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Application of Six Sigma to Reduce Defect in Tofu Products at UD Tahu Dua Saudara

Abdiel Khaleil Akmal [a,1,*], Jumelia Ardika [b,2], Dahnil Ikhwan [a,3], Zulia Ananda [c,4]

[a] *Department of Industrial Engineering, Teuku Umar University, Aceh Barat 23681, Indonesia*
[b] *Department of Civil Engineering, Syiah Kuala University, Banda Aceh 23113, Indonesia*
[c] *Department of biology, Syiah Kuala University, Banda Aceh 23113, Indonesia*

[1] *abdielkhaleilakmal@utu.ac.id;* [2] *jumeliaardika10@usk.ac.id*;* [4] *zuliaananda@usk.ac.id;*
* *corresponding author*

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ABSTRACT

Every company must experience problems related to the transportation sector. One of these problems is the TSP (Traveling Salesman Problem) where the problem is used in determining the shortest route with the requirement that the vehicles used must start and end at the same point. The above conditions were found in one of the companies engaged in the distribution of bottled water, especially the Kuades brand, located in Padang Panyang, Kuala Pesisir sub-district, Nagan Raya district, Aceh. The distribution system carried out by this AMDK company is not optimal because the distribution carried out only tries to meet the demand of each outlet or shop without taking into account the distance and travel time of the distribution. In this study using the Genetic Algorithm approach in solving problems in research. With this method, two results will be found, namely the shortest distribution path and the optimal cost. The use of the Genetic Algorithm method in solving the problem discussed provides results to achieve the optimal position, namely with the results of the shortest route is found in chromosome 2 in generation 1 being the best chromosome with a fitness value of 0.0016 and the length of the route traveled is 626 km, the optimal cost based on the distribution route that has been determined, the optimal cost result is Rp 1.38 Km Unit.

I. Introduction

Improving product quality has become an important issue in the industrial sector, including in traditional food industries such as tofu. Although tofu is a highly nutritious, affordable, and popular food in Indonesia, the challenge of maintaining its high quality remains a serious problem, especially at the Micro, Small, and Medium Enterprises (MSMEs) level [1][2].

Defective products such as soft texture, uneven sizes, or even the presence of dirt can damage the business's reputation and cause financial losses [3]. Amid these challenges, the application of technology and data-based quality management methods becomes crucial to enhance efficiency and reduce defect rates [12][13]. One of the proven effective approaches is the Six Sigma method, which is a statistical-based methodology that uses the DMAIC (Define, Measure, Analyze, Improve, Control) stages in the quality improvement process [4][5]. This approach has been widely applied in various industries, including the food industry and small manufacturing [14][6].

In the context of small industries like UD Tahu Dua Saudara, the Six Sigma approach is very suitable because it can provide quality improvement through the identification of root causes of problems and continuous process improvement [20][7][8][15]. Supported by the Failure Mode and Effect Analysis (FMEA) method, the improvement process becomes more systematic as it can map potential failures and prioritize solutions based on the Risk Priority Number (RPN) [16][8][17]. During the observation conducted at UD Tahu Dua Saudara (2024), 4,569 defective product units

were found out of a total of 256,896 products within a period of 1 month. This indicates that approximately 1.78% of the products do not meet quality standards. Therefore, the implementation of Six Sigma and FMEA is expected to reduce defects, increase production efficiency, and enhance the competitiveness of SMEs in the food sector [18][19].

In previous studies, various innovations have been successfully implemented to improve the quality of tofu products through the integration of Six Sigma and simple technologies (Jenji et al., 2019; Tri Lestari & Supardi, 2022). References from the Inotera Journal also show that such systematic approaches can be adapted by micro-entrepreneurs under conditions of technological and resource limitations (Ilyas et al., 2023). Thus, this research aims to apply the Six Sigma approach in an effort to reduce the defect rate in tofu products at UD Tahu Dua Saudara and to formulate FMEA-based recommendations for its production process.

II. Method

A. Type of Research

This research is a quantitative study because it uses numerical data and statistical methods systematically to evaluate product defect issues in the tofu production process.

B. Location and Research Object

- Location: UD Tahu Dua Saudara, Jl. Letnan Mubin, Desa Lapang, Kec. Johan Pahlawan, Aceh Barat.
- Research Object: Focus on the defects of tofu products analyzed using the Six Sigma method (DMAIC).

