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IMPLEMENTATION OF THE SEVEN TOOLS METHOD FOR PRODUCT QUALITY CONTROL: A CASE STUDY AT RUMAH TEMPE INDONESIA

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Abstract
This study applied the Seven Quality Control Tools to Soyagreen tempe products produced at Rumah Tempe Indonesia from 14 to 19 April, 2025. Analysis via Check Sheets, Flowcharts, Histograms, Pareto Diagrams, Control Charts, Scatter Plots, and Fishbone Diagrams revealed a 12.19% defect rate out of a total production of 1,091 units, consisting of 96% under-fermentation and 4% spoilage. Regression analysis found that each 1 °C increase in fermentation temperature led to an average of 7.57 additional defects. To address these findings, we recommend implementing a preventive-maintenance schedule daily calibration and cleaning of sensors, weekly deep-cleans of fermenter piping and external surface, monthly replacement of gaskets and seals, and quarterly servicing of heating and humidification components. This should be complemented by automated temperature-humidity controls, standardized standard operating procedures (SOP), operator training, and regular Seven Tools audits.

Keywords: *Quality Control, Tempe Production, Rumah Tempe Indonesia, Seven Tools.*

INTRODUCTION

Tempe is a traditional Indonesian fermented soybean product renowned for its high content of plant-based protein, dietary fiber, and a variety of essential micronutrients, making it not only a nutritious staple food but also a functional food with potential health benefits. Recent studies demonstrate that tempe consumption play a preventive role against degenerative diseases such as diabetes mellitus and cardiovascular disorders, through of isoflavone compounds and bioactive peptides released during fermentation (Sudaryantiningsih & Pambudi, 2024). The integration of data-driven approaches for maintaining tempe quality continues to advance. Istiadi et al., (2023) applied Principal Component Analysis combined with the K-Nearest Neighbor algorithm to accurately detect the optimal maturation point of tempe fermentation, a critical factor for ensuring consistent texture and flavor in large-scale production.

Medium-scale tempe producers continue to encounter difficulties in ensuring consistent product quality. Fluctuations in temperature and humidity during fermentation often lead to defects such as incomplete mycelial growth, overly soft tempe, or premature spoilage (Astiana et al., 2024). Astiana and colleagues found that strict control of fermentation conditions, specifically maintaining temperatures between 28 °C and 35 °C and relative humidity between 65 % and 70 %, is critical for producing high-quality tempe in small to medium-scale industrial. An investigation by Zendrato et al., (2022) employed the Seven Tools of Quality Control, especially Pareto and Fishbone diagrams, and reported a reduction in defect rates from 15 % to 6 % after process improvements guided by these analytical techniques. These findings highlight the practical benefits of applying systematic quality control tools in mitigating common production issues. At Rumah Tempe Indonesia, quality control remains heavily reliant on manual record-keeping and fragmented documentation, which obstructs the systematic identification of root causes for product defects. In contrast, Permono et al., (2022) conducted a case study at the Kebon Agung sugar factory in Malang in which they integrated the classic Seven Tools and the New Seven Tools with Failure Mode and Effects Analysis (FMEA) over a three-month production period, driving defect rates down to below 5%.

Personnel competence and training are also recognized as critical factors influencing tempe quality. Aini and Sukanta, (2024) demonstrated that regular training sessions combined with standardized SOPs supported by Control Charts (P-Charts) and Fishbone Diagrams can reduce human error factors by as much as 30 % in the Arummanis AT medium-scale tempe production. Furthermore, Pratama et al., (2023) demonstrated that the combined use of Check Sheets and Pareto Analysis accelerates the prioritization of corrective actions, facilitating faster and more measurable quality improvements. Collectively, these studies affirm comprehensive application of the Seven Tools Check Sheet, Flowchart, Histogram, Pareto Diagram, Control Chart, Scatter Plot, and Fishbone Diagram has proven effective across various food industry contexts for identifying defect causes, monitoring process stability, and guiding systematic improvement initiatives (Nastiti et al., 2022).

Nonetheless, there remains a research gap in the comprehensive and integrated implementation of all seven tools, specifically within medium-scale tempe production facilities in Indonesia, including a case study of Rumah Tempe Indonesia. To address this gap, the present study aims to (1) accurately identify and classify types of production defects, (2) analyze the primary causal factors of these defects, and (3) formulate data-driven systematic recommendations to reduce defect rates below established industry benchmarks.

