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Analysis Quality Control of White Tofu Products using The Six Sigma Method at UD Al Jaliil Tofu Factory in Jember Regency

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Abstract

UD Al Jaliil is one of the white tofu producing agroindustry in Jember Regency. The challenge faced in maintaining quality is that defective products are still found. To deal with this problem, UD Al Jaliil needs to carry out quality control using the Six Sigma method. This study aims to 1) analyze the implementation of quality control at UD Al Jaliil using the Six Sigma method 2) determine the DPMO value and Sigma level of white tofu products 3) identify the factors that cause defective products so that efforts to improve the quality of white tofu can be determined. Quality control is carried out using the Six Sigma method. Six Sigma is a quality control method by reducing the level of defects through five DMAIC stages, namely Define, Measure, Analyze, Improve and Control. The results showed that the process at UD Al Jaliil had not been fully controlled properly because there were still processes that were outside the control limits. The DPMO value of 306,300 units/process means that in one million products produced there is a possibility of 306,300 defective products. The Sigma level of UD Al Jaliil is 2.0064 Sigma. And there are several factors that cause texture defects of white tofu, namely man, machine, method, material and environment factors.

Keywords
White tofu; quality control; six sigma; texture test; organoleptic test

I. Introduction

In the era of globalization, technological developments have occurred which have resulted in increasingly fierce industrial competition, so that product quality must be a priority for business people. Efforts to produce quality products require good quality control. Companies need to strive for continuous quality control. The application of continuous improvement can reduce the occurrence of defects in the hope of achieving a level of defects close to zero defects. Six Sigma can be used as a basis for reducing product defects. Six Sigma is a vision of improving quality towards the target of 3.4 failures per one million opportunities (Defects per million opportunities) [1].

Tofu is a lump of soy protein obtained by filtering ground soybeans and adding water [2]. It was recorded that in 2010, approximately 35% of Jember Regency's soybean demand was used as raw material for the tofu agroindustry. There are 720 tofu agroindustries in Jember Regency spread over 20 sub-districts [3].

UD Al Jaliil is one of the white tofu producing agroindustry in Jember Regency. This business is located in Krajan Kopang Hamlet, Darsono Village, Arjasa District, Jember Regency. Tofu production capacity is 4 quintals and produces ±320 tofu boards or ±22,400 pieces of tofu per day. The challenge faced in maintaining product quality is that defective products are still found. Damage to the product such as the texture of the tofu crumbles easily, there is dirt on the tofu, and there is also tofu that has a yellowish color on one side. As a result of the existence of these defective products, customers make complaints to the owner, so the owner must replace the defective product with a good product. If defective

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products continue to be produced, it will affect the profits earned by the company. Based on the problems above, UD Al Jaliil needs to carry out quality control using the Six Sigma method through the DMAIC approach.

II. Review of Literature

2.1 Quality

Quality is a form of producer effort to fulfill consumer satisfaction by providing the needs, expectations and even expectations of consumers, where the effort is visible and measurable in the final product produced [4]. Quality has traditionally been defined as the basis for the view that a product or service must meet the requirements of the user [5].

Quality relates to the presence of goods and services that are in accordance with standard specifications from consumers so that they can provide satisfaction for consumers, increase company profits and minimize expenses for production costs [6].

2.2 Quality Control

Quality control is an effort to reduce the variation in product quality characteristics so that they can meet specified needs, in order to increase consumer satisfaction [7].

2.3 Six Sigma

Six Sigma is a vision to improve quality towards the target of 3.4 failures per one million opportunities (defects per million opportunities) for every product transaction (goods or services) [1].

2.4 Six Sigma Implementation Stage

Quality improvement programs using the Six Sigma method can be implemented using the DMAIC (Define, Measure, Analyze, Improve and Control) approach [1].

2.5 Tofu

Tofu is a food product in the form of soft solids made through soybean processing by precipitating soy protein, with or without the addition of other ingredients [8].

