



Analysis of Quality Control of White Tofu Products Using the Six Sigma Method at the Tofu Factory UD. Al Jaliil in Balikpapan City

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ABSTRACT

UD Al Jaliil is one of the agro-industry producers of white tofu in Balikpapan City. The challenge faced in maintaining quality is that defective products are still found. To handle this problem, UD AlJaliil needs to carry out quality control methods Six Sigma. This research aims to 1) analyze the implementation of quality control at UD Al Jaliil using methods Six Sigma 2) Determine the DPMO value and level Sigma white tofu products 3) Identify the factors that cause defective products so that efforts can be made to improve the quality of white tofu. Quality control is carried out using methods Six Sigma. Six Sigma is a quality control method by reducing the level of defects through five stages of DMAIC, namely Define, Measure, Analyze, Improve and Control. The results of the research show that the processes at UD Al Jaliil are not yet completely under control because processes are still found that are outside the control limits. The DPMO value is 306,300 units/process, meaning that in one million products produced there is the possibility of 306,300 defective products. Level Sigma UD Al Jaliil is 2.0064 Sigma. And there are several factors that cause defects in the texture of white tofu, namely factors man, machine, method, material and environment.

Keywords — white tofu, quality control, six sigma, texture test, organoleptic test

1. Introduction

In the era of globalization, competition between companies in the food industry is getting tighter due to technological developments. Business people compete to produce superior products with the best quality through innovation and product development. Manufacturers must focus on quality and competitiveness to survive in a competitive market. Quality control is important to prevent defective products and ensure they comply with established quality standards. Continuous improvement and improvement of product quality is necessary to meet consumer expectations. The Six Sigma method is used to reduce product nonconformities and increase the effectiveness of quality control. Product quality must be a top priority for businesses to remain competitive and provide assurance to consumers. Maintaining

quality from input to product output is vital in product development.

Six Sigma is a vision to improve quality towards the target of 3.4 failures per million opportunities (*defects per million opportunities*) for each product transaction (goods and/or services) [1]. *Six Sigma* used to measure the performance of an industrial system that can encourage companies to experience drastic quality improvements with actual strategy implementation. So, *Six Sigma* is a quality control method that focuses on customers with pay attention to process capabilities. Implementation *Six Sigma* can improve product quality by reducing the level of defects through the five stages of DMAIC, namely *Define* (Identification), *Measure* (Measurement), *Analyze* (Analysis), *Improvement* (Repair), and *Control* (Control). The application of the DMAIC method is intended so that companies



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can carry out quality control and improvement *continue* so that you can achieve the target *Six Sigma*, approaching zero failure rate (*zero defect*).

Tofu is a lump of soy protein obtained from the process of filtering ground soybeans and adding water [2]. Tofu is a common vegetable protein used as a side dish to replace animal protein. Balikpapan City is an area with a food industry, especially tofu, which has quite large production. Based on the sales of tofu which run out quickly every day, UD Al Jaliil experienced a loss of sales (*lost sales*) during 2022. From January to December, total *lost sales* tofu reached 816 kg, with a loss of income of Rp. 20,400,000. Therefore, it is necessary to carry out analysis to measure performance with the aim of reducing product nonconformities and increasing the effectiveness of quality control. Here's the data *lost sales* UD Al Jaliil is shown in Table 1.

Table 1. Lost Sales Tofu UD. Al Jaliil in 2022

Periode	Tofu Produktio n (Kg)	Deman d (Kg)	Lost Sale s (Kg)
January	5550	5678	128
February	3700	3700	0
March	5650	5746	96
April	4600	4712	112
Mey	4650	4730	80
June	4600	4600	0
July	5550	5550	0
August	5550	5646	96
September	6600	6712	112
October	6550	6630	80
November	6600	6712	112
Desember	4900	4900	0
/			
Total	64500	65316	816

Source : Rumah Produksi Tahu UD Al Jaliil (2023)

UD Al Jaliil is one of the agro-industries in Balikpapan City which produces white tofu in Somber Komplek. Production capacity reaches 7 tons per day. The main challenge is defective products in the form of crumbly tofu texture and wood impurities. This triggers customer complaints and Therefore, UD Al Jaliil needs to apply the Six Sigma method to control product quality in order to improve the production process and minimize defective products.

Research on this matter is very important for the company's progress.

