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Achieving Zero-Defect Production: A Data-Driven Strategy for Reject Reduction in a B2B Frozen Food Factory

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A B S T R A C T
This study aims to formulate a data-driven strategy to reduce high product reject rates at a B2B frozen food factory. High rejects threaten productivity and operational sustainability. This research employs an explanatory sequential mixed-methods design. The quantitative phase analyzes production and reject data from 2023-2025 using Pareto Analysis and Statistical Process Control (SPC) with a census sample. The qualitative phase uses interviews and a Focus Group Discussion (FGD) to explore root causes. Results show the process is statistically out of control, with 80.5% of rejects from 40 products. Key root causes are reactive maintenance, process bottlenecks, and a lack of formal operator competency standards.

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INTRODUCTION

The global frozen food industry faces a critical operational challenge: high rates of product rejects, which directly undermine productivity and threaten operational sustainability. This issue is not merely an internal cost but aligns with global imperatives like the UN's Sustainable Development Goal 12 (Responsible Consumption and Production) by contributing to food loss within the production chain. This study addresses this problem at PT. XYZ, a B2B frozen food central kitchen in Indonesia. Despite holding FSSC 22000 certification, the company's reject rate escalated from 0.64% in 2023 to an alarming 1.02% in early 2025, surpassing its internal target and the 4-Sigma industry benchmark of 0.62%.

This research contributes to knowledge by applying a holistic, mixed-methods framework to a complex and under-researched operational context: a B2B central kitchen with a highly diverse product portfolio. While Lean Six Sigma is a proven methodology, its application in such a specific environment requires a nuanced approach that integrates quantitative data with deep qualitative insights. This study fills that gap. The objectives of this research are to: (1) identify the dominant factors causing high reject rates using quantitative analysis; (2) evaluate the statistical stability of the production process; and (3) formulate a systematic improvement strategy based on the Lean Six Sigma framework to reduce rejects, thereby enhancing productivity and operational sustainability.

LITERATURE REVIEW

Lean Six Sigma

To systematically analyze and address the product reject problem, this research adopts the Lean Six Sigma framework. This integrated approach combines Lean Manufacturing's focus on waste elimination with Six Sigma's data-driven methodology for reducing process variation and defects. In this study's context, product rejects are a primary form of "Defect" waste. The core of the Six Sigma methodology is the DMAIC (Define, Measure, Analyze, Improve, Control) cycle, which provides a structured path for problem-solving. This research utilizes the Measure and Analyze phases, employing key tools such as Pareto Analysis to prioritize problems based on impact, Statistical Process Control (SPC) to assess process stability, and the Cause-and-Effect (Fishbone) Diagram to explore root causes identified through qualitative inquiry. The application of this integrated framework has been proven effective for minimizing waste in food manufacturing.

Operational Sustainability and Quality Management

Operational sustainability is the ability to conduct business efficiently while minimizing environmental impact and enhancing social well-being, often framed by the Triple Bottom Line (Profit, Planet, People). Reducing product rejects directly addresses all three dimensions: improving profitability by cutting waste-related costs (Profit), reducing resource depletion (Planet), and fostering a more stable work environment (People). In quality management theory, rejects are a significant "Internal Failure Cost". By focusing on reducing these failures, companies lower their Cost of Poor Quality and enhance performance. This study's focus on reject reduction is therefore grounded in the principle that quality improvement is a direct driver of sustainable operational excellence. The conceptual framework below illustrates the logical flow of this research