RESEARCH METHODS

Research Type and Design

The research approach used is descriptive quantitative, with the main objectives to:
1. Analyze the quality of tempe products,
2. Identify types of defects,
3. Analyze the causes of defects, and
4. Formulate systematic corrective actions.

The research design includes the following data collection methods:
1. Direct observation in the production area to record defect occurrences,
2. Interviews with the production manager and operators to obtain explanations of the processes and challenges, and
3. Documentation in the form of production records, quality inspection reports, and standard operating procedures (SOPs).

This approach enables mapping of the actual conditions in the field and data validation through multiple sources.**

Location and Time of Research

This research was conducted at Rumah Tempe Indonesia, located at Jl. Raya Semplak No.27, RT.02/RW.06, Semplak, Bogor Barat District, Bogor City, West Java 16114. The location was chosen due to challenges in maintaining consistent tempe quality caused by manual fermentation and quality control.

Data Analysis Technique

The data analysis in this study employed the Seven Quality Control Tools: Check Sheet, Flowchart, Histogram, Pareto Diagram, Control Chart, Scatter Diagram, and Fishbone Diagram (Ishikawa Diagram), selected for their demonstrated effectiveness in the fermented food industry, as evidenced by Zendrato et al., (2022) the application of these tools facilitates the proper identification of defects and process improvements to reduction in defect rates.

RESULTS AND DISCUSSION

1. *Control Chart*

Product deviation data enable the calculation of defect rates and support control chart analysis to assess compliance with acceptable limits (Table 1).

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Table 1. Control chart analysis results for defective tempe production

Date	Tempe Soyagreen (pcs) (n)	Type of Defect		Number of Defective Products (np)	Xi (a+b)/2
		Under Fermented (a)	Spoiled Products (b)		
14-Apr-25	266	4		4	2
15-Apr-25	195		45	45	22,5
16-Apr-25	140		12	12	6
17-Apr-25	145		6	6	3
18-Apr-25	190		54	54	27
19-Apr-25	155		12	12	6
Total	1.091	4	129	133	66,5

Source: Primary Data

Based on the Tempe product defect data that has been collected, the proportion of nonconformities can be calculated and analyzed using the P Control Chart (P-chart) (Table 2). The following steps are used:

1. Calculating the Center Line (CLp):
$$CL = P = \frac{\Sigma np}{\Sigma n} = \frac{133}{1091} = 12{,}19\%$$
2. Determining the Upper Control Limit (UCL) and Lower Control Limit (LCL):
$$UCL = P + 3\sqrt{\frac{P\,(1-p)}{n}} \;\&\; LCL = P - 3\sqrt{\frac{P\,(1-p)}{n}}$$
3. Creating the P Control Chart:
Visualizing the defect proportion for each sample with CLp, UCL, and LCL to identify whether the production process is within statistical control.

Table 2. Results of P-Chart Calculation for Defective Tempe Production

Date	Tempe Soyagreen (pcs) (n)	Number of Defective Products (np)	Defect Proportion (np/n)	CL	UCL	LCL
14-Apr-25	266	4	0,015	0,1219	0,1821	0,0617
15-Apr-25	195	45	0,231	0,1219	0,1922	0,0516
16-Apr-25	140	12	0,086	0,1219	0,2049	0,0390
17-Apr-25	145	6	0,041	0,1219	0,2034	0,0404
18-Apr-25	190	54	0,284	0,1219	0,1931	0,0507
19-Apr-25	155	12	0,077	0,1219	0,2007	0,0431
Total	1.091	133	0,121	0,1219	0,1516	0,0922

Source: Primary Data

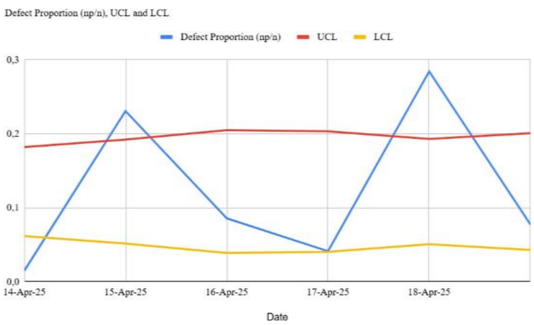

Figure 1. P Control Chart (P-Chart): Defective Tempe Production
Source: Primary Data

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P-Chart analysis reveals that defect rates exceed the upper control limit, indicating the presence of cause variation and signaling that the process is out-of-control. The major causes are overpacked stacking, which blocks air circulation for *Rhizopus* sp. mycelium and uncontrolled distribution temperatures that damage the mycelial layer and hasten spoilage, consistent with the findings of Zendrato et al., (2022) on the need for tight temperature and humidity control. Recommended fixes:

1. Reorganize the stacking to improve airflow.
2. Upgrade ventilation in the fermentation area.
3. Implement temperature control to protect the mycelium during distribution.