2. Method

This research uses the Six Sigma method to reduce defects in white tofu products at UD Al Jaliil through five DMAIC stages: Define, Measure, Analyze, Improve, and Control. Calculations are carried out to assess process stability, capability, DPMO, and sigma level. Factors causing product nonconformity are also identified to propose quality improvements. Samples were taken 20 times with 4 samples per observation to analyze quality based on smell, taste, color and texture using organoleptic tests and Six Sigma analysis.

3. Discussion

Quality control analysis by method Six Sigma in this study using the DMAIC flow (Define, Measure, Analyze, Improve, and Control).

3.1. Define (Identification)

The problem identification process is carried out by focusing on several Critical to Quality (CTQ) taken from predetermined variables. The quality of white tofu at UD Al Jaliil follows the Indonesian National Standard (SNI 01-3142-1998) which includes aspects of smell, taste, color and texture. The tofu quality attribute in SNI regarding texture is not mentioned in detail but only mentions its appearance [3]. This standard is implemented by UD Al Jaliil to ensure and maintain the quality of tofu products until they reach the hands of consumers. The following are the standards that have been set by UD Al Jaliil for the four variables that have been determined, namely the aroma variable (stinks of tofu/no foreign smell), the taste variable (normal taste typical of tofu/bland), the color variable (normal white typical of tofu/free from impurities) and variable texture (springy (5-7.00 N/m²)).

3.1.1. Stinks Of Tofu

The tofu aroma variable at UD Al Jaliil is determined based on normal odor standards, namely the typical odor of tofu without foreign



odors, which is also regulated by the Indonesian National Standard (SNI). Testing was carried out through organoleptic tests with hedonic quality tests by three panelists. Panelists were asked to inhale the aroma of white tofu and give specific assessments, not just based on likes or dislikes. Tofu samples are taken randomly, and if a sour or rotten odor is detected, the product is considered defective because it does not meet quality standards. The stinks of tofu is important to assess the quality and shelf life of the product. This is supported by Riani (2016), that tofu products that have a sour or foreign aroma are caused by poor quality soybean raw materials and additional ingredients, namely water that is not clean and vinegar that is of low quality [4].

3.1.2. Color

Color variables The color variables of tofu at UD Al Jaliil are determined by the standard white color typical of tofu, free from impurities, in accordance with the Indonesian National Standard (SNI). The test was carried out through an organoleptic test using a hedonic quality test by three panelists, who gave a specific assessment of the surface color of the tofu. Samples are taken randomly, and if they are found to be yellow, brownish, dirty, or moldy, the product is considered defective and does not meet quality standards. Tofu color is important to evaluate the quality, cleanliness and shelf life of the product.

3.1.3. Texture

Texture variables The texture variables of tofu at UD Al Jaliil are set to a chewy standard, with a value of 5-7.00 N/m² according to additional recommendations in SNI. Testing was carried out using **texture analyzer** which measures tofu's resistance to compressive forces and its ability to return to its original shape after the load is removed. Samples are tested randomly, and a product is considered defective if it has a soft/soft texture with a value of 3-5.00 N/m² or a hard texture with a value of 7-9.00 N/m², because it does not meet quality standards. Texture is important because it is used as a parameter by consumers to assess the quality of tofu. This is supported by Midayanto who stated

that the texture of tofu is influenced by coagulation time and also pressing time [3].

3.2. Measure (Measurement)

At the level *measure* will present the number of defects in white tofu products produced according to the number of samples studied through calculations using tools *Six Sigma*. Steps on the level *measure* these are as follows:

3.2.1. Determination Critical to Quality (CTQ)

Determination Critical to Quality in the analysis of defects in white tofu products at UD AL Jaliil including the variables of smell, taste, color and texture. On *tools Six Sigma* that is *run chart* the following A number of white tofu products will be presented that do not comply with the standards set by the company. Based on the results of the data studied, with a sample size of 80 white tofu products, there were 98 product defects or nonconformities. This type of product defect is included in type 5. Figure 4.1 above shows that *defect product* because it is possible that the number of defects will be greater than the number of products sampled. Product defects consisted of 6 pieces of tofu occurring due to a mismatch in smell, 9 pieces of tofu occurring due to a mismatch in taste, 17 pieces of tofu occurring due to a mismatch in color, and 66 pieces of tofu occurring due to a mismatch in texture.