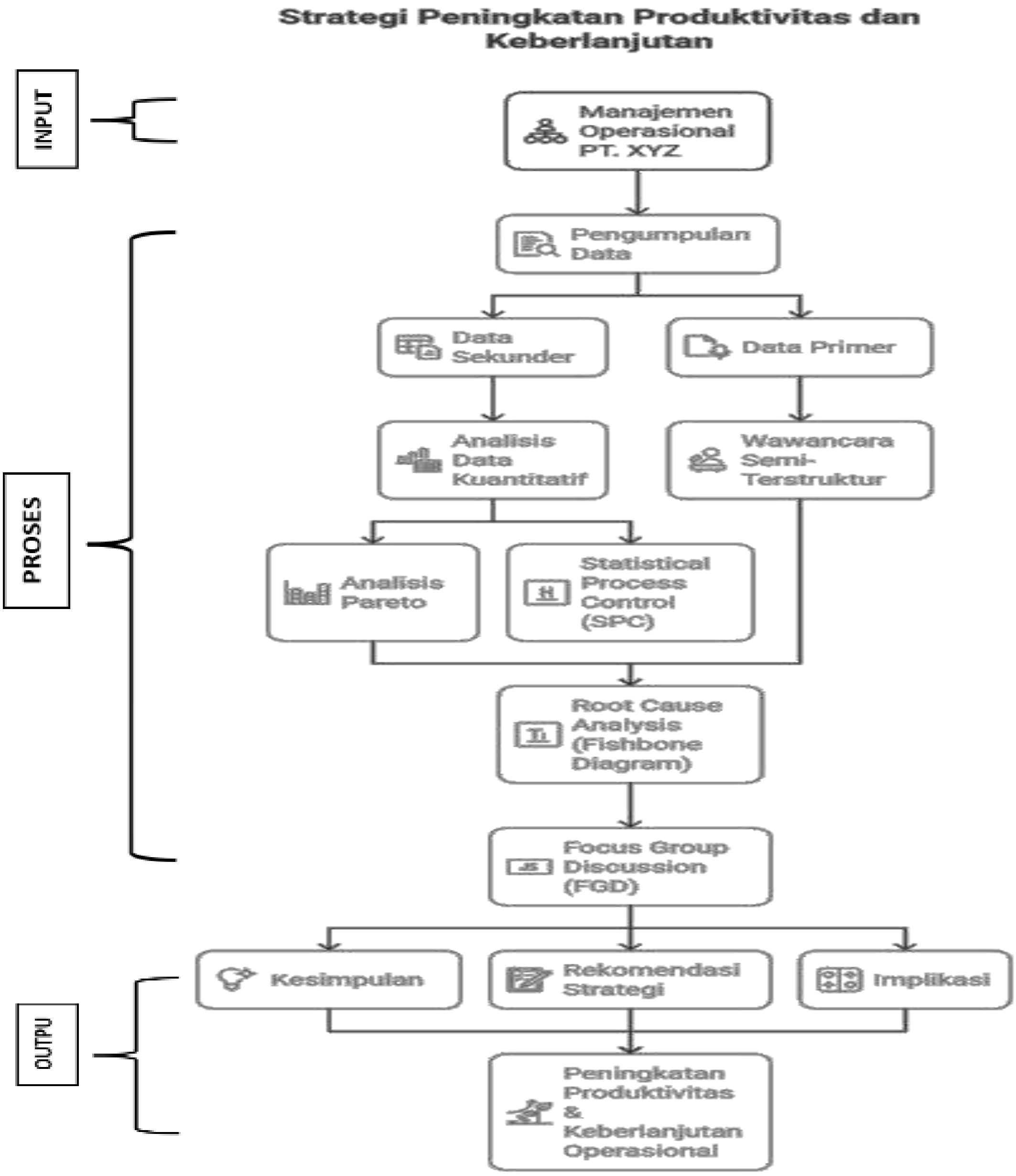

Figure 1. Conceptual Framework

METHODOLOGY

This research employed an explanatory sequential mixed-methods design (QUAN → qual) within a case study at PT. XYZ. This design was chosen to first quantitatively identify the scale of the problem and then qualitatively explore the underlying reasons to formulate a contextually rich solution.

The initial quantitative phase involved analyzing secondary data. The population consisted of the entire production and reject data record from all production lines at PT. XYZ from January 2023 to April 2025. A census (saturated sampling) technique was used, analyzing all 81,048,514 production units and 576,848 reject units to eliminate sampling error. Data analysis tools included Pareto Analysis to identify the "vital few" products and Statistical Process Control (SPC) using a p-Chart to evaluate process stability.

The subsequent qualitative phase was guided by the quantitative findings. Data was collected through purposive sampling to select informants. Semi-structured interviews were conducted with production managers, supervisors, and leaders to explore root causes. Finally, a Focus Group Discussion (FGD) was held with key managerial personnel to validate these causes and formulate a strategic improvement plan.

RESEARCH RESULT

The Analysis Followed the Measure and Analyze Phases of the DMAIC Framework

In the Measure phase, a Pareto analysis was conducted on reject data from 218 product types. The analysis (Table 1 and Figure 2) revealed that the top 40 products (18% of all types) accounted for 80.5% of the total reject volume. The single largest contributor was "KFC PERKEDEL KENTANG," accounting for 10.01% of all rejects. This finding confirms the Pareto principle and allowed the research to focus subsequent analysis on these "vital few" products.