2. Fishbone

The Fishbone (Ishikawa) analysis distilled five principal categories underpinning soybean quality and storage failures at Rumah Tempe Indonesia (Figure 2):

1. Measurement: Irregular temperature logging in thermalization rooms and lack of standardized durability assessments.
2. Environment: Exposure to weather swings (rain, heat extremes) and suboptimal stacking that amplify humidity fluctuations.
3. Methods: Manual temperature tweaks, inconsistent inoculum application (0.5–3.5 Hg variance), and departures from recommended start of fermentation temperature protocols.
4. Materials: Non-uniform incoming-bean inspection and absence of rigorous quality checks at reception.
5. Machinery/Technology: Dependence on outdated Expeight TMR monitors for environmental control.

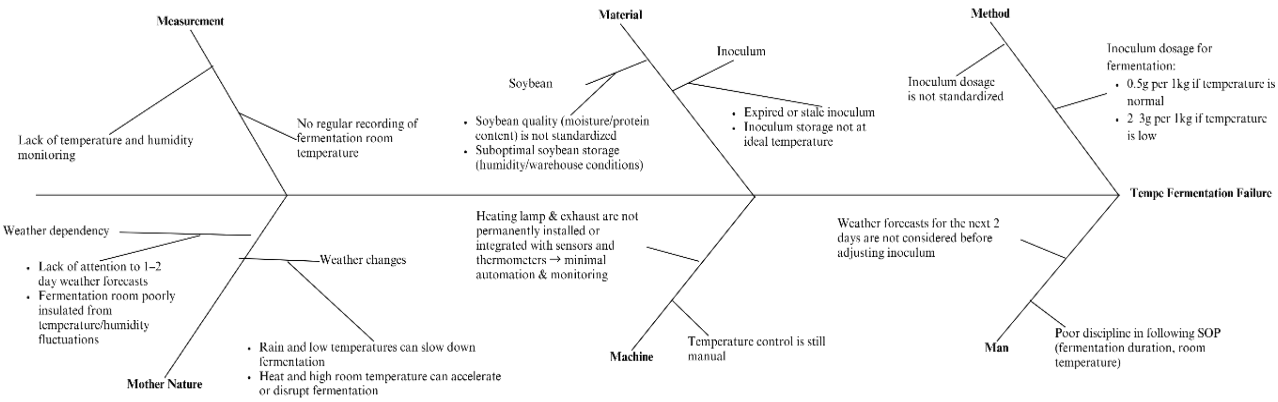

Figure 2. Fishbone Diagram for Identifying Root Causes of Defects in Tempe Production
Source: Primary Data

The primary causes are erratic fermentation temperatures, unmanaged climatic impacts, and operator-dependent procedures. To mitigate these, we propose implementing automated temperature and humidity control systems, standardizing inoculum application and inspection SOPs, and upgrading to real-time monitoring technologies. These measures align with Pratama et al., (2023) findings, which demonstrate how the integrated use of the Seven Tools methodologies fosters systematic quality improvements in small-scale food production.

3. Scatter Plot

A scatter plot one of the Seven Tools was used to analyze the relationship between fermentation temperature and the number of defective tempe products at Rumah Tempe Indonesia, revealing a clear positive correlation: as temperature fluctuations exceeded the optimal range of 30–32 ℃, defect rates increased (Table 3, Figure 3).