3.2.2. Process Stability Measurement

Measuring the stability of the tofu production process is carried out using *tools Six Sigma* namely the control chart. For the odor, taste and color variables, attribute data control charts are used, namely This process stability measurement aims to measure whether the tofu production process at UD Al Jaliil is within control limits or not. So you will see which processes on which days are not controlled by the upper or lower limits, and vice versa, the control chart will also show processes that are still within the upper or lower control limits.



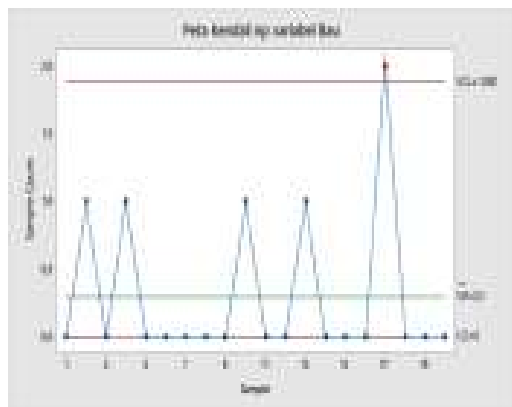


Figure 1. Control Map e.g. Odor Variable

Source: Processed Primary Data (2023)

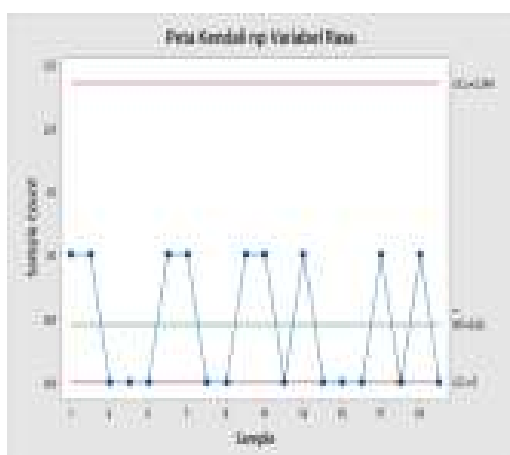


Figure 2. Control Map e.g. Taste Variable

Source: Processed Primary Data (2023)

There is 1 process that is outside the upper control limit, namely at the 17th observation. Control chart analysis e.g. for the taste variable presented in Figure 4.2 shows that there are no processes that are out of control and are still within the upper and lower control limits. Control chart analysis e.g. for the color variable, it shows that there are no processes that are out of control and are still within the upper or lower control limits. Then for the texture variable there are two control charts used is a control map \bar{x} and R. Control chart analysis \bar{x} for the texture variable, it shows that there are 6 processes consisting of 4 processes that are outside the lower control limit, namely at the 1st observation, 2nd observation, 4th observation, and 5th observation and 2 processes that are outside the limit. upper control, namely at the

12th observation and 16th observation. Analysis of the R control chart for the texture variable presented in Figure 4.5 shows that there are 3 processes that are outside the upper control limits, namely at the 2nd observation, 7th observation, and 20th observation.

3.2.3. Process Capability Measurement

a. Process Capability Value (Cp)

UD Al Jaliil has low processing capabilities in four main tofu product variables. In the odor variable, the Cp value of 0.9250 indicates that 92.50% of the product complies with standards, while 7.5% does not meet standards. For the taste variable, the Cp value of 0.8875 indicates that 88.75% of the product complies with standards, with 11.25% not complying. In the color variable, the Cp value of 0.7875 indicates that 78.75% of the products meet the standards, while 21.25% do not comply. The lowest process capability is found in the texture variable, with a Cp value of 0.3432 which shows that only 34.32% of products meet standards, while 65.68% do not meet standards.

b. Value (Defect Per Million Opportunity) DPMO

Based on the calculation results of the DPMO value and level Sigma It can be seen that the resulting DPMO value is 306,300. This value means that in one million units/processes of white tofu products produced, there is a possibility of failure of 306,300 units/processes of white tofu products.

c. Level Sigma

Based on the DPMO value above 6 improvements are needed to reduce then it will be converted into sigma level using help software Microsoft Excel then obtained a sigma level of 2.0064 Sigma. This shows that the level sigma 2.0064 from UD Al Jaliil is the level sigma Indonesian industry average with standard level sigma namely 2 sigma and it is necessary to continue to make quality improvements so that the defect value becomes smaller so that the level sigma from UD Al Al Jaliil can increase.