Table 1. Pareto Analysis of Top Reject Products

No.	Product Name	Total Reject (Pcs)	Percentage Contribution	Cumulative Percentage
1	KFC PERKEDEL KENTANG	57.719	10,01%	10,01%
2	IK CHUROS	38.654	6,70%	16,71%
3	GYOZA AYAM (GRILL)	29.797	5,17%	21,87%
4	GYOZA AYAM	28.769	4,99%	26,86%
5	MG CHICKEN KATSU PLATE	25.500	4,42%	31,28%
6	MG SWEET POTATO BALL	24.894	4,32%	35,60%
7	MG GYOZA AYAM	22.579	3,91%	39,51%
8	KC GYOZA AYAM	15.164	2,63%	42,14%
9	CJ CHURROS ORIGINAL	15.035	2,61%	44,75%
10	JAY FURA	12.085	2,10%	46,84%
11	BL STEAK	11.863	2,06%	48,90%

12	**MG STICK SIOMAY 2pcs**	**11.363**	**1,97%**	**50,87%**
13	**KM GYOZA AYAM**	**11.151**	**1,93%**	**52,80%**
14	**PP CHICKEN SAUSAGE 8pc**	**10.976**	**1,90%**	**54,70%**
15	**ST TAKOYAKI**	**10.110**	**1,75%**	**56,45%**
16	**IDM SOSIS AYAM**	**8.909**	**1,54%**	**58,00%**
17	**JAY FURA CHEESE**	**8.422**	**1,46%**	**59,46%**
18	**ARABIKI FRANK(CHEESE)**	**8.340**	**1,45%**	**60,91%**
19	**CHICKEN CORDON BLEU 2PCS**	**8.188**	**1,42%**	**62,32%**
20	**ENACHIKI CHEESE**	**7.812**	**1,35%**	**63,68%**
21	**IK SWEET POTATO BALL**	**7.374**	**1,28%**	**64,96%**
22	**MG SWEET POTATO BALL**	**6.417**	**1,11%**	**66,07%**
23	**TAMAGOYAKI (TNT)**	**6.328**	**1,10%**	**67,17%**
24	**IK PANCAKE**	**6.173**	**1,07%**	**68,24%**
25	**POTATO BALL**	**6.137**	**1,06%**	**69,30%**
26	**HS FRIED BREAD SPICY CHICKEN**	**6.028**	**1,04%**	**70,35%**
27	**BEEF CROQUETTE PLATE 50gr**	**5.458**	**0,95%**	**71,29%**
28	**LW STICK SIOMAY**	**4.911**	**0,85%**	**72,14%**
29	**IK CHICKEN CORDON BLEU BALL**	**4.610**	**0,80%**	**72,94%**
30	**COATED WING**	**4.541**	**0,79%**	**73,73%**
31	**ROASTED CHICKEN**	**4.408**	**0,76%**	**74,49%**
32	**CHEESE IN BURGER 150gr**	**4.377**	**0,76%**	**75,25%**
33	**PL BURGER STEAK 55gr**	**4.240**	**0,74%**	**75,99%**
34	**MMB EGG CHICKEN ROLL**	**3.952**	**0,69%**	**76,67%**

35	AE STICK SIOMAY	3.880	0,67%	77,35%
36	CHICKEN CORDON BLEU 6PCS	3.837	0,67%	78,01%
37	KC GYOZA UDANG	3.735	0,65%	78,66%
38	AE CHICKEN LUNCHEON	3.597	0,62%	79,28%
39	SUSHI BURGER	3.513	0,61%	79,89%
40	MINI CHICKEN CORDON BLEU	3.502	0,61%	80,50%
41	Other products	112.500	19,50%	100,00%
	Grand Total	576.848	100%	