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Table 3. Fermentation Temperature Observation Data and Number of Defective Products (Scatter Plot)

Date	Fermentation Temperature(°C) (x)	Defect Count (y)	x^2	xy
14-Apr-25	31,2	4	973,44	124,8
15-Apr-25	34,0	45	1156,00	1530,0
16-Apr-25	29,5	12	870,25	354,0
17-Apr-25	30,0	6	900,00	180,0
18-Apr-25	35,0	54	1225,00	1890,0
19-Apr-25	28,7	12	823,69	344,4
Total	188,4	133	5948,38	4423,2

Source: Primary Data

1. In simple linear regression, the slope b (also called $\beta 1$) is the change in the predicted response y for a one-unit increase in the predictor x that we are going to calculate the slope b

$$b = \frac{n.\sum xy - (\sum x).(\sum y)}{n.\sum x^2 - (\sum x)x^2}$$

$$b = \frac{6 \cdot 4423{,}2 - 188{,}4 \cdot 133}{6 \cdot 5948{,}38 - (188{,}4)^2} = \frac{1482}{195{,}72} \approx 7{,}57$$

2. The intercept a (also called $\beta 0$)) is the predicted value of y when $x = 0$. In many practical cases, $x = 0$ lies outside the observed range, so a serves as a mathematical anchor for the regression line rather than an operational forecast point, here is the calculation of intercept a:

$$a = \frac{\sum y}{n} - b\frac{\sum x}{n} = \frac{133}{6} - 7{,}57 \cdot \frac{188{,}4}{6} \approx -215{,}59$$

3. The regression equation

$$\bar{y} = -215{,}59 + 7{,}57\,x$$

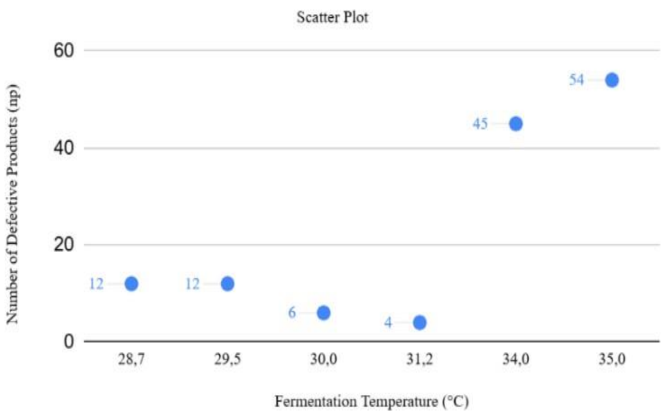

Figure 3. Scatter Plot of The Correlation Between Temperature and Tempe Product Defects
Source: Primary Data

Table 3 presents daily fermentation temperatures (x) alongside corresponding defect counts (y), as well as the sums of squares (x^2) and cross-products (xy) used to fit a simple linear regression. When these paired observations are plotted in the scatter diagram (Figure 3), a clear positive trend emerges: fermentation temperatures of 28.7–30.0 °C correspond with relatively low defect counts of 4–12 units, while temperatures rising to 34.0–35.0 °C align with defect counts increasing to 45–54 units. The regression coefficient of 7.57 confirms this relationship quantitatively, indicating that each 1 °C rise in fermentation temperature is associated with an average increase of approximately 7.57 defective units. Statistical analysis of both Table 3 and the scatter plot confirms a strong linear relationship between fermentation temperature and defect frequency, highlighting temperature control as a crucial factor in tempe quality.

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4. *Histogram*

A histogram is one of the tools in the Seven Tools method used to visualize the frequency distribution of numerical data in the form of a bar chart (Zendrato et al., 2022). The histogram analysis reveals that under-fermented defects account for 96% of the total defects, while spoiled products account for 4% (Table 4). This visualization enables the production team to prioritize improvements in the fermentation process, which is the primary cause of defects. Addressing under-fermentation would resolve 96% of all defects, and combined with spoilage, these two issues account for 100% of the defects.

Table 4. Defect Tempe Production Count

No.	Type of Defect	Defect Count	Defect Percentage (%)	Cumulative Percentage (%)	Priority
1	Under Fermented	4	4	4	2
2	Spoiled Products	129	96	100	1
	Total	133	100		

Source: Primary Data

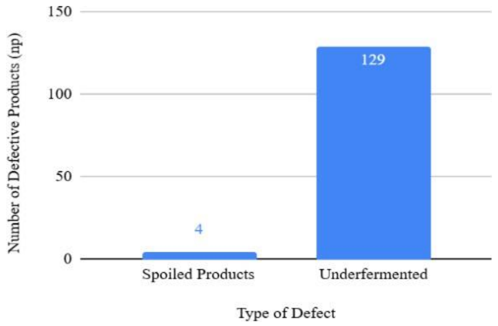

Figure 4. Defective Tempe Production Histogram
Source: Primary Data

5. *Check Sheet*

Under-fermentation was the most dominant type of defect (Table 5). The highest spike in under-fermentation defects was recorded on the 2nd and 5th days, indicating variability in the control of temperature and humidity during fermentation (Zendrato et al., 2022). These emphasized the importance of maintaining an optimal temperature range of 30–32 °C to prevent defects caused by incomplete fermentation.

