IMPLEMENTATION OF P-CHART METHOD FOR QUALITY CONTROL IN CANNED CORNED BEEF PRODUCTION (A Case Study at PT Suryajaya Abadiperkasa)

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ABSTRAK

This study investigates the effectiveness of the P-chart method in monitoring quality control within the canned corned beef production line at PT Suryajaya Abadiperkasa. Using daily production data from multiple batches, the proportion of defective units was analyzed through Statistical Process Control (SPC). Data collection involved direct observation, internal documentation, and defect tracking at the end of the production line. The P-chart analysis revealed that all data points fell within the upper and lower control limits, indicating the process was statistically stable. Despite this, an average defect rate of 2.21% persisted, suggesting the presence of common cause variations. These findings confirm the applicability of the P-chart as a monitoring tool; however, further root cause analysis is needed to reduce recurring defects. Future quality improvements are recommended through the integration of additional tools such as Pareto analysis and cause-and-effect diagrams..

1. Introduction

Quality assurance is a critical aspect of modern food manufacturing, especially in highly regulated industries such as canned meat production. Maintaining consistent product quality is vital to meet consumer expectations, enhance brand reputation, and comply with safety standards. In this competitive environment, companies must adopt systematic approaches to ensure that every stage of production operates within acceptable quality limit (Mittal & Gupta, 2021).

PT Suryajaya Abadiperkasa, a food manufacturing company in Probolinggo, Indonesia, is known for its canned corned beef products. Despite the use of standardized processing techniques, the occurrence of defective units in production remains a concern. These defects not only increase production costs due to waste and rework but also pose risks to customer satisfaction and brand trust. To address these quality challenges, many manufacturing firms have turned to Statistical Process Control (SPC) tools. Among these tools, the P-chart is particularly suitable for monitoring processes involving attribute data, such as the proportion of defective items per batch. It enables practitioners to detect whether a process is under statistical control and identify potential causes of variation (Martin et al., 2025);(Ata et al., 2020). Prior studies emphasize the growing role of statistical quality control in Industry 4.0 settings, where real-time monitoring and proactive decision-making are required to sustain operational excellence (Reddy, 2023). For example, P-charts have been effectively used to control defect rates in textile production (Ata et al., 2020) and healthcare systems (Martin et al., 2025), and they continue to serve as reliable indicators for process performance in diverse manufacturing environments.

In food-related industries, risk-based quality assessment has become a strategic imperative to ensure product integrity and customer safety. The need for systematic quality risk evaluation along the food supply chain highlights the importance of preventive methods like Statistical Process Control (SPC) to identify process variations before they lead to quality failures (Bai et al., 2018). Moreover, as manufacturing enters the Industry 4.0 era, quality control is increasingly integrated into cyber-physical systems to enable faster decision-making and enhanced traceability(Santoso et al., 2021). These developments reinforce the role of real-time process monitoring and data-driven intervention in supporting manufacturing performance and product consistency .

This study aims to apply the P-chart method to evaluate the quality control performance in the canned corned beef production process at PT Suryajaya Abadiperkasa. The primary objective is to assess whether the process is stable and within control limits, based on defect rate data. By identifying whether variations stem from common or assignable causes, the study offers practical insights into improving operational quality and reducing product nonconformities. Ultimately, the findings are expected to support the company's efforts to enhance product consistency, reduce quality-related costs, and align with broader quality assurance strategies, such as Total Quality Management (TQM) and continuous improvement frameworks.

2. Literature Review

2.1 Quality Control in Food Manufacturing

Quality control plays a vital role in food production, where ensuring product consistency and safety is critical for maintaining consumer trust and regulatory compliance. The complexity of food processing operations, ranging from raw material variability to machine precision, requires manufacturers to implement proactive monitoring systems that go beyond traditional inspection approaches (Bai et al., 2018). These systems are expected not only to detect defects but also to predict and prevent their recurrence through structured analysis and data-driven tools.

