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## Abstract

Manual quality control processes in the dairy industry are highly prone to human error, inefficiency, and inconsistencies, which often lead to production delays, additional costs, and significant risks to overall product quality and compliance with strict regulations. This research addresses these challenges by implementing an automated quality control system specifically designed for pH, acidity, and bacteriological testing, ensuring greater consistency. Using the DMADV methodology, structured interviews, direct observations, and comparative laboratory experiments were conducted to evaluate performance. Results showed a 40% reduction in overall testing time, more than 70% decrease in error rates, and substantially improved consistency. Automation highlighted improved traceability, better documentation, and a notable reduction in rework. Furthermore, automation encouraged greater reliability in results. Staff members reported very positive a stronger culture of quality and accountability within the teams. This article concludes that automation is a reliable, efficient, and superior alternative to manual testing, enhancing efficiency, accuracy, compliance, and sustainability in the dairy industry.

**Key Terms** — Automation, Dairy Industry, DMADV, Quality Control, Six Sigma.

## Problem Statement

Manual quality control processes in the food manufacturing industry often face inefficiencies, inconsistencies, and human error, which can delay production and compromise quality. To address these challenges, this research proposes implementing an automated quality control system in the dairy industry, focusing on pH, acidity, and bacteriological testing. The project analyzes current practices, designs and applies automation, trains staff for adoption, and evaluates improvements in accuracy, speed, and reliability. Results are expected to show reduced testing errors, faster processes, and more consistent outcomes. Beyond technical gains, automation enhances regulatory compliance, supports safer products, and integrates modern technology into traditional manufacturing. Employees benefit by acquiring new skills while organizations gain improved productivity and efficiency. Ultimately, the study serves as a benchmark case, offering valuable insights and a scalable model for other food industry companies seeking to modernize their quality control systems through automation.

## Methodology

This research followed the DMADV methodology (Define, Measure, Analyze, Design, Verify) and applied a mixed-methods approach combining qualitative and quantitative techniques. On the qualitative side, interviews with laboratory technicians, supervisors, and managers, along with direct observations and focus groups, were conducted to understand the challenges of manual testing, such as errors, inefficiencies, and staff perceptions toward automation.

	Table 1: DMAVD Methodology	Timeline
<b>DEFINE</b>	Define the process and establish goal	Aug 4 – Aug 16
<b>MEASURE</b>	Measure to determine process needs	Aug 11 – Aug 25
<b>ANALYZE</b>	Analyze the data to find the best design	Oct 3 – Oct 12
<b>DESIGN</b>	Design and test the process	Aug 18 – Sep 3
<b>VERIFY</b>	Ensure that design meets the design input requirements to achieve the goal	Sep 3 – Sep 19 Oct 12 – Oct 20