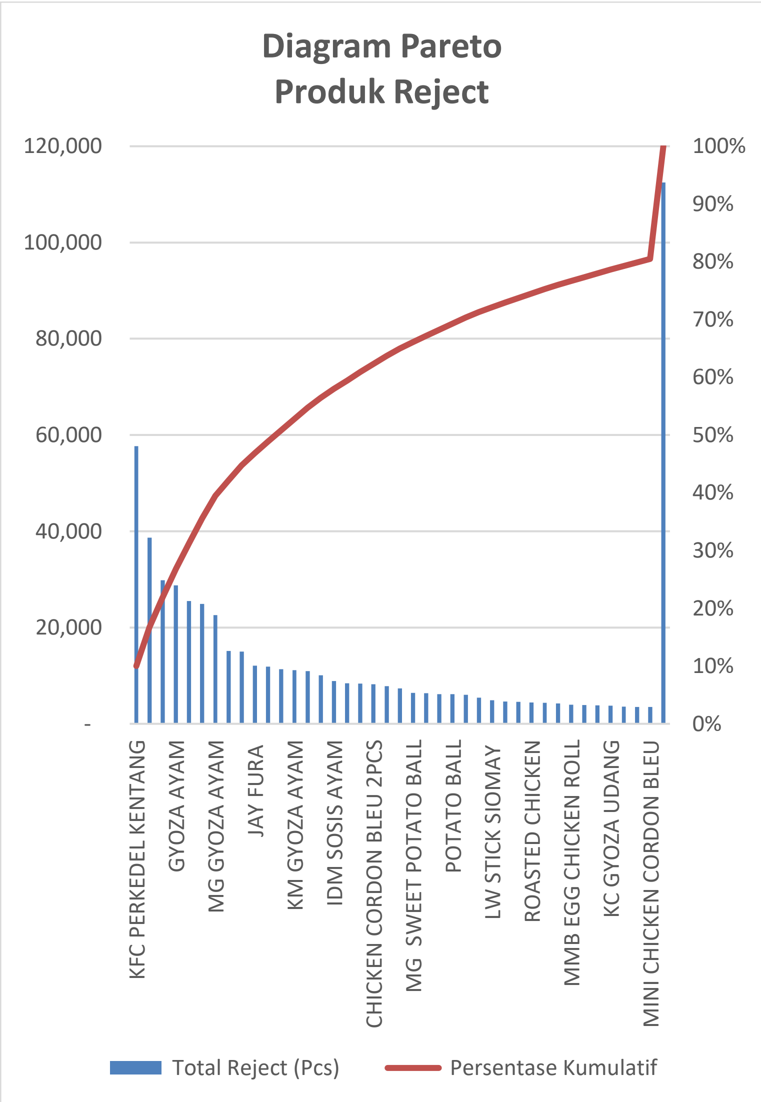

Figure 2. Diagram Pareto

In the Analyze phase, process stability was evaluated using SPC. A p-Chart was constructed using the monthly proportion of rejects (Figure 3). The chart clearly indicates that the process is out of statistical control, evidenced by 10 data points falling above the Upper Control Limit (UCL). These points signify the presence of special cause variation, meaning non-random events are disrupting the process and causing unpredictable reject spikes. This instability confirms the production system is not predictable and requires fundamental intervention.