III. Research Method

3.1 Research Design

This research uses the Six Sigma method to reduce the level of disability through the DMAI stage. This research includes applied research, experimental research and quantitative research.

3.2 Research Population and Research Sample

The population in this study includes white tofu products at UD Al Jaliil in February and March 2023 (± 22,400 pieces of tofu per day).

The sample in this study is 4 samples in one observation. Observations were made 20 times. The sample technique used is simple random sampling.

3.3 Research Variable

Determination of variables in this research refers to the Indonesian National Standard on tofu (SNI 01-3142-1998) which includes smell, taste, color and for texture variables refers to the Journal of Food and Agroindustry where in the journal determines the quality attributes of tofu texture to be recommended as a requirement addition to SNI **Error! Reference source not found.**.

a. Smell

Smell is a physical characteristic possessed by tofu and can be detected using the sense of smell. Tests on smell, taste and color variables were carried out by organoleptic tests, namely hedonic quality tests. Hedonic Quality Test is a test with panelists expressing a more specific hedonic quality impression, which is not just a like or dislike but is a specific impression of the distinctive properties of the product **Error! Reference source not found.**. In this study the hedonic quality test uses a limited type of panel, where the panel will consist of 3 panelists, namely panelists with an educational background in the Food Industry Technology Study Program, Jember State Polytechnic. Following are the specifications for the evaluation of smell variables in white tofu products:

Table 1. Tofu Smell Specifications

Smell Research Attributes	Score
Normal (Typical tofu smell, no foreign smell)	3
Smells sour	2
Smells bad	1

Source: UD Al Jaliil (2023)

Tofu products are categorized as defective if they have a specific smell, namely sour or bad smell. Tofu products are categorized according to standards if they have a normal smell (a typical tofu smell, no foreign smell).

b. Taste

Taste is a physical characteristic that exists in tofu and can be assessed using the sense of taste. Taste testing is done by organoleptic test, namely hedonic quality test. The following are specifications for the evaluation of taste variables in white tofu products:

Table 2. Tofu Taste Specifications

Taste Research Attributes	Score
Normal (Taste of tofu, plain)	3
Sour taste	2
Rotten, bitter taste	1

Source: UD Al Jaliil (2023)

Tofu products are categorized as defective if they have taste specifications, namely sour taste or rotten, bitter tastes. Tofu products are categorized according to standards if they have a normal taste (taste of tofu, plain).

c. Color

Color is a physical characteristic that presents an attractive effect on tofu products by using the sense of sight. Testing of color is done by organoleptic test, namely hedonic quality test. The following are specifications for color variable assessment of tofu products:

Table 3. Spesifikasi Warna Tahu

Color Research Attributes	Score

Normal (Typical white tofu, free of impurities)	3
Slightly yellow in color, there is dirt	2
brownish yellow, moldy	1

Source: UD Al Jaliil (2023)

Tofu products are categorized as defective if they have variable color specifications, namely slightly yellow or brownish yellow, moldy. Tofu products are categorized according to standards if they have a normal color (typical white tofu, free from impurities).

1. Texture

Texture is a physical characteristic of tofu which can be chewy, soft or hard. In this study, the texture of tofu was measured using a texture measuring tool, namely the Texture Analyzer. The working principle of the texture analyzer is product durability due to the compressive force from the tool or the ability to return the pressed food to its initial condition after the compressive load is removed **Error! Reference source not found.**. Following are the specifications for evaluating texture variables in white tofu products:

Table 4. Tofu Texture Specifications

Texture Research Attributes	Score
Hard	7 – 9,00 N/m^2
Chewy	5 – 7,00 N/m^2
Mushy/soft	3 – 5,00 N/m^2

Source : [9]

Tofu products are categorized as defective if they have texture specifications, namely hard or mushy/soft. Tofu products are categorized according to standards if they have a normal texture with a value of 5 – 7.00 N/m2.