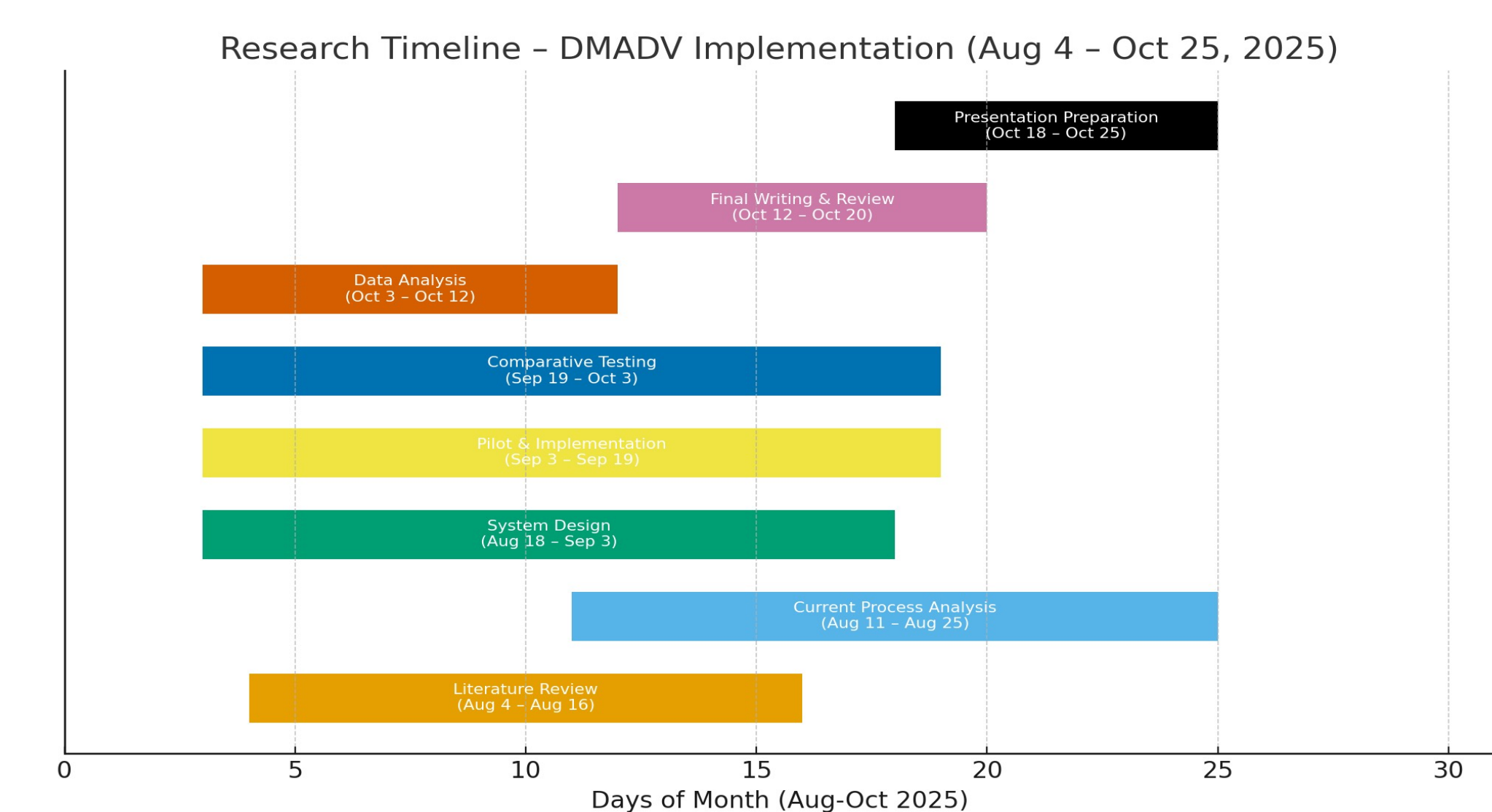


Figure 1: Timeline – DMADV Implementation

## DEFINE PHASE

Table 2: Project Charter	
<b>Project Description</b>	Design and implement an automated quality control system in the dairy industry using the DMADV methodology.
<b>Project timeline</b>	August 4, 2025 – October 25, 2025
<b>Project Goal</b>	Improve efficiency and accuracy in pH, acidity, and bacteriological testing through automation, reducing human error and ensuring compliance with safety standards.
<b>Benefits</b>	<b>Quality</b> – Enhanced precision, traceability, and consistency in testing.
	<b>Efficiency</b> – 40% reduction in testing time and 70% decrease in error rates
	<b>Regulatory Compliance</b> – Stronger adherence to food safety regulations
	<b>Employee Development</b> – Training in modern laboratory automation tools.
<b>Project Support</b>	Academic advisor, university faculty, and dairy industry stakeholders.
<b>Project Member</b>	Graduate student, Master in Manufacturing Competitiveness.