2.2 Statistical Process Control (SPC)

Statistical Process Control (SPC) has long been adopted in manufacturing as a preventive quality assurance strategy. By distinguishing between common cause and assignable cause variation, SPC enables the identification of process instabilities and supports continuous improvement initiatives (Montgomery, 2009). Control charts serve as the backbone of SPC, allowing process behavior to be visualized over time. Among these, the P-chart is especially relevant for processes that monitor the proportion of defective units rather than continuous measurements.SPC tools have been widely applied in various sectors, including printing, textiles, and healthcare. Their effectiveness lies in enabling early detection of quality shifts, thus reducing waste and improving productivity (Santoso et al., 2021). As manufacturing evolves toward cyber-physical systems and real-time monitoring, SPC remains a foundational technique due to its simplicity, cost-efficiency, and interpretability.

2.3 P-Chart and Its Applications

The P-chart, a binomially-based control chart, is commonly used to monitor the proportion of defective units in production. It is particularly useful for categorical or attribute data such as "defective" vs. "non-defective" items (Montgomery, 2009). By plotting the proportion of defects across production runs and comparing them against control limits (UCL and LCL), manufacturers can determine if a process is statistically stable or if intervention is required.The use of P-charts has been extensively documented in literature. Ata et al. (2020) applied P-charts to control defects in denim washing, while Martin et al. (2025) used them in healthcare quality monitoring. In both cases, P-charts effectively captured shifts in quality and guided corrective action. In Indonesia, Iswahyudi et al. (2019) extended the application by introducing a multivariate P-chart, which accommodates multiple defect types in a single chart. Their study on newspaper production (Kaltim Post) demonstrated the added sensitivity of multivariate charts in capturing variations related to color blur, misalignment, and print dirtiness.

2.4 P-Chart in Food and Beverage Industry

In the food industry, where visual inspections often determine quality grading, P-charts provide a practical means to manage quality control. The food supply chain is inherently exposed to numerous risks—microbiological, mechanical, or operational—which require structured quality risk evaluation. Bai et al. (2018) emphasized that tools such as SPC can serve as proactive mechanisms to assess such risks and mitigate quality failures before they escalate.

Santoso et al. (2021) further argued that quality control remains a critical component within human-centered manufacturing systems. As food manufacturing transitions into smart and connected environments, P-charts can be seamlessly embedded into digital dashboards to support real-time decision-making and transparency.

2.5 Summary

From traditional printing processes to food canning lines, the P-chart continues to offer practical advantages for monitoring product conformity. Its integration into broader SPC frameworks—and even more advanced versions like multivariate P-charts—reflects the evolving needs of industries aiming for zero-defect production. The current study builds upon this body of knowledge by applying the P-chart method to the canned beef production process at PT Suryajaya Abadiperkasa.

3. Methodology

3.1 Research Design

This study adopts a quantitative case study approach, focusing on the application of the P-chart method to monitor and evaluate the quality control process in the production of canned corned beef at PT Suryajaya Abadiperkasa. The objective is to assess the stability of the production process by analyzing defect proportions and determining whether the process operates within statistically controlled limits.

3.2 Data Collection Methods

Data were obtained using a combination of observation, documentation, and direct participation within the company's production facility. The researcher, who is also employed at the company, conducted in-depth observations of the production line and recorded relevant information concerning the quality of finished goods. Additional information was gathered through interviews with quality control personnel and production supervisors, as well as from internal company documentation. These multiple sources of evidence ensured the validity and accuracy of the data.

The types of data collected included:

- Daily production quantities,
- Number and type of defective units,
- Production flow and process structure

To ensure objectivity, only aggregated data were used, and confidentiality of company-specific production parameters was maintained.

3.3 Process Flow and Quality Monitoring

The production process for canned corned beef was mapped to understand the sequence of operations and critical quality checkpoints. Inspection of final products was conducted through attribute sampling, where units were categorized as either "conforming" or "non-conforming." The defects identified included visual deformities, improper sealing, and contamination indicators. These categorical outcomes formed the basis for the application of the P-chart method.

3.4 P-Chart Construction Procedure

The steps followed in constructing the P-chart were as follows:

1. Data Compilation: Defect counts and sample sizes for each production batch were recorded.
2. Proportion Calculation: The proportion of defective items
$$P = \frac{d}{n}$$

where d is the number of defective units and n is the sample size.