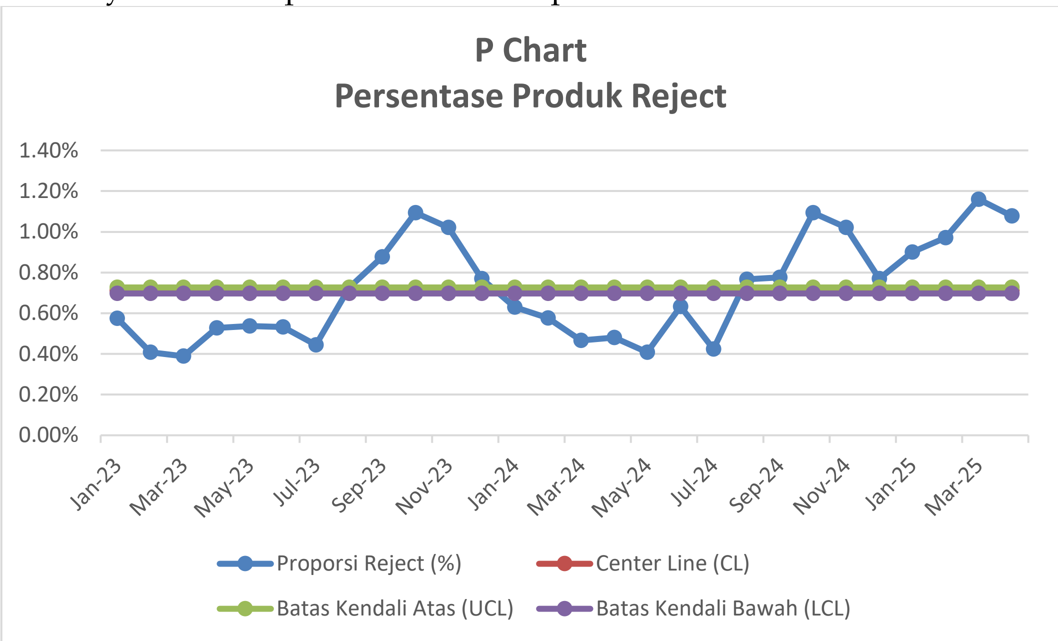

Figure 3. P Chart

To understand the "why" behind these findings, qualitative data from interviews were analyzed. Key themes emerged related to Manpower (lack of formal competency standards), Machine (reactive, breakdown-based maintenance), and Method (frying process as a major bottleneck). These themes were synthesized into a Cause-and-Effect (Fishbone) Diagram (Figure 4).

Figure 4. Diagram Fishbone

Finally, these findings were presented in a Focus Group Discussion (FGD). The participants validated the findings and reached a consensus on the three most critical root causes: (1) The reactive maintenance strategy, (2) The frying process bottleneck, and (3) The absence of formal operator competency standards

DISCUSSION

This study's findings provide a multi-faceted diagnosis of the quality challenges at PT. XYZ. The Pareto analysis result, pinpointing that 80.5% of rejects originate from just 40 products, is a classic demonstration of the 80/20 rule. This is a critical strategic insight, allowing the company to concentrate its resources on areas with the highest potential for impact, validating the first step in any effective Lean Six Sigma project.

The finding that the production process is statistically out of control is the most significant from a quality management perspective. The p-Chart (Figure 3) provides objective evidence of an unstable and unpredictable system. According to Six Sigma principles, a process must first be brought into a state of statistical control before any efforts to improve its capability can be effective. The instability shown can be directly attributed to the root causes identified in the Fishbone diagram (Figure 4). For instance, a sudden machine breakdown (a consequence of reactive maintenance) would manifest as a special cause, pushing the monthly reject rate above the UCL. This confirms research highlighting SPC's effectiveness in identifying out-of-control conditions in food manufacturing.

The synthesis of quantitative and qualitative data provides a holistic view of the problem. The three prioritized root causes—reactive maintenance (Machine), frying bottleneck (Method), and lack of competency standards (Manpower)—reveal a systemic weakness. This aligns with Total Quality Management (TQM) theory, which posits that quality issues are often the result of interconnected system deficiencies. The proposed strategies directly address these deficiencies. The shift to Preventive Maintenance is a core tenet of Total Productive Maintenance (TPM), designed to enhance machine reliability. The recommendation for a time and motion study on the frying process aims to improve process flow and eliminate bottlenecks, a key Lean principle. Finally, developing a competency matrix for operators addresses the human element of quality, ensuring standardization and continuous skill development

CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis, this study concludes that the dominant factors causing high product rejects are concentrated in 40 products, with the primary root causes being a reactive maintenance strategy, a significant bottleneck in the frying process, and the absence of formal operator competency standards. The production process is in a state of statistical instability, characterized by special cause variations. A systematic improvement strategy based on Lean Six Sigma was formulated, centered on implementing a preventive maintenance program, optimizing the bottlenecked frying process, and developing a structured operator competency systemProvide some conclusions and implementation of the research results.

For practical implementation, it is recommended that PT. XYZ form a dedicated cross-functional team to execute these three strategic initiatives. Management should prioritize investment in shifting from a reactive to a preventive maintenance culture. The Human Resources and Production departments should collaborate to develop a skill matrix for operators, starting with the highest-reject production lines as a pilot project.

ADVANCED RESEARCH

This study has limitations that open avenues for future research. The research scope covers the problem identification and strategy formulation phases but does not extend to implementation. Future research could conduct a longitudinal study to measure the quantitative impact of the implemented strategies. Furthermore, this study did not perform a detailed financial analysis of the Cost of Poor Quality. A subsequent study could quantify these financial losses and calculate the Return on Investment (ROI) for the proposed strategies. Finally, future work could expand the analysis to include external factors, such as supply chain.

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