## MEASURE PHASE

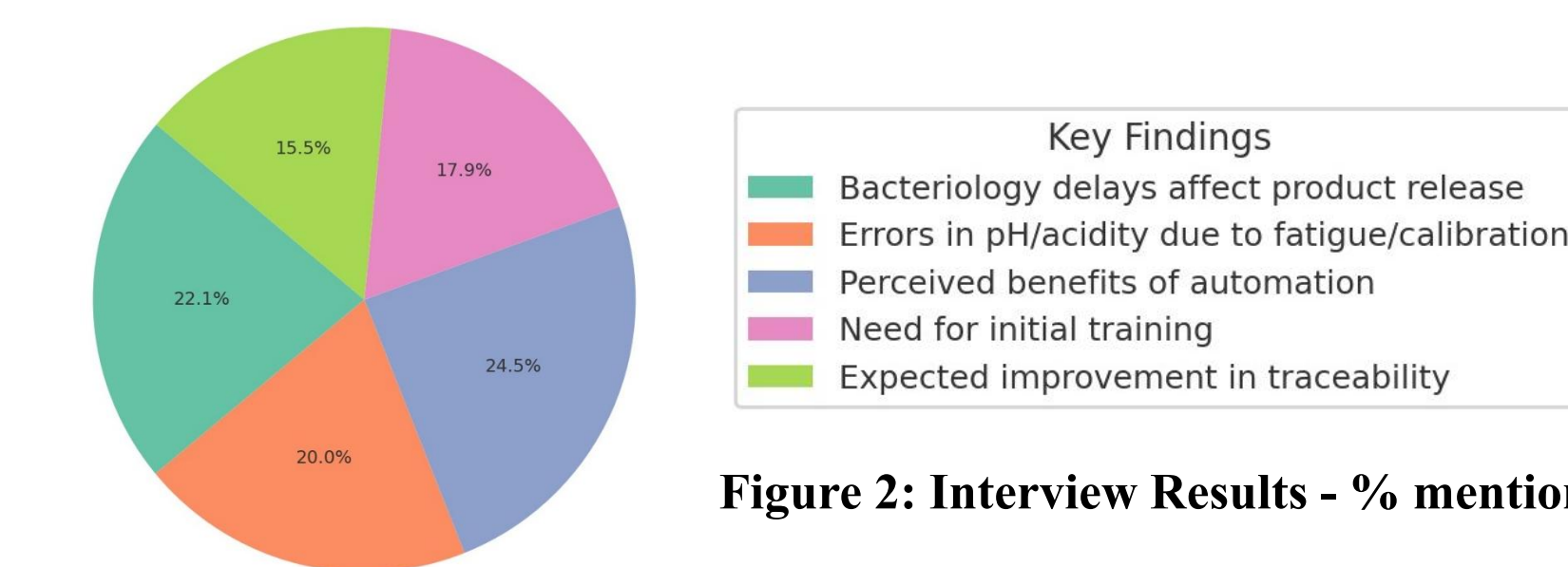


Figure 2: Interview Results - % mentions

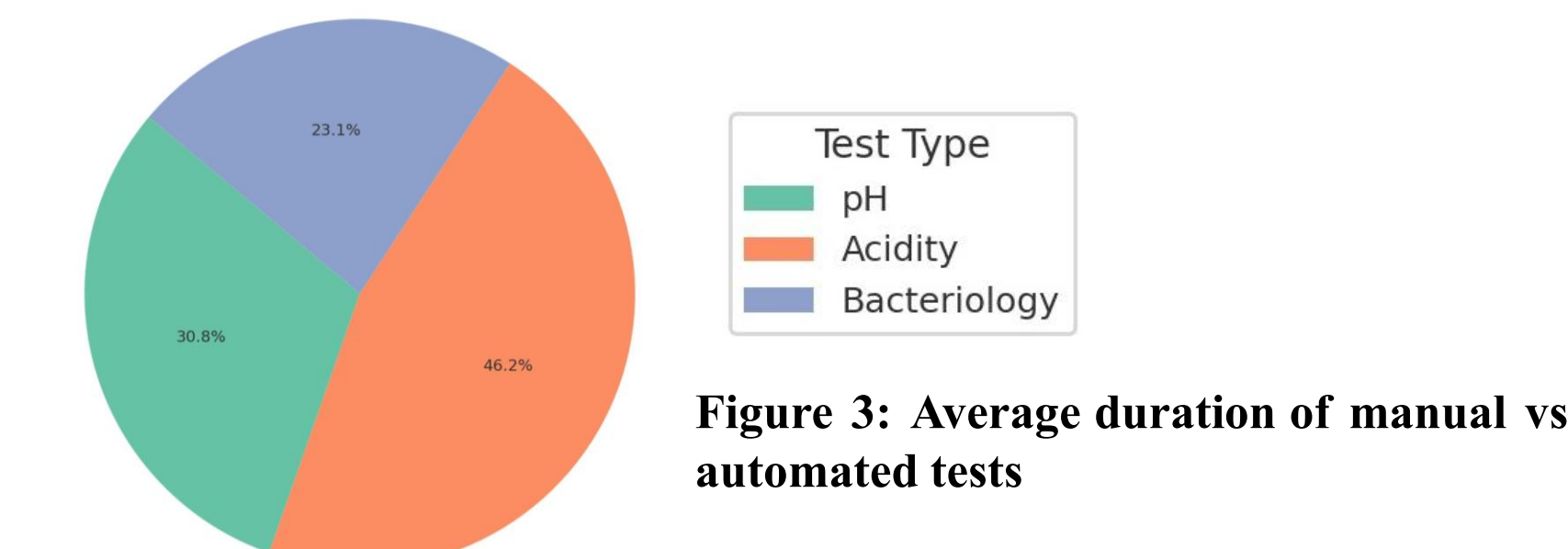


Figure 3: Average duration of manual vs. automated tests

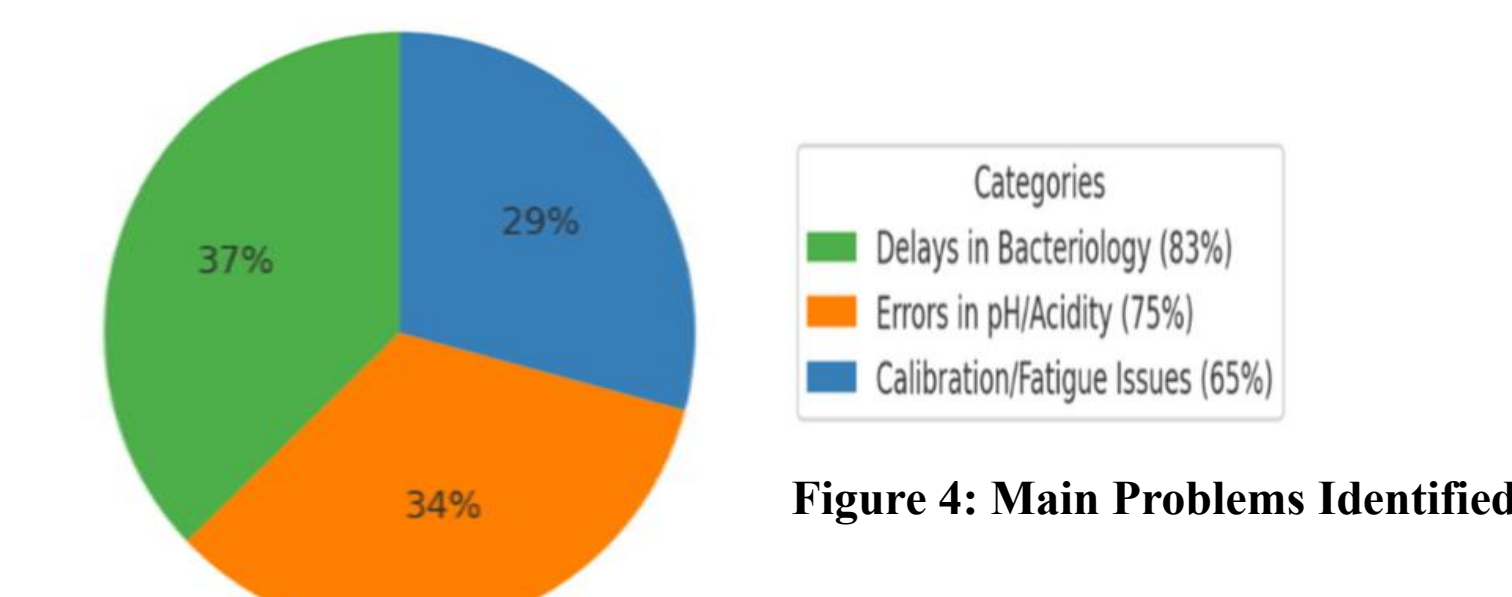


Figure 4: Main Problems Identified

## ANALYZE PHASE



Figure 5: ANOVA Comparison Manual vs Automated