C. Population and Sample

- Population: All tofu products produced from August to November 2024. The population includes various variations of tofu products produced (size, shape, and type).
- Sample: Selected purposively, specifically only defective products such as: holes, odor, unevenness, sourness, hardness/softness, etc. Focus on defects that appear at certain stages of production (e.g., printing, steaming, packing).

D. Data Source

- Primary Data: Obtained from direct observation and interviews with employees/owners about the process and production defects.
- Secondary Data: Books, journals, articles, and data from previous companies.

E. Data Collection Techniques

- Field Study: Direct observation of the production process.
- Interview: Employees and management about defects and the production process.
- Literature Study: To support concepts and theories in the analysis.

F. Research Steps (DMAIC Approach)

- Define:

  The steps taken at this stage are identifying quality issues, determining critical to quality (CTQ) such as size, texture, cleanliness, and creating an Operation Process Chart (OPC).

- Measure:

  The measure phase aims to measure and collect data related to process performance. The steps at this stage include using a Pareto diagram to identify dominant defects, calculating DPMO (Defect Per Million Opportunities), and determining the Sigma Level.

- Analyze:

  This stage involves analyzing the root cause using the Fishbone Diagram (Ishikawa) and tracing the aspects of Man, Machine, Method, Material.

- Improvement:

  The improve stage aims to develop and implement improvement solutions. The steps at this stage involve using Failure Mode and Effect Analysis (FMEA) (e.g., scoring Severity, Occurrence, and Detection, calculating the Risk Priority Number (RPN), and designing improvement solutions based on the highest RPN (e.g., employee training, cutting aids, new SOPs).

- Control:

  Implementation of improvements, monitoring to ensure sustainable results, and evaluation of post-improvement outcomes.

G. Final Stage

Drawing conclusions from the results of data processing and analysis, and providing recommendations for the company and future researchers.

H. Research Schedule

The research was conducted from August to November 2024 according to the stages outlined above.

I. Research Flow Diagram

Described in the form of a flowchart in the original document (Fig. 1), from problem identification to result control.

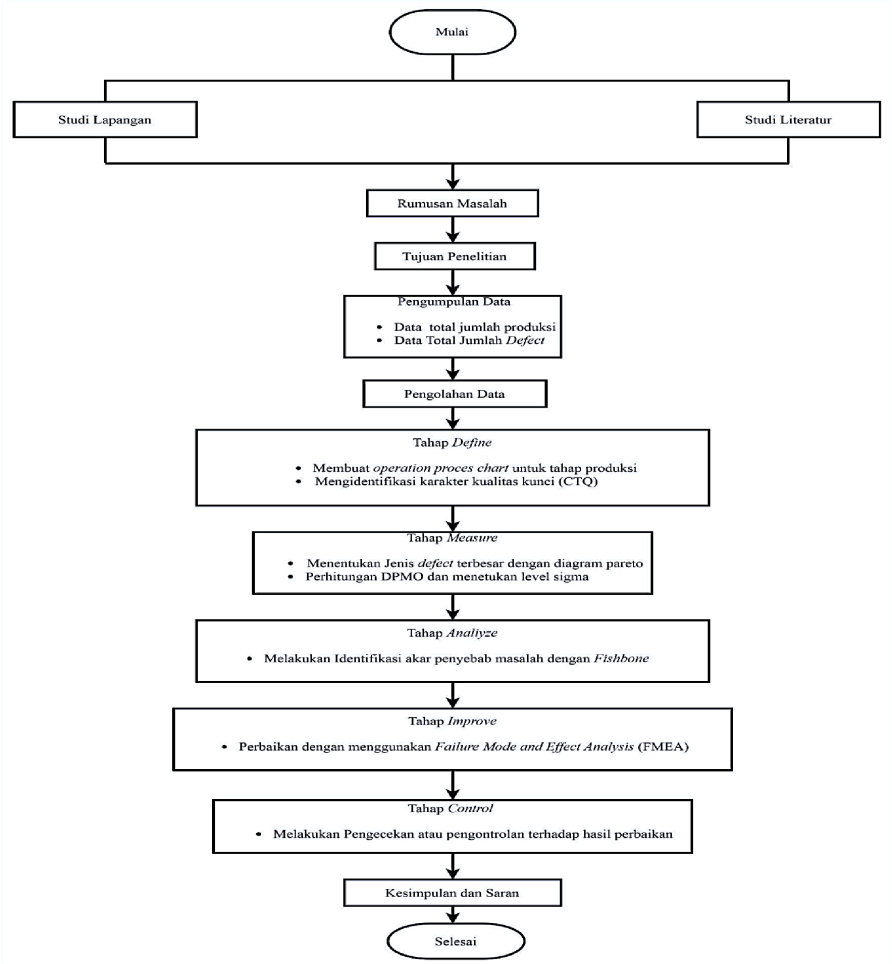

Fig. 1. Research Flow Diagram

III. Results and Discussion

A. Product Overview

The main product of UD Tahu Dua Saudara is white tofu with standard dimensions of 3 × 4 × 3 cm. The production process is done manually, so there is a high potential for product defects.