3. Central Line (CL): The overall proportion of defects was calculated as:
$$\overline{p} = \frac{\sum d}{\sum n}$$
4. Control Limit :
$$UCL = \overline{p} + 3\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$$
$$UCL = \overline{p} - 3\sqrt{\frac{\overline{p}(1-\overline{p})}{n}}$$
If $LCL < 0$, it was set to zero to maintain interpretability.
5. Chart Interpretation: Data points were plotted against the control limits to assess whether the process was in control (all points within bounds) or out of control (one or more points outside bounds).

3.5 Validity and Limitations

This method is suitable for binary defect classification but does not account for the severity or root causes of defects. The analysis focuses on identifying whether the process is statistically stable, not on diagnosing specific causes. Further research incorporating tools like Pareto analysis, cause-and-effect diagrams, or machine learning-based defect classification could complement this approach.

4. Results and Discussion

4.1 Overview of Production Process

The production process of canned corned beef at PT Suryajaya Abadiperkasa consists of a series of standardized steps designed to ensure product consistency, hygiene, and shelf stability. The process begins with the preparation of raw meat and continues through mixing, cooking, packaging, sterilization, and storage. Figure 1 illustrates the main stages involved in this process.

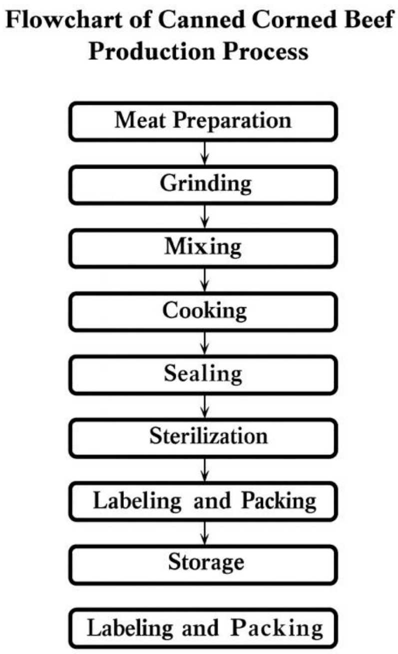

Figure 1. Flowchart of Canned Corned Beef production Process

Description of Each Stage:

Meat Preparation

Raw beef is selected and prepared according to the required specifications. Excess fat and undesirable parts are trimmed, and the meat is cut into appropriate sizes for further processing.

Grinding

The trimmed meat is ground to achieve a uniform consistency. Grinding facilitates better mixing and ensures even seasoning distribution.

Mixing

The ground meat is transferred into a mixing machine where it is combined with spices, salt, preservatives, and other approved additives. This step ensures a homogeneous mixture and desired flavor profile.

Cooking

The meat mixture is cooked at a controlled temperature to partially process the protein and improve texture. This step also enhances food safety before filling.

Filling

The cooked meat mixture is filled into pre-cleaned cans using a mechanical filling system that ensures accurate weight and volume.

Sealing

The filled cans are sealed hermetically using an automated seaming machine. Proper sealing is crucial to prevent air and microbial contamination.

Sterilization

The sealed cans undergo thermal sterilization in an autoclave or retort. High pressure and temperature are applied to eliminate potential pathogens and extend product shelf life.

Labeling and Packing

Once sterilized and cooled, the cans are labeled with product and batch information. They are then packed into boxes or cartons for shipment.

Storage

The finished goods are stored in a temperature-controlled warehouse until distribution. Inventory is managed to ensure product rotation based on production date.

4.2 Defect Data and Initial Observations

Table 1 presents the production data and number of defective units recorded across 22 production days in December. Each row reflects the total number of units produced and the corresponding number of defects identified through post-packaging inspection. Additionally, the proportion of defective units relative to total production was calculated to provide a clearer view of process performance.The observed defect proportions ranged from 2.05% to 2.35%, with an average defect rate of 2.21%, indicating moderate but consistent quality variation. The relatively small standard deviation (0.11%) suggests stable performance across production days, with no extreme deviations. However, given that the process still consistently produces nonconforming units, further analysis is needed to determine whether these variations are due to random common causes or assignable factors that require corrective action.This dataset forms the basis for subsequent control chart analysis using the P-chart method.