3.4 Research Instruments

In this research, panelists used the smell, taste and color variables as organoleptic test instruments for hedonic quality, while for the texture variable the research instrument used was a texture analyzer. This research also uses a research instrument in the form of an open questionnaire.

3.5 Analysis Techniques3

The analysis technique used in this research is the Six Sigma method through the four DMAI stages as follows:

1. Define
   In the Define stage, identification of tofu product discrepancies is carried out. The steps include process mapping and problem identification.
2. Measure
   The Measure stage is carried out by measuring the type of defect and calculating it with an analytical tool. The steps include determining critical to quality (CTQ), measuring process stability and capability.
3. Analyze
   The Analyze stage is carried out by analyzing and determining the factors that cause product defects. The steps include determining priority repairs and tracing the root cause of the problem.

4. Improve
   The Improve stage is carried out by determining the quality improvement proposal by applying the 5W + 1H concept.

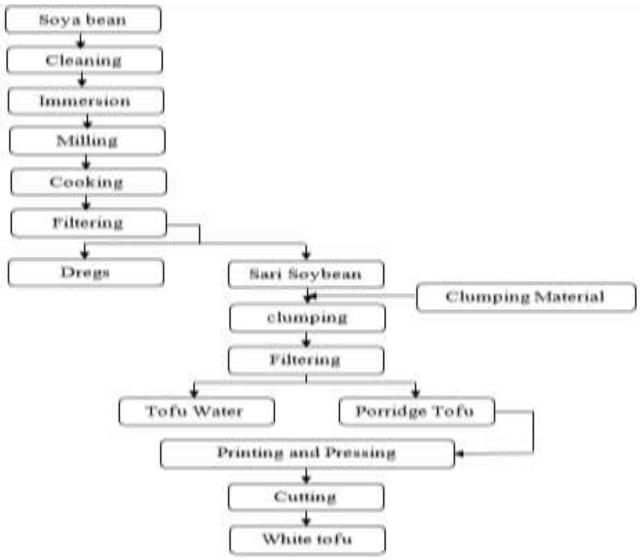
IV. Result and Discussion

Analysis of quality control using the Six Sigma method in this study uses the DMAI flow (Define, Measure, Analyze, and Improve). The following are the steps for implementing the DMAI method:

4.1 Define

At this early stage, the steps taken were to clearly identify problems with defects in white tofu products at UD Al Jaliil.

a. Mapping Process



Source: UD Al Jaliil (2023)

Figure 1. *White Tofu Production Process Flow Chart*

b. Identification of problems

The process of identifying this problem is carried out on several CTQs (Critical to Quality) which are taken based on predetermined variables. Tofu quality parameters used refer to the Indonesian National Standard on Tofu (SNI 01-3142-1998) which includes smell, taste, and color and for texture variables refers to the Journal of Food and Agroindustry. The following are the standards set by UD Al Jaliil for the four variables that have been determined:

Table 5. Smell, Taste, Color and Texture Quality Standards

No	Variable	Quality Standards
1	Smell	Normal (Typical tofu smell, no foreign smell)
2	Taste	Normal (Typical tofu taste, plain)
3	Color	Normal (Typical white tofu, free of impurities)
4	Texture	Chewy l (5-7,00 N/m^2)

Source: UD Al Jaliil (2023)

c. Measure

In the measure stage, measurements of the types of defects and calculations are also carried out with analytical tools.