3.3. Analyze (Analysis)

The analyze stage in the Six Sigma method aims to analyze the factors causing defects in white tofu products at UD Al Jaliil. At this stage, two main steps are carried out: identifying the factors that cause defects and describing in detail how these factors affect product quality.

3.3.1. Determine Improvement Priorities

Determining repair priorities for product defects or nonconformities that occur based on the variables of smell, taste, color and texture. Then use tools namely the Pareto diagram as a determinant of improvement priorities so that improvements can be made immediately first.

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3.3.2. Tracing the Root Cause of the Problem

After identifying texture as a priority defect in white tofu products at UD Al Jaliil, root cause analysis was carried out through cause and effect diagrams and interviews with the owner. The main causes of texture defects come from five elements: humans, machines, raw materials, methods and the environment. This identification is possible level of defect in white tofu products.

a. Man

Do not have written SOPs that apply. The workers at UD Al Jaliil in carrying out the white tofu production process do not have definite procedures because UD Al Jaliil does not have Standard Operating Procedure (SOP) written in effect. Apart from that, workers in carrying out white tofu production only rely on memory and

personal assumptions. As a result, every time the production process produces products with non-uniform quality every day, it even causes product failure. in line with Irawati, R. and Hardiastuti, 2016 A series of written instructions known as Standard Operating Procedures (SOP) are used for repetitive or routine tasks) so that the product is stable [4].

b. Machine

The weights in the tofu pressing process at UD Al Jaliil greatly affect the quality of the tofu texture. If the weight is too light, the tofu will become soft, whereas if it is too heavy, the tofu will become tough. The weight used is a bucket filled with water, weighing around 20 kg, but the water is not always full, so the weight is not standard. Apart from that, the stacking of 10 tofu planks during pressing causes the process to be less than optimal, resulting in a non-uniform and often deformed tofu texture.

c. Method

The tofu coagulation process at UD Al Jaliil is often imperfect because the addition of vinegar as a coagulant does not have a standard standard. Workers add vinegar based on personal assumptions, and the amount of vinegar used varies with each production. As a result, the texture of the tofu often experiences defects, such as being too soft due to a lack of vinegar or too hard due to an excess of vinegar. Apart from that, the duration of pressing tofu at UD Al Jaliil does not yet have a standard, ranging from 10-15 minutes, but workers often do not pay attention to this time. and sometimes presses less than it should. This causes the resulting tofu to have a soft, hollow and less dense texture.

d. Material

- Imported soybeans that are stored for too long before production UD Al Jaliil uses imported soybeans which have a lower protein content compared to local soybeans, so the tofu is 7 sticks in the production area so that the The resulting product is of lower quality, especially in terms of texture and quantity obtained. Even though imported soybeans are more economical, the low protein content causes



the texture of tofu to be softer. UD Al Jaliil once used local soybeans which produced better quality tofu, but stopped using them because local traders often added impurities to the soybeans. Apart from that, imported soybeans that are stored for too long before production, up to three days, also reduce the quality of the tofu produced.

- Lack of regular replacement/addition of vinegar. The use of vinegar as a coagulant at UD Al Jaliil is also less controlled because there is no regular replacement or addition. The acid content of vinegar decreases because it is used continuously without standard measurements, which causes the tofu to have a soft and less dense texture. New vinegar is added if the production results show signs of defects, which means the quality of the vinegar is not maintained and affects the final result of the tofu product.

e. Environment

The work environment at UD Al Jaliil is not kept clean, with dirty, slippery and moldy floors and soybean residue that has accumulated and sprouted. Lack of regular sanitation causes the growth of fungi, insects and microorganisms that damage soy protein. This results in the tofu produced being of poor quality, with a softer texture due to reduced protein content and the amount of tofu produced being smaller.

3.4. Improve (Repair)

Level improve is the improvement stage, where at this stage several proposed plans for improving quality control of tofu products at UD Al Jaliil will be determined. Preparing a quality improvement plan is carried out by applying the 5W+1H question concept [5].

