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

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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.*

Key Terms *— Acceptance Criteria, Plan-Do-Check-Act, Plant Trial, Sensory Evaluation*

INTRODUCTION

Food Company XYZ is a global manufacturer of branded processed consumer goods sold through retail and foodservice channels; the name is used in this document as a fictitious designation to preserve confidentiality. The company has manufacturing facilities across North America, including a plant in Georgia, USA. This plant consists of two buildings, multiple production systems, and packaging lines dedicated to the manufacture of widely recognized branded cereal products.

Manufacturing production of a conventional branded ready-to-eat cereal product (CP) requires the printing of swirl patterns on the product. Technicians working in this system perform a visual inspection of the product to ensure that the swirls are present. A scheduled production run for a limited-edition CP presented a new challenge. This product introduced a new piece of equipment to the system, new testing techniques for operations and differential product quality to ensure its success in the market. The limited-edition cereal contains unique images on square-shaped cereal pieces. Images were printed on the product while a conveyor belt moved a sheet of product through a printer, cutter, and slitter. The production system configuration is shown in Figure 1. Image print quality was a new quality attribute for this cereal, since the conventional CP only contains printed swirls that do not require the same level of visual product quality.

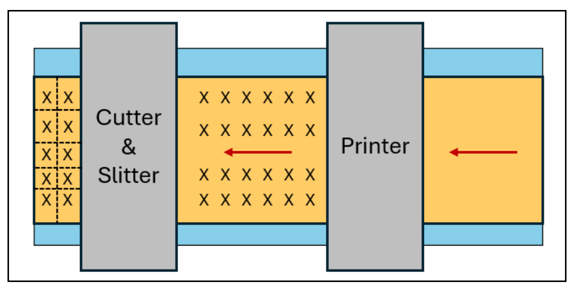

Figure 1
Production System Configuration

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. Table 2 describes the acceptance criteria for image print quality. Figure 2 and Figure 3 illustrate examples of how products are classified into two different categories.

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)

Figure 2
Acceptable Images

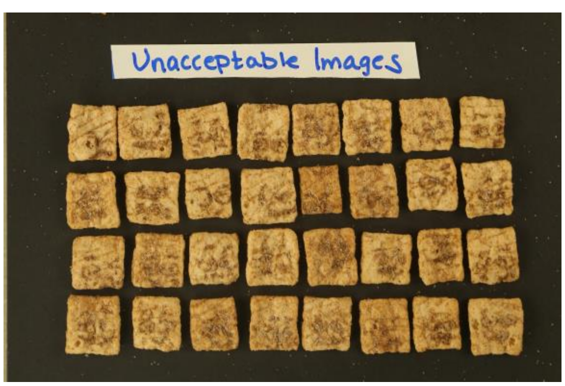

Figure 3
Unacceptable Images

LITERATURE REVIEW

Effective quality planning for a manufacturing production run requires a clear understanding of product and process characteristics, beginning with the evaluation of the product design and extending into the organization of the manufacturing environment [1]. Identifying the attributes that define product function and appearance is essential, as these characteristics guide inspection activities and help distinguish acceptable units from defective or unacceptable ones. Visual inspection techniques play a critical role in verifying that physical design requirements have been met, particularly when image clarity and consistency are central to product quality [2]. At Food Company XYZ, sensory evaluation is used as part of internal quality practices to establish product targets and to enable trained evaluators to detect differences in visual attributes that may signal process variation.

Throughout production, rigorous collection of real-time quality information ensures that data used for decision-making is accurate, validated, and aligned with process-control needs [3]. Together, these elements support error-proofing, reliable measurement, and process monitoring and form a comprehensive framework that helps maintain consistent image print quality and overall product integrity during specialized production runs. Incorporating the PDCA cycle provides a structured approach to continuously assess results and refine processes, reinforcing ongoing improvement throughout the production effort [4].

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 (PDCA) methodology was applied.

During the Plan phase, the Quality team developed a comprehensive testing plan. More than two weeks prior to the plant trial, collaboration with the Technical Center team took place to determine the required proportion of images on the total product to achieve the desired finished product quantity. During this time, criteria defining acceptable versus unacceptable print quality were also established. This phase included identifying the subject matter experts (SMEs) needed to support training, evaluation, and decision-making during the trial. In parallel, resources required to execute the testing plan were secured one week prior to the trial. These preparations included requesting personnel and materials, as well as gathering all necessary tools and equipment.

One day prior to the trial, training and communication activities were conducted by the Quality team to ensure alignment among all participants regarding testing expectations. Technicians received sensory training focused on the fundamentals of image quality, with active involvement from the Sensory SME to promote clarity, consistency, and alignment in evaluations. The finalized testing plan and objectives were communicated to all team members to ensure a shared understanding of procedures and goals for the experimental period. This preparation established the foundation for smooth execution of the two-day plant trial, during which optimal sample-collection points within the production system were identified and product samples were evaluated. The data collected during the trial supported the development of a print quality assessment tool and informed the determination of the desired image print product quality. A potential constraint during the trial was the limited time available for experimentation. Product samples were collected and sent to the Technical Center for further analysis and validation of the recommended quality range.

Following completion of the plant trial, procedures for ongoing image quality monitoring were documented to ensure sustained control during production. Prior to the full production run, additional training and communication were delivered by the Quality team to Operations to reinforce expectations and ensure operational readiness. During the production run, monitoring practices were closely observed, and coaching was provided as needed to maintain adherence to the established quality range. Upon completion of the run, the monitoring procedure was reviewed and revised as necessary. Overall, this project generated valuable insights into the new quality attribute and established a robust framework for maintaining desired quality standards during the limited-edition CP production run.

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.

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.

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