Table 5. Defective Product Check Sheet Tempe Production

Date	Tempe Soyagreen (pcs)	Type of Defect		Defective Products
		Under Fermented	Spoiled Products	
14-Apr-25	266	4		4
15-Apr-25	195		45	45
16-Apr-25	140		12	12
17-Apr-25	145		6	6
18-Apr-25	190		54	54
19-Apr-25	155		12	12
Total	1.091	4	129	133

Source: Primary Data

6. *Diagram Pareto*

The Pareto principle states that approximately 80% of the effects are caused by 20% of the main causes, so by addressing the key problems within that 20%, significant quality improvement

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can be achieved. At Rumah Tempe Indonesia, spoiled products accounted for 96% (129 of 133) of defects, significantly exceeding the 80% Pareto threshold (Figure 5). This enabled the production team to prioritize post-fermentation temperature control and sanitation. Similarly, studies in tempe chip manufacturing have demonstrated that integrating Pareto Charts with Fishbone Diagrams can reduce defect rates by as much as to 75% in a single improvement cycle (Ramadhany et al., 2021).

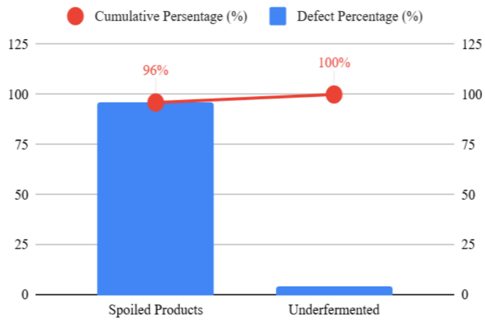

Figure 5. Pareto Chart Defective Tempe Production
Source: Primary Data

7. Flowchart

A visual representation of the steps and decisions in the production process, this diagram facilitates a comprehensive understanding of the workflow from start to finish. The following outlines the process flow of tempe production at Rumah Tempe Indonesia, as shown in Figure 6:

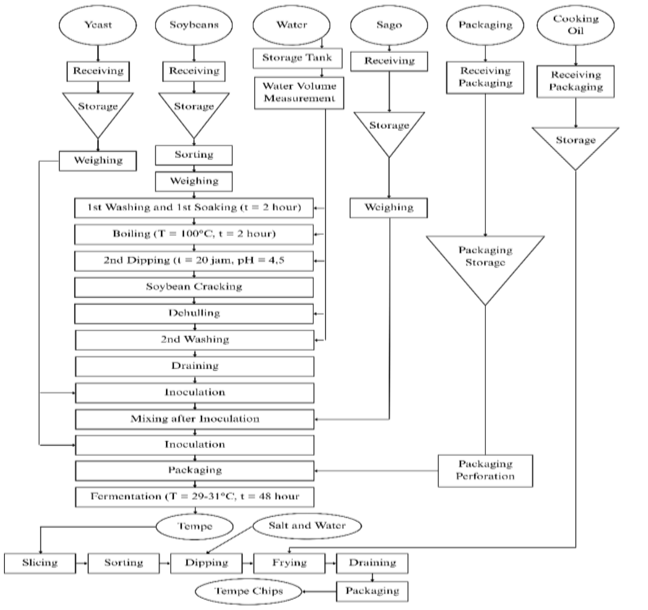

Figure 6. Tempe Production Flowchart at Rumah Tempe Indonesia
Source: Primary Data

CONCLUSIONS AND SUGGESTIONS

Data analysis reveals a significant positive correlation between fermentation temperature and defect rates at Rumah Tempe Indonesia, with each 1°C increase resulting in an average rise of 7.57 defective units, explaining 80% of defect variability. Defects remained low (4–12 units) at temperature 28.7–30.0°C but surged to 45–54 units at 34.0–35.0°C. Maintaining temperatures within the optimal 30–32°C range is critical. To effectively reduce variability, it is imperative to implement strategic measures that include implementing automated temperature-humidity control systems, standardizing procedures, training operators, and routine monitoring via the Seven Tools methodology.

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