Table 1. Daily Production and Defect Proportion Summary

Day	Total Production	Defect Quantity	Defect Proprortion
	unit	unit	%
1	35048	720	2.05
2	40140	930	2.32
3	41092	924	2.25
4	55484	1150	2.07
5	49304	1144	2.32
6	43384	896	2.07
7	46872	988	2.11
8	51324	1190	2.32
9	45892	968	2.11
10	40316	892	2.21
11	43296	992	2.29
12	43588	948	2.17
13	50556	1132	2.24
14	35123	823	2.34
15	35956	809	2.25
16	48549	1138	2.34
17	43141	1001	2.32
18	37961	780	2.05
19	41013	857	2.09
20	44909	1005	2.24
21	40156	847	2.11
22	35277	830	2.35

4.3 Data Adequacy Test

Before constructing the P-chart, a data adequacy test was performed to ensure that the sample size used was sufficient for statistical analysis. This test is influenced by the assumed confidence level (90%) and precision level (10%) and follows the formula:

$$N' = \left(\frac{\frac{k}{s}\sqrt{N\sum x^2 - ((\sum x)^2)}}{\sum x} \right)^2$$

Where:
k=90%≈1.65 (confidence coefficient)
s=10%=0.10 (precision level)
N=22 (number of observations)
∑x=20964
∑x2=20348290
(∑x)2=439489296

By substituting these values into the formula, the required minimum number of observations N' was calculated. The result showed that the existing sample size (22 days of data) meets the adequacy requirement for further statistical processing.Thus, the dataset was considered sufficient to proceed with P-chart analysis.

4.4 P-Chart Analysis

After confirming the adequacy of the dataset, a P-chart was constructed to analyze the stability of the canned corned beef production process. The P-chart is a control chart used for monitoring the proportion of non-conforming units in production over time.

Central Line and Control Limits Calculation

$$p = \frac{\sum d}{\sum n} = \frac{20964}{948381} = 0.0221 \; or \; 2.21\%$$

where:
d is the total number of defective items,
n is the total number of items produced.

Since the sample sizes vary daily, control limits were calculated individually for each day's sample. However, in this case, the average sample size was used to approximate constant limits, yielding:

Center Line (CL): 2.21%
Upper Control Limit (UCL): ≈ 5.1%
Lower Control Limit (LCL): ≈ 0% (set to zero when negative).

P-Chart Interpretation

All daily defect proportions fell within the control limits. No single point exceeded the UCL, and no abnormal patterns (such as trends, cycles, or runs) were observed.This indicates that the process was in a state of statistical control, and the variations observed were likely due to common causes inherent to the process, rather than special causes or external disturbances.

To construct the P-chart, the proportion of defective products for each production day was calculated by dividing the number of defects by the total number of units produced. Given that the sample size per day is relatively consistent, average control limits were used across all samples. Table 2 presents the calculated defect proportions along with the corresponding Center Line (CL), Upper Control Limit (UCL), and Lower Control Limit (LCL) for each day.

Table 2. Daily Defect Proportion and Control Limit Values for P-Chart Construction

NO	**Defect Proportion**	**CL**	**UCL**	**LCL**
1	0,021	0,02	0,024	0,020
2	0,023	0,02	0,024	0,020
3	0,022	0,02	0,024	0,020
4	0,021	0,02	0,024	0,020
5	0,023	0,02	0,024	0,020
6	0,021	0,02	0,024	0,020
7	0,021	0,02	0,024	0,020
8	0,023	0,02	0,024	0,020
9	0,021	0,02	0,024	0,020
10	0,022	0,02	0,024	0,020
11	0,023	0,02	0,024	0,020
12	0,022	0,02	0,024	0,020
13	0,022	0,02	0,024	0,020
14	0,023	0,02	0,024	0,020
15	0,022	0,02	0,024	0,020
16	0,023	0,02	0,024	0,020
17	0,023	0,02	0,024	0,020
18	0,021	0,02	0,024	0,020
19	0,021	0,02	0,024	0,020
20	0,022	0,02	0,024	0,020
21	0,021	0,02	0,024	0,020
22	0,024	0,02	0,024	0,020

As shown, the control limits remain constant at CL = 0.022, UCL ≈ 0.024, and LCL ≈ 0.020, while the daily defect proportions fluctuate slightly but remain within the control boundaries. This table serves as the basis for plotting the P-chart, which will further illustrate the stability of the production process over time.