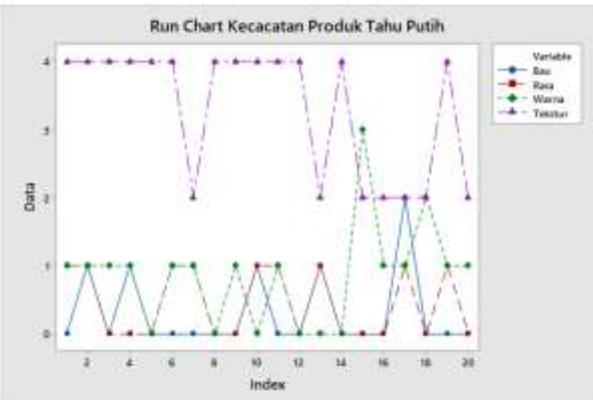
1. Determination of Critical to Quality (CTQ)

Determination of Critical to Quality in the analysis of white tofu product defects at UD AL Jaliil includes smell, taste, color and texture variables. These four variables are determined because these variables are the main parameters that determine the quality of white tofu products. On the Six Sigma tools, namely the following run chart, will display the number of white tofu products that are not in accordance with the standards set by the company.

Table 6. Product Defects Run Chart Calculation Data

No	Sample	Type of Disability				Number of defects
		Smell	Taste	Color	Texture	
1	4	0	1	1	4	6
2	4	1	1	1	4	7
3	4	0	0	1	4	5
4	4	1	0	1	4	6
5	4	0	0	0	4	4
6	4	0	1	1	4	6
7	4	0	1	1	2	4
8	4	0	0	0	4	4
9	4	0	0	1	4	5
10	4	1	1	0	4	6
11	4	0	1	1	4	6
12	4	0	0	0	4	4
13	4	1	1	0	2	4
14	4	0	0	0	4	4
15	4	0	0	3	2	5
16	4	0	0	1	2	3
17	4	2	1	1	2	6
18	4	0	0	2	2	4
19	4	0	1	1	4	6
20	4	0	0	1	2	3
Num	**80**	**6**	**9**	**17**	**66**	**98**

Source: Processed Primary Data (2023)



Source: Processed Primary Data (2023)

Figure 2. *Run Chart of White Tofu Product Defects*

On the run chart it can be seen that with a total sample of 80 white tofu products, there were 98 product defects or discrepancies. Product defects consisted of 6 pieces of tofu due to a mismatch in smell, 9 pieces of tofu due to a difference in taste, 17 pieces of tofu due to a mismatch in color, and 66 pieces of tofu due to a mismatch in texture.

2. Measurement of Process Stability

Measuring the stability of the tofu production process is carried out using Six Sigma tools, namely control charts.

a) Control Chart for Smell Variables

Table 7. Calculation Data of np Control Chart for Smell Variable

Observation	Number of defects	P	CL	UCL	LCL
1	0	0,000	0,300	1,880	0,000
2	1	0,250	0,300	1,880	0,000
3	0	0,000	0,300	1,880	0,000
4	1	0,250	0,300	1,880	0,000
5	0	0,000	0,300	1,880	0,000
6	0	0,000	0,300	1,880	0,000
7	0	0,000	0,300	1,880	0,000
8	0	0,000	0,300	1,880	0,000
9	0	0,000	0,300	1,880	0,000
10	1	0,250	0,300	1,880	0,000
11	0	0,000	0,300	1,880	0,000
12	0	0,000	0,300	1,880	0,000
13	1	0,250	0,300	1,880	0,000
14	0	0,000	0,300	1,880	0,000
15	0	0,000	0,300	1,880	0,000
16	0	0,000	0,300	1,880	0,000
17	2	0,500	0,300	1,880	0,000
18	0	0,000	0,300	1,880	0,000
19	0	0,000	0,300	1,880	0,000
20	0	0,000	0,300	1,880	0,000
Number	6	1,500			
Average	0,300	0,075			

Source: Processed Primary Data (2023)

The above data is obtained based on the calculation below:

1) Calculates for each subgroup the value of the proportion of defective units

$$\hat{p}i = \frac{pi}{n} \quad i = 1,2,\ldots,m$$

$$\hat{p}1 = \frac{0}{4}$$

$= 0,0000$

The calculation above is a calculation of the proportion of defective units in the 1st observation and the calculation is valid until the 20th observation.