## Results and Discussion

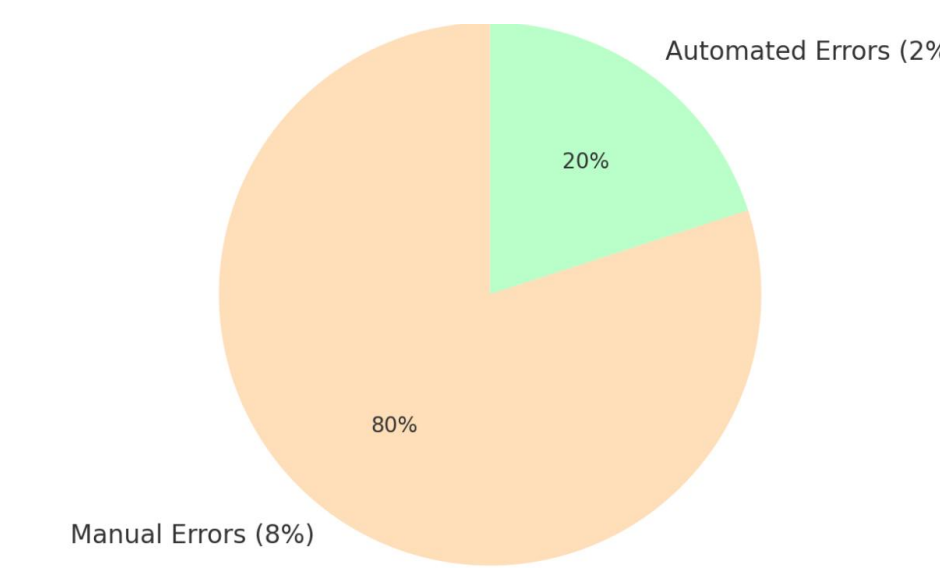


Figure 6: Comparison of Acidity Error Rates

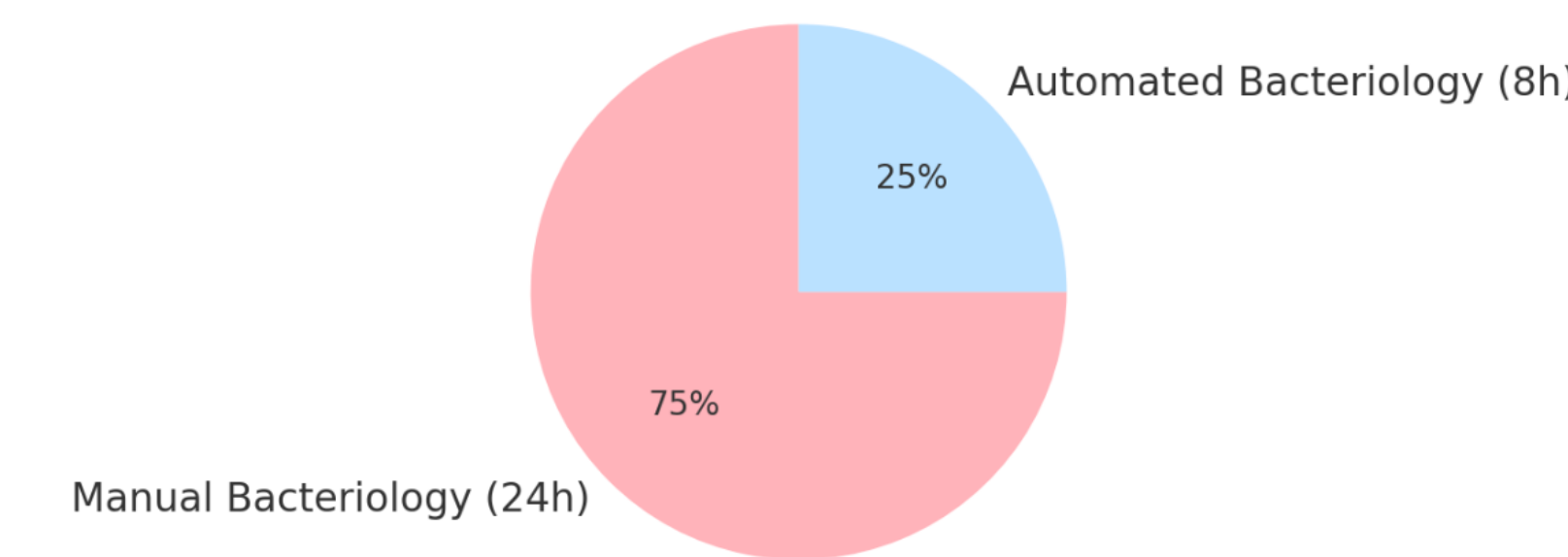


Figure 7: Comparison of Bacteriology Test Times

## DESIGN PHASE

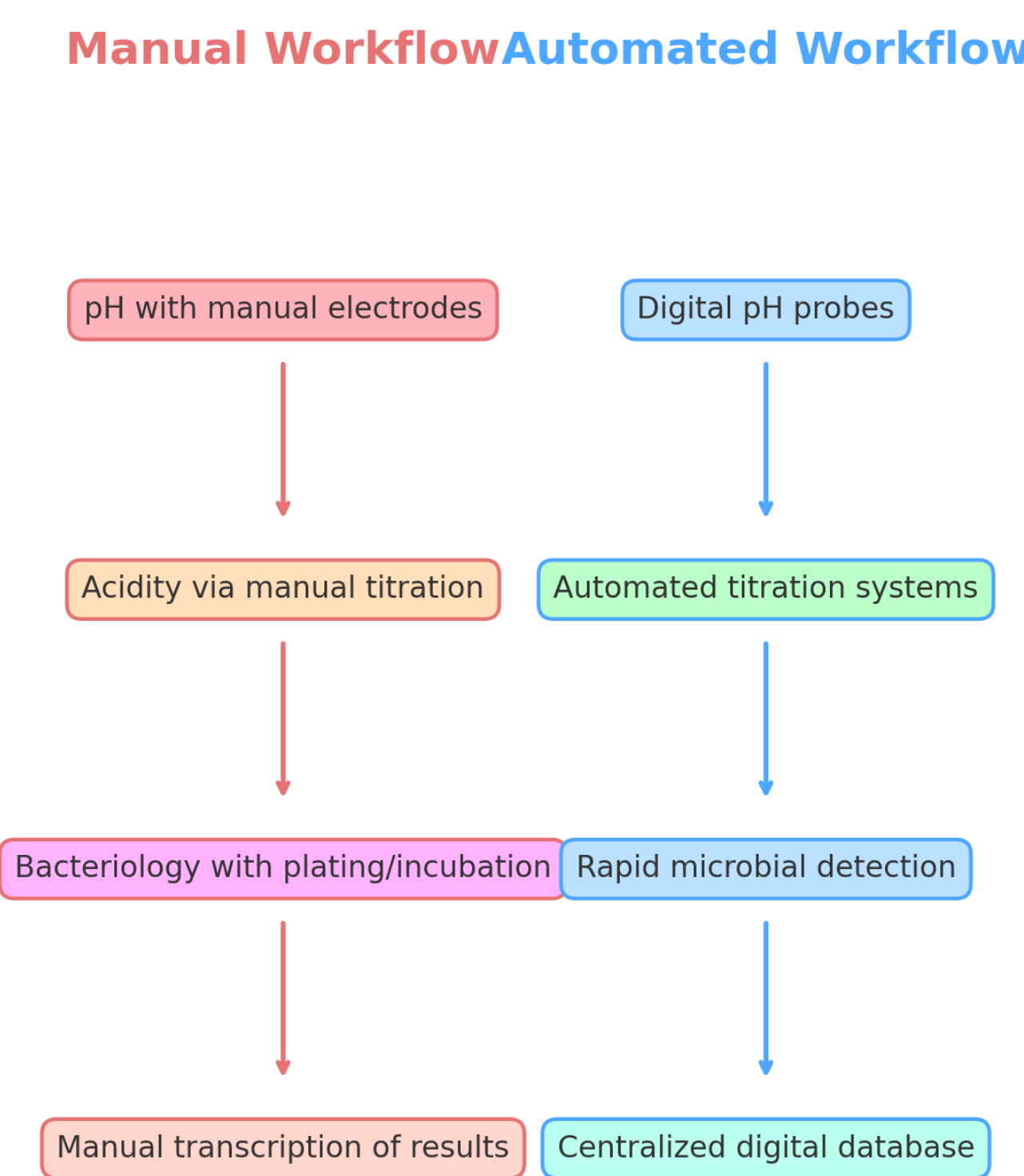


Figure 8: Workflow Comparison Manual vs. Automated Quality Control

The design focused on transforming manual quality control into an automated workflow. Traditional processes, such as manual pH measurement, titration, and bacteriological culture, were replaced with digital probes, automated titrators, and rapid microbial detection methods. These technologies reduced testing times from 18 minutes to 7 minutes for acidity and from 24 hours to less than 8 hours for bacteriology. A centralized database was integrated to automatically record results, ensuring real-time traceability and compliance with international standards. This design not only optimized accuracy and reduced human error but also created a streamlined and reliable quality control system ready for daily operations.