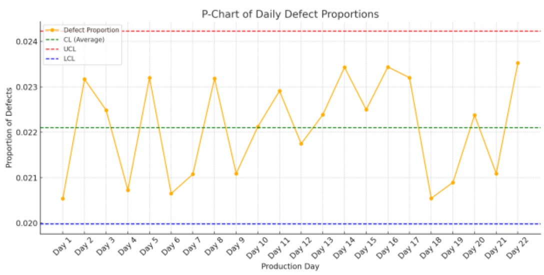

Fig.1 P-chart visualization

The average defect proportion of 2.21% suggests a moderately stable quality level. Although the process is in control, there remains room for quality improvement by reducing common cause variations.The results are consistent with prior research (Ata et al., 2020; Montgomery, 2009), which emphasizes the importance of using control charts to monitor stability and guide corrective action when necessary.

4.5 Discussion

The P-chart analysis reveals that the canned corned beef production process at PT Suryajaya Abadiperkasa is currently operating under statistical control. This conclusion is based on the fact that all observed daily defect proportions fall within the established control limits (UCL and LCL), and no unusual patterns such as consecutive upward/downward trends or cycles are present in the chart.

Although the process appears statistically stable, the average defect proportion of 2.21% indicates that quality losses still occur on a daily basis. This supports Montgomery's (2009) view that statistical control does not necessarily imply optimal process performance. A process can be in control yet still produce an unacceptable level of defects, particularly if the common causes of variation are not systematically addressed.

The uniform control limits used in this analysis, based on average sample size, provide a practical overview of the process. However, in more sensitive applications—especially in food production—dynamic control limits (based on exact sample size per day) may offer better detection of small shifts in quality.

These findings are consistent with previous research. Ata et al. (2020) used P-charts in textile production and found that stable processes still benefited from defect-type analysis using Pareto tools. Similarly, Iswahyudi et al. (2019) suggested enhancing single-variable control charts with multivariate approaches to detect hidden process anomalies.

To move from stability to improvement, PT Suryajaya Abadiperkasa should incorporate additional quality tools, such as:

Pareto Analysis: To identify the most frequent defect types,

Cause-and-Effect (Fishbone) Diagrams: To determine potential root causes of defects,

Process Capability Analysis (Cp, Cpk): To evaluate whether the process meets product specification limits.

In addition, implementing real-time SPC monitoring integrated into production dashboards could allow quicker responses to variations, supporting the broader goals of Industry 4.0 and digital quality assurance.

5. Conclusion and Recommendation

5.1 Conclusion

This study demonstrated the application of the P-chart method for monitoring the proportion of defective products in the canned corned beef production process at PT Suryajaya Abadiperkasa.

Based on the analysis of 22 production days:

The average defect proportion was calculated at 2.21%, and all daily observations were found to lie within the control limits.The absence of points outside the control boundaries and the lack of irregular patterns indicate that the process is statistically in control.While the process is stable, the presence of consistent defects suggests that quality losses still occur due to common cause variation.Thus, the P-chart has proven to be an effective tool for assessing process stability and identifying opportunities for improvement within the company's quality control system.

5.2 Recommendation

Although the process is under control, it is not yet optimized. The following recommendations are proposed:

- Conduct Pareto Analysis

Identify the most dominant types of defects to focus improvement efforts on the most impactful sources of quality loss.

- Perform Root Cause Investigation

Utilize cause-and-effect diagrams and quality audits to trace defects back to specific causes, whether they stem from raw materials, machinery, or operator error.

- Implement Process Capability Analysis

Assess whether the current process meets customer specifications using Cp and Cpk indices. This will help determine if stability also translates to capability.

- Enhance Preventive Maintenance and Operator Training

Equipment reliability and operator awareness are essential to minimizing variation. Ongoing training and maintenance schedules should be prioritized.

- Integrate Real-Time Quality Monitoring

Adopt digital dashboards and real-time SPC tools to allow faster detection and response to deviations, aligned with modern Industry 4.0 practices.

By implementing these strategies, PT Suryajaya Abadiperkasa can not only maintain a stable process but also achieve higher levels of quality, efficiency, and customer satisfaction.

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