2) Calculating the average value of the sample np, namely $n\bar{p}$

$$\overline{np} = \frac{\sum_{i=1}^{m} pi}{n}$$

$$\overline{np} = \frac{6}{20}$$

= 0,3000

CL = $\overline{np}$

CL = 0,3000

3) Calculating the control limits from the np control chart

$$UCL = \overline{np} + 3\sqrt{\bar{n}p(1-\bar{p})}$$

$$UCL = 0{,}3000 + 3\sqrt{0{,}3000(1-0{,}0750)}$$

= 0,3000 + 3(0,5268)

= 1,8803

$$LCL = \overline{np} - 3\sqrt{\bar{n}p(1-\bar{p})}$$

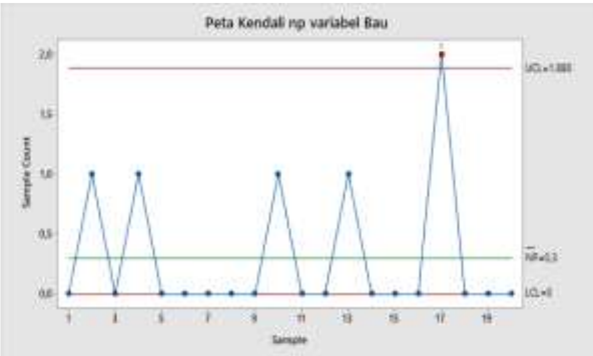
$$LCL = 0{,}3000 - 3\sqrt{0{,}3000\,(1-0{,}0750)}$$

= 0,3000 - 3(0,5268)

= -1,2803

= 0

4) Plot the defect proportion (percentage) data onto the np control chart



Source: Processed Primary Data (2023)

Figure 3. *Np Control Chart for Smell variables*

In the control chart for the odor variable np above, it shows that there is 1 process that is outside the control limits, namely the 17th observation.

b) Control Chart for Taste Variables

Table 8. Calculation Data of np Control Chart for Taste Variable

Observation	Number of defects	P	CL	UCL	LCL
1	1	0,250	0,450	2,346	0,000
2	1	0,250	0,450	2,346	0,000
3	0	0,000	0,450	2,346	0,000
4	0	0,000	0,450	2,346	0,000
5	0	0,000	0,450	2,346	0,000
6	1	0,250	0,450	2,346	0,000
7	1	0,250	0,450	2,346	0,000
8	0	0,000	0,450	2,346	0,000
9	0	0,000	0,450	2,346	0,000

10	1	0,250	0,450	2,346	0,000
11	1	0,250	0,450	2,346	0,000
12	0	0,000	0,450	2,346	0,000
13	1	0,250	0,450	2,346	0,000
14	0	0,000	0,450	2,346	0,000
15	0	0,000	0,450	2,346	0,000
16	0	0,000	0,450	2,346	0,000
17	1	0,250	0,450	2,346	0,000
18	0	0,000	0,450	2,346	0,000
19	1	0,250	0,450	2,346	0,000
20	0	0,000	0,450	2,346	0,000
Number	9	2,250			
Average	0,450	0,113			

Source: Processed Primary Data (2023)

The above data is obtained based on the calculation below:

1) Calculates for each subgroup the value of the proportion of defective units

$\hat{p}i = \frac{pi}{n} \quad i = 1,2, \ldots, m$

$\hat{p}1 = \frac{1}{4}$

$= 0{,}2500$

The calculation above is a calculation of the proportion of defective units in the 1st observation and the calculation is valid until the 20th observation.

