plastic tubs and transported to a large freezer in the back of the facility in order to be frozen to a temperature below the upper specification limit of 40°F. They are then transported to packaging.

It was determined that egg rolls require only 27 minutes of value-added time to fill, wrap, fry and spiral freeze. The longest step in the production process involved sending the incompletely frozen egg rolls to the main freezer. This step represented 200 minutes, or 80% of the 250-minute total lead time to ready egg rolls for packaging and, eventually, shipping (lead time is the period of time between the initiation of any production process and the completion of that process.) To cut the non-value-added step of sending the egg rolls to the main freezer and instead going directly from the spiral freezer to packaging, the internal temperature of the fried egg rolls exit from the spiral liquid nitrogen freezer would need to be 32°F to 35°F. A plan was created to capture data on the internal temperature of the egg rolls as they exited from the spiral freezer. The Green Belt developed a standard protocol for measuring the primary Y and trained QA in this modified procedure to ensure data integrity throughout the project. To monitor the integrity of the data, the data collection process was standardized and documented.

The temperature data collected revealed that during the month of October 2008, the average internal temperature of the egg rolls after the spiral freezer step averaged 56.7°F – higher than the temperature that was being recorded by QA in their normal process. Interestingly, QA was recording and reporting averages just below the upper specification limit of 40°F, with a standard deviation of 5°F. This discrepancy, which was discovered during the measurement systems analysis, led us to drill down deeper on measurement protocol and the results temperature readings.

The upper specification limit on egg roll temperature, from Defect, was set at 40°F and our target level was an average of 32°F to 34°F. The temperature readings we took showed that there was a significant (20°F) gap that needed to be closed in order to allow the process to provide for immediate packaging of the egg rolls prior to the spiral freezer station. QA temperature readings depicted a less significant gap (less than 3°F) but also influenced the team's decision to close the gap.

The team discovered that in the current state, there was no way to tell whether or not the fans inside the spiral freezer were actually working.

**MEASURE**

**Reduction in Egg Roll Temperature**

**Project Scope**

Reduce wastes between egg roll frying and packaging.

**Problem Statement**

Egg roll internal temperatures post spiral freeze station do not achieve specifications enough of the time to allow for direct packaging.

**Objectives**

- Ensure that internal egg roll temperatures post spiral freeze do not exceed the 40°F upper specification limit.
- Reduce overall lead time by 5 hours.
- Eliminate the WIP caused by the second freeze step.
- Eliminate the unnecessary handling that currently exists between spiral freeze and packaging.

**Value Stream Map**

![Value Stream Map](image)

**Kahiki Foods** produces more than 20 products that can be found in retail grocery stores, membership warehouse clubs, convenience stores and food-service operations. The company began in 1961 as Kahaki Superb Cucumbers, an Asian and Polynesian restaurant in Columbus, Ohio. In 2006, the restaurant was closed so the company could focus on the freezer food business. Today, Kahiki’s operations are housed in a 185,000-square-foot facility in Gahanna, Ohio. The company is deploying Lean Six Sigma as a method to drive continuous improvement, and supports internships and student projects as a way of sparking progress.

**Cause-and-effect Diagram**

![Cause-and-effect Diagram](image)

**Process Capability of High (F)**

- **USL**
  - Target: 108°F
  - USL: 110°F
- **LSL**
  - Sample Mean: 90°F
  - Sample N: 260°F
- **StDev (Within)**: 2.56°F
- **StDev (Overall)**: 1.14°F

**Observations**

- Average internal egg roll temperature was 56.7°F post spiral freezer.
- A gap of more than 25°F needed to be closed in order to meet target temperature levels.
- There was no method to determine whether the freezer fans were working properly.
- The process manager did not have a constant temperature guideline.
Another significant root cause: The internal temperature of the egg rolls continued to rise for a period of 2 minutes after the frying process.

Line and fierce the temperature was being changed over time due to lack of consistently communicated standard operating procedures.

The next step was to do a more detailed analysis to determine additional input variables that were causing the output temperatures to be higher than the upper control limit. Using a cause-and-effect matrix, the team identified three input variables as having the greatest impact on the internal egg roll temperature: 1) percentage of the six fans in each spiral freezer that are functional at any given time; 2) spiral freezer temperature settings not consistent and not low enough; and 3) exposure time of egg rolls in the spiral freezer. Two of these confirm that the quick win implemented (the fan fix ensuring that six fans are functional at all times and the standard operating procedures on temperature settings for the spiral freezer) were indeed major impacts. The third input that impacts the output temperature and has not yet to be dealt with was the duration of exposure of egg rolls to liquid nitrogen. Based on this additional cause-and-effect analysis, the next step is to add a temperature monitoring system to ensure consistent temperature and temperature settings across the entire process.
A solution was also generated to target the rising internal temperature as the egg rolls entered the spiral freezer. A one-of-a-kind pre-cooling machine was inserted where the current feed conveyor exists, between the fryer step and the spiral freezer. The pre-cooling machine will further reduce the temperature of the egg rolls post-frying.

Additional root cause discussion led to a conclusion that the liquid nitrogen freezing was inefficient. The spiral freezers rely heavily on the fans to circulate the liquid nitrogen. The current mechanism sprayed the liquid nitrogen into the atmosphere of the freezer. By adding nozzle heads to the current liquid nitrogen spray, we could redirect the flow of the nitrogen and improve its utilization and impact.

All solution elements are now in place, and ongoing testing and measurement have occurred. It is now the standard process to go directly from the spiral freeze step in the process to packaging, which is adjacent to the spiral freeze exit point. This configuration has been in operation since June of 2009.

**Control**

A control plan is being utilized to monitor the new process capability of the egg roll freezing process. The plan calls for monitoring the following: internal egg roll temperature on exit from the spiral freezer, machine settings and the throughput of egg rolls each shift. Throughput was measured to ensure that consequential metrics were not impacted (i.e., that slowing down the spiral freezer to get temperatures right did not affect throughput).

Response plans are also in place in case the process gets out of control, e.g., the process capability shifts such that the upper specification limit of 40 F is not met. A RACI (responsible, accountable, consulted, and informed) matrix for all key control points in the process has been established and training on this was provided.

To realize the business benefits of the new process capability, a packaging line now directly connects to the spiral freezer and thus eliminates the waste associated with additional freezing prior to packaging. A formal Final Tollgate was held with all stakeholders, and the value stream owner has signed off on the business case and the final project documentation.

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Scott Sindi is the program director for LeanSigma certification in the College of Engineering and Integrated Systems Engineering at The Ohio State University. He holds a doctorate in industrial and systems engineering. Ben Chen completed his bachelor of science in integrated systems engineering at Ohio State, and this project was his capstone senior design project. Jeff Michalski is a Black Belt and was the manager of quality at Kahlbii when this project was completed.