B. DMAIC Phases

1. Define (Problem Definition)
   - Main issue: Tofu products have defects such as incorrect size, holes, rough/soft texture, and dirt.
   - CTQ (Critical to Quality): Focus on size, shape, texture, and cleanliness.
   - Operation Process Chart (OPC): Used to map the production flow from soybean boiling to packaging.
2. Measure

   The data used in this research is the total number of products produced and the number of defective products generated during the period from October to November 2024, as shown in Table 1. Here is the obtained data:

Table 1. Total Production and Total Defects October November 2024

No	*Observation*	*Production quantity (boards)*	*Production quantity (pcs)*	*Number of defects (pcs)*
1	Week 1	418	60.192	1.200
2	Week 2	441	63.504	1.185
3	Week 3	486	69.984	1.068
4	Week 4	439	63.216	1.116
Amount		1.784	256.896	4.569

Source: UD Tahu Dua Saudara.

- Production Data:
  - Total production (4 weeks): 256,896 pcs
  - Total defects: 4,569 pcs
- Calculation of DPO and DPMO:
  The results of the recapitulation and calculation of DPO, DPMO, and Sigma data are shown in Table 2 below.

Table 2. Recapitulation Results of DPO, DPMO, and Sigma Level Calculations

No	*Observation*	*Production quantity (boards)*	*Production quantity (pcs)*	*Number of defects (pcs)*	*DPO*	*DPMO*	*Level sigma*
1	Week 1	418	60.192	1.200	0,00498405	4.984,05	4,1
2	Week 2	441	63.504	1.185	0,00466506	4.665,06	4,1
3	Week 3	486	69.984	1.068	0,00381516	3.815,15	4,2
4	Week 4	439	63.216	1.116	0,00441344	4.134,44	4,1
Average		446	64.224	1.142	0,004469	4.399,67	4,125

Source: Data Processing, 2024

Based on the calculations, the tofu production at UD Tahu Dua Saudara over four weeks shows the following results: the total average production reached 64,224 pcs, with a total average defect of 1,142 pcs. The average Defect Per Opportunity (DPO) during that period was 0.004469, while the average Defect Per Million Opportunities (DPMO) recorded was 4,399.67. The average sigma

level achieved was 4.125. With an average DPMO of 4,399.67, it means there are approximately 4,399 defective products out of 1,000,000 opportunities in the production process. This indicates that improvements are still needed in the production system to reduce defects and enhance the quality of tofu production.

3. Analysis Stage

At the analyze stage, an investigation was conducted to identify the root causes of the most significant defects, therefore a Fishbone Diagram (Ishikawa) was used to identify the causes of size and texture defects, with the following results.

