Development of Image Print Quality Standards for a Limited-Edition Cereal Production Run

Lianne Hernández Rijos

Master of Engineering Management

Advisor: Dr. Héctor J. Cruzado, Graduate School

Polytechnic University of Puerto Rico

Abstract

At a global manufacturer of branded processed consumer goods, the introduction of a limited-edition cereal product required the establishment of image print quality as a new product quality attribute not previously controlled in conventional production. The use of new printing equipment to apply images to moving product sheets increased the complexity of visual inspection and quality assurance. The production process was studied to define acceptable image print quality standards and ensure consistent product appearance prior to full-scale manufacturing. A plant trial was conducted to evaluate image clarity, print alignment, and base product consistency, and to establish measurable acceptance criteria. It was found that defining clear performance thresholds, implementing sensory-based evaluation, and applying structured monitoring during production enabled effective control of image print quality. The results demonstrated that the definition of measurable acceptance criteria, supported by sensory-based evaluation and structured monitoring, enabled effective control of image print quality during the limited-edition production run.

Introduction

A global food manufacturer operates a cereal production facility in Georgia, USA, with multiple production and packaging systems. While a conventional branded ready-to-eat cereal product (CP) relies on simple printed swirl patterns verified through visual inspection, a limited-edition cereal introduced a new manufacturing challenge. This product required high-resolution image printing on square-shaped cereal pieces using new equipment and testing methods. As a result, image print quality emerged as a critical new quality attribute, requiring enhanced inspection and quality assurance approaches.

This project aimed to determine the desired image print product quality prior to the production of the limited-edition CP. The accomplishment of the final goal was verified with two key performance indicators, as listed in Table 1 below. For a CP piece to be considered acceptable, there are certain criteria that must be met, as shown in Table 2.

Table 1

Key Performance Indicators (KPIs)

KPIs		Description
1	% Pieces Printed	Minimum percentage of printed cereal pieces in a sample
2	% Image Print Quality	Minimum percentage of acceptable pieces from total printed in a sample

Table 2

Acceptance Criteria for Image Print Quality

Product Sample Sorting		Description
1	Acceptable	Identifiable images, correct print alignment on cereal pieces, consistent processing of product.
2	Unacceptable	Blurry or unclear images, print misalignment, inconsistent process of base product (e.g., blisters or heavy coating that affect print)

Methodology

As part of the project, a plant trial was conducted to evaluate printed image quality and establish effective monitoring procedures for production. The experimental period was essential for defining acceptable image quality standards and determining how those standards could be consistently maintained throughout the production run. Establishing an acceptable image print quality range, along with methods for sustaining performance during production, contributed directly to the successful launch of the limited-edition product. To ensure a structured, consistent, and repeatable approach to improving print quality, the Plan-Do-Check-Act methodology was applied. See Figure 1.

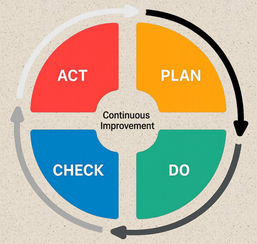

Figure 1

Plan-Do-Check-Act (PDCA) Methodology

Plan Phase

- Develop a comprehensive testing plan in collaboration with Technical Center
- Defined acceptable vs. unacceptable image print quality criteria
- Identified image proportions to meet finished product targets
- Secured resources, tools, personnel, and subject matter experts (SMEs) for plant trial

Do Phase

- Delivered sensory training to Technicians
- Communicated pre-trial alignment on image print quality
- Executed a two-day plant trial to evaluate image print quality
- Collected samples at defined points within production system
- Developed print quality assessment tool to capture findings
- Determined percentage of print needed to meet desired image print product quality
- Determined percentage image print quality

Check Phase

- Analyzed trial data to establish acceptable operating range
- Sent product samples to Technical Center for additional analysis and validation
- Established procedure for ongoing monitoring

Act Phase

- Documented standardized procedure for ongoing monitoring
- Delivered additional training to Operations prior to full-scale production
- Observed monitoring practices during production and provided coaching as needed
- Reviewed and refined monitoring procedures following production run
- Documented learnings for future reference and application

Results

The plant trial and subsequent production activities successfully established and validated image print quality standards for the limited-edition CP. During the two-day trial period, multiple product samples were collected at defined sampling points within the production system to allow rapid upstream adjustments when image print defects were observed. Samples were sorted through visual inspection into acceptable and unacceptable categories based on predefined criteria. See Figures 2 and 3.

Figure 2

Acceptable Images

Figure 3

Unacceptable Images

The data collected during the trial enabled the development of a print quality assessment tool that quantified the two key performance indicators, as previously presented in Table 1. Following analysis and verification by the Technical Center, the minimum acceptable thresholds were approved. Results established that at least 25% of cereal pieces in a finished product sample must contain printed images, and a minimum image print quality of 50% must be achieved within the printed subset.

To support real-time decision-making during production, a sensory scoring system was implemented. The sensory evaluation consisted of collecting a sample of 100 grams, sorting cereal pieces into two groups – with images and without images – and sorting acceptable from unacceptable images based on the established criteria.

Based on sample weight and expected printer capability of 30 grams of printed pieces per 100 grams, the acceptance percentage was calculated, and a sensory score was assigned. A target score of 5, corresponding to an image print quality of 70% or higher, was defined as optimal performance, while scores of 7 or higher triggered production system verification or production holds. Technicians were trained in this procedure, enabling consistent monitoring and corrective action throughout the production run. Table 3 summarizes the scoring system followed, as well as the sample weight guidance to determine acceptable percentage and sensory score.

Table 3

Image Print Quality Determination

Acceptable Images Weight (g)	Unacceptable Images Weight (g)	% Acceptable	Sensory Score for Quality
21g	9g	70%	5
18g	12g	60%	6
15g	15g	50%	7
<15g	>15g	<50%	8

Some risks were identified during the trial period. First, the initial sampling plan had to be adjusted due to delays in product delivery to the first sampling point. Since the two-day trial could not be extended, there was an increase in sampling frequency and additional personnel supporting product sample collection and measurement. In addition, potential for poor image quality during system start-up required diverting nonconforming product to waste bins until the acceptance criteria were met. While mitigation strategies resulted in a cost overrun of $4,552.50, the project remained successful based on achievement of its primary objective.

Conclusion

This project successfully developed and implemented standardized image print quality criteria for a limited-edition cereal production run, addressing a new and complex quality attribute not previously required for conventional products. Through structured application of PDCA methodology, the project translated qualitative visual expectations into measurable acceptance criteria supported by data-driven monitoring tools.

The establishment of clear key performance indicators, validation of operating ranges, and a sensory-based decision framework allowed effective control of image print quality during production. Cross-functional collaboration, targeted training, and proactive risk mitigation were critical contributors to project success. Despite a modest budget overrun due to additional sampling and start-up waste, these investments ensured product quality and reduced the risk of consumer dissatisfaction.

The outcomes of this work provided a robust and repeatable framework for managing image print quality in future limited-edition or visually differentiated cereal products. Lessons learned offer guidance for continuous improvement and broader application across similar manufacturing systems.