3.4.1. Man (Man)

- Does not have a valid written SOP so it needs internal improvements
- What : create process flow SOP simple production of white tofu

- Why : so that each stage of the process production carried out has clear procedures and conditions and uniform
- Where: The UD Al Jaliil than SOP the workers can read easily
- When : as soon as possible
- Who : owners and employees who competent
- How : UD Al Jaliil needs to prepare a written SOP for the white tofu production process flow as a reference for workers, so that the production process runs more regularly and in accordance with company standards.

b. Workers experience fatigue while working

- What : Implement a shift work system
- Why : So that workers don't experiencing excessive fatigue because the production process continues from morning to evening
- Where: The Tofu Factory UD Al Jaliil
- When : The shift system can carried out every day with divided into 2 shifts, namely the morning afternoon shift and the afternoon-afternoon shift
- Who : The workers at UD Al Jaliil
- How : UD Al Jaliil can implement a shift work system, so that workers work in shifts according to the specified distribution company, replacing the system full work from morning to evening.

3.4.2. Machine (Machine)

a. The ballast does not have a standard weight

- What : Use weights that have a standard weight of 30 kg
- Why : so that the ballast is constant
- Where: At the ptuhi tofu pressing place
- When : when pressing white tofu
- Who : workers in the white tofu pressing section
- How : UD Al Jaliil can replace the water tank weights with constant weight weights of 30 kg, such as those made from stone or other solid materials, and limit the stacking of tofu boards to a maximum of 5 boards. If the budget is sufficient, mechanization of the pressing process with a hydraulic



machine can also be considered to increase efficiency.

3.4.3. Method (Method)

- a. The addition of vinegar does not have standard
 - What : It is necessary to determine the standards for adding vinegar during the agglomeration process
 - Why : So that the added vinegar has a definite standard size/measure, not just based on workers' assumptions
 - Where: In place of the white tofu clumping process
 - When :during the white coagulation process
 - Who : workers in the coagulation process section
 - How : UD Al Jaliil can determine the ideal amount for adding vinegar, namely 74 ml per 0.5 kg of soybeans. With a cooking capacity of 14 kg of soybeans, the amount of vinegar added should be 2,184 ml or 2,184 liters
- b. Pressing time has no standard
 - What : need to determine the standard pressing time
 - Why : Pressing orders have definite time standards and are not based on assumptions
 - Where: In place of the white tofu pressing process
 - When : during the pressing process of white tofu
 - Who : workers in the pressing process section
 - How : UD Al Jaliil should set the pressing duration for 15 minutes to ensure the water really stops dripping and the texture of the tofu is denser and not mushy.

3.4.4. Material (Raw material)

- What : using local soybeans and setting a soybean purchasing schedule
- Why : Agarpressing has time standards that are certain and not based on assumptions
- Where: At the UD Jaliil Tofu factory
- When : during the white tofu production process

- Who : owner and workers in the white tofu production section
- How : UD Al Jaliil can switch to local soybeans by establishing direct partnerships with farmers, as well as arranging raw material purchases so that soybean stocks do not pile up

3.4.5. Environment (Environment)

- What : carry out regular sanitation every week
- Why : so that the environment is kept clean
- Where: At the UD Jaliil Tofu factory
- When : once every 1 week
- Who : all workers at the UD Al Jaliil tofu factory
- How : UD Al Jaliil need to carry out regular sanitation by ensuring clean water, clean floors, grinding machine, holding tank, tank boiling, washing filter cloth, and the mold knows so that the product quality stay awake.

4. Conclusion

The results of quality control using the Six Sigma method at UD Al Jaliil show that texture is the variable that most influences the quality of white tofu. The DMAIC stage revealed that of the four variables (smell, taste, color, and texture), smell and texture were not well controlled, while taste and color were controlled. All variables have a process capability $C_p \leq 1$, and a Sigma level of 2.0064, which indicates low process capability. In the Analyze stage, texture is a priority for improvement with the highest defect at 67.35%. The calculation results show a DPMO of 306,300, reflecting a significant product failure rate.

Factors causing texture defects involve several aspects: from a human perspective, the absence of written SOPs and worker fatigue; from a machine perspective, ballast that does not have a standard weight; in terms of method, the addition of vinegar and the duration of pressing have no standards; in terms of materials, imported soybeans stored for too long and lack of regular addition of vinegar; and from an environmental perspective, there is no regular sanitation.



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