## VERIFY PHASE

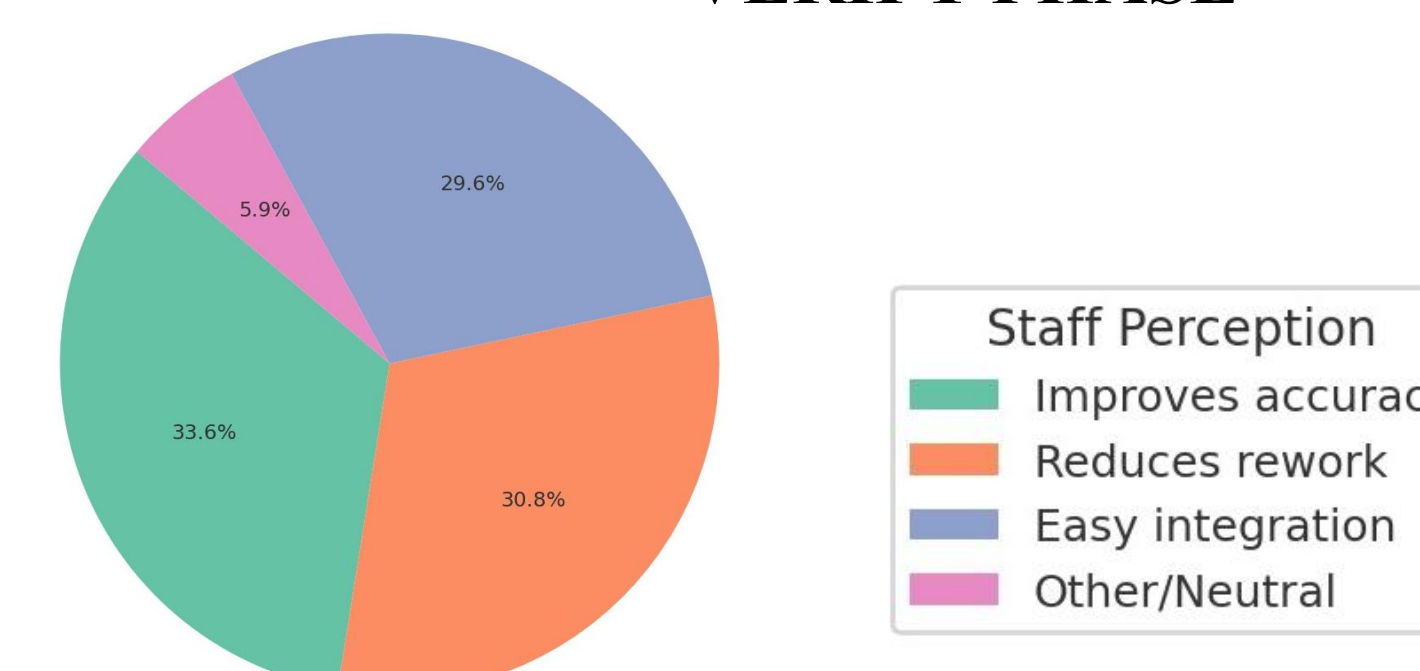


Figure 9: Staff Perception on Automated Quality Control System

Figure 4.6 - Verification Results: Error Rates Manual vs Automated

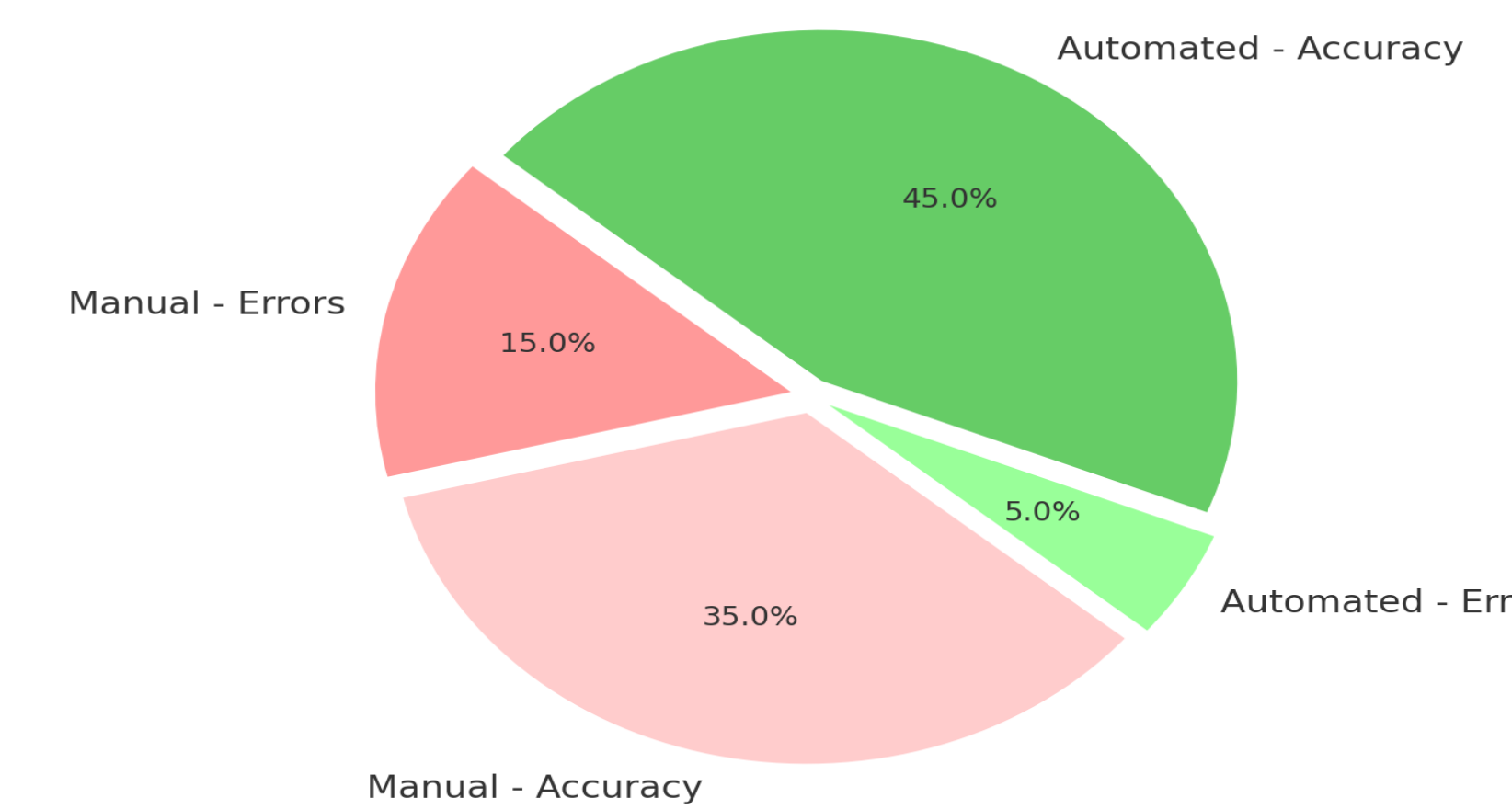


Figure 10: Verification Results: Error Rates Manual vs. Automated

## Conclusions

The implementation of an automated quality control system for pH, acidity, and bacteriological testing in the dairy industry proved highly effective compared to manual methods. Using the DMADV framework, the project systematically identified inefficiencies, designed a tailored solution, and validated its effectiveness through data and staff feedback. Results confirmed that automation reduced testing times by more than half, cut error rates by over 70%, and improved consistency across shifts.

Statistical analyses, including t-tests and ANOVA, showed significant improvements with large effect sizes, demonstrating the robustness of automation as an alternative to manual testing. Staff surveys revealed strong acceptance, citing greater reliability, reduced rework, and ease of integration, while learning curves remained manageable. Technical upgrades included digital pH probes, automated titration systems, rapid microbial detection, and centralized databases to ensure accuracy, traceability, and compliance. Overall, this project highlights automation as a feasible and advantageous solution, modernizing dairy quality control while setting a benchmark for efficiency, reliability, and industry competitiveness.

## Acknowledgements

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