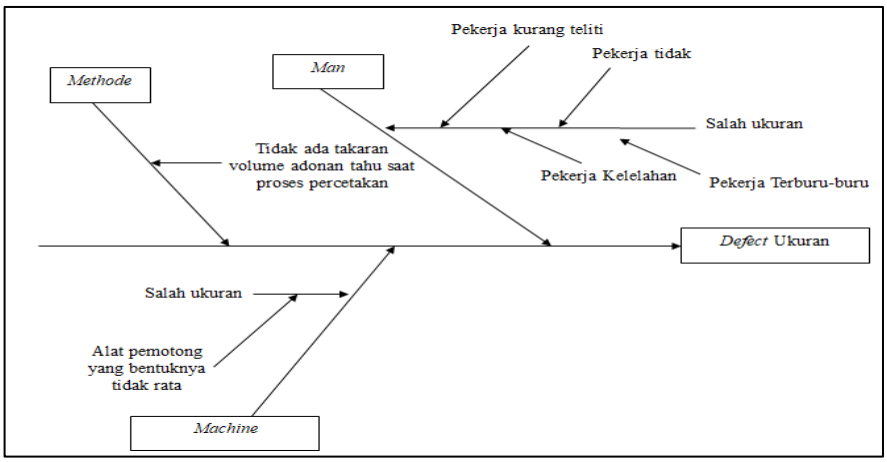

Fig. 2. Size Defect Fishbone Diagram

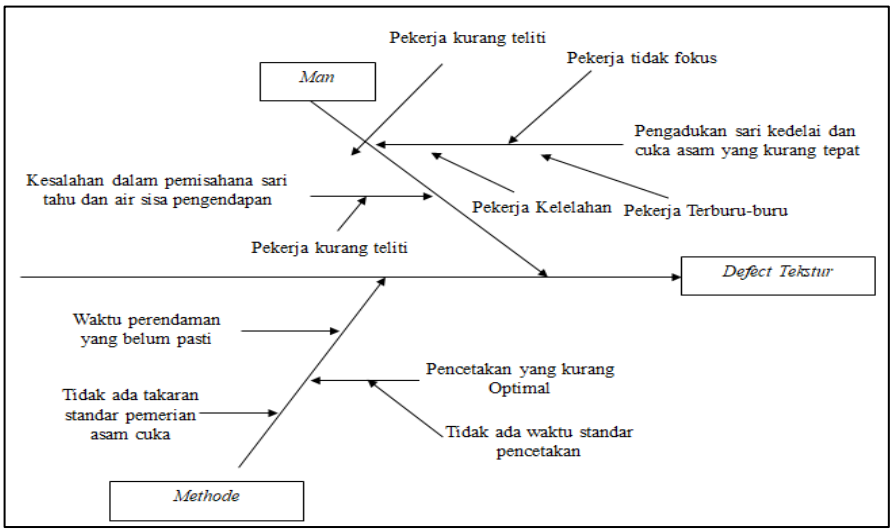

Fig. 3. Texture Defect Fishbone Diagram

Conclusion:

- Human Factor: Lack of skills in cutting tofu.
- Method Factor: The absence of written work standards.
- Machine Factor: Manual cutting tools are not precise

4. Improve

- FMEA Analysis (Failure Mode and Effect Analysis):
  - Calculating the RPN (Risk Priority Number) based on Severity, Occurrence, and Detection.
  - Focus on improvements:

a. Procurement of precision tofu cutting tools
b. Employee retraining
c. Standardization of production procedures

- Recommendation:
  - Use an automatic cutting tool
  - Create SOP for tofu size
  - Schedule regular training for the operators.

5. Control
   - Monitoring is conducted with:
     - Daily recording of the number of defects
     - Periodic evaluation of SOP implementation
     - Internal audit of production quality
   - The goal is to maintain the sustainability of improvements and enhance operational efficiency.

C. Discussion

- The application of Six Sigma has proven to identify and reduce the main causes of defects.
- A sigma level of 4.125 indicates that the production process is still within acceptable limits, but has not yet reached world-class status (6 sigma)
- Implication: If the proposed improvements are implemented, the potential to reduce the defect rate to <1% is highly likely to be achieved.
- Research limitations:
  - The data only covers 4 weeks.
  - Focus only on production, not distribution or sales.
  - Dependence on the accuracy of manual reporting by employees.

IV. Conclusion

The following are six conclusions from the results of this study related to the objectives and benefits of this research.

1. The factors that influence the quality of tofu products at UD Tahu Dua Saudara include size, texture, cleanliness, and product shape. Based on the Critical to Quality (CTQ) analysis, the most crucial characteristics affecting product quality are the size of the tofu and its soft texture, which are the main focus for improvement.
2. The types and frequency of the highest product defects during the study period are size defects (non-compliant with standards) and texture defects (too soft or hard). The Pareto diagram shows that these two types of defects dominate the total defects occurring during the production process.
3. The sigma level of the tofu production process is at 4.125, with a DPMO value of 4,399.67, which still indicates a significant chance of defects compared to the world-class standard (6 sigma = 3.4 DPMO). This indicates that the production process still requires continuous improvement.

4. Root cause analysis using a fishbone diagram shows that human factors (lack of skills), work methods (absence of SOP), and work tools (lack of precision) are the main causes of defects.
5. The improvement stage using the FMEA method indicates that the focus of the improvements should be on the tofu cutting and molding processes, with proposed improvements including the use of automatic cutting aids, employee training, and the formulation of standard production SOPs.
6. The control stage is carried out through periodic monitoring, SOP evaluation, and production quality audits to ensure that the improvements made are sustainable and to prevent the recurrence of defects.

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