2) Calculating the average value of the sample np, namely $n\bar{p}$

$\overline{np} = \frac{\sum_{i=1}^{m} pi}{n}$

$\overline{np} = \frac{9}{20}$

$= 0{,}4500$

CL = $\overline{np}$

CL = 0,4500

3) Calculating the control limits from the np control chart

$UCL = \overline{np} + 3\sqrt{\bar{n}p(1-\bar{p})}$

$UCL = 0{,}4500 + 3\sqrt{0{,}4500\,(1-0{,}1125)}$

$= 0{,}3000 + 3(0{,}6320)$

$= 2{,}3459$

$LCL = \overline{np} - 3\sqrt{\bar{n}p(1-\bar{p})}$

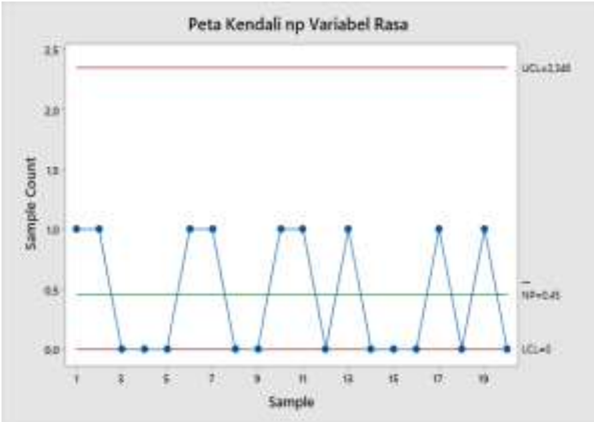
$LCL = 0{,}4500 - 3\sqrt{0{,}4500\,(1-0{,}1125)}$

$= 0{,}4500 - 3(0{,}6320)$

$= -1{,}4459$

$= 0$

4) Plot the defect proportion (percentage) data onto the np control chart



Source: Processed Primary Data (2023)

Figure 4. Np Control Chart for Taste variables

In the np control chart for the taste variable above, it shows that there are no processes that are outside the control limits

c) Control Chart for Color Variables

Tabel 9. Calculation Data of np Control Chart for Color Variable

Observation	Number of defects	P	CL	UCL	LCL
1	1	0,250	0,850	3,304	0,000
2	1	0,250	0,850	3,304	0,000
3	1	0,250	0,850	3,304	0,000
4	1	0,250	0,850	3,304	0,000
5	0	0,000	0,850	3,304	0,000
6	1	0,250	0,850	3,304	0,000
7	1	0,250	0,850	3,304	0,000
8	0	0,000	0,850	3,304	0,000
9	1	0,250	0,850	3,304	0,000
10	0	0,000	0,850	3,304	0,000
11	1	0,250	0,850	3,304	0,000
12	0	0,000	0,850	3,304	0,000
13	0	0,000	0,850	3,304	0,000
14	0	0,000	0,850	3,304	0,000
15	3	0,750	0,850	3,304	0,000
16	1	0,250	0,850	3,304	0,000
17	1	0,250	0,850	3,304	0,000
18	2	0,500	0,850	3,304	0,000
19	1	0,250	0,850	3,304	0,000
20	1	0,250	0,850	3,304	0,000
Number	17	4,250			
Average	0,850	0,213			

Source: Processed Primary Data (2023)

The above data is obtained based on the calculation below:

1) Calculates for each subgroup the value of the proportion of defective units

$$\hat{p}i = \frac{pi}{n} \quad i = 1,2, \dots, m$$

$\hat{p}1 = \frac{1}{4}$
$= 0{,}2500$

The calculation above is a calculation of the proportion of defective units in the 1st observation and the calculation is valid until the 20th observation.

2) Calculating the average value of the sample np, namely $n\bar{p}$

$$\overline{np} = \frac{\sum_{i=1}^{m} pi}{n}$$

$$\overline{np} = \frac{17}{20}$$

$$= 0{,}8500$$

CL = $\overline{np}$
CL = 0,8500

3) Calculating the control limits from the np control chart

$$UCL = \overline{np} + 3\sqrt{\bar{n}p(1-\bar{p})}$$

$$UCL = 0{,}8500 + 3\sqrt{0{,}8500(1-0{,}2125)}$$

$$= 0{,}8500 + 3(0{,}8182)$$

$$= 3{,}3045$$

$$LCL = \overline{np} - 3\sqrt{\bar{n}p(1-\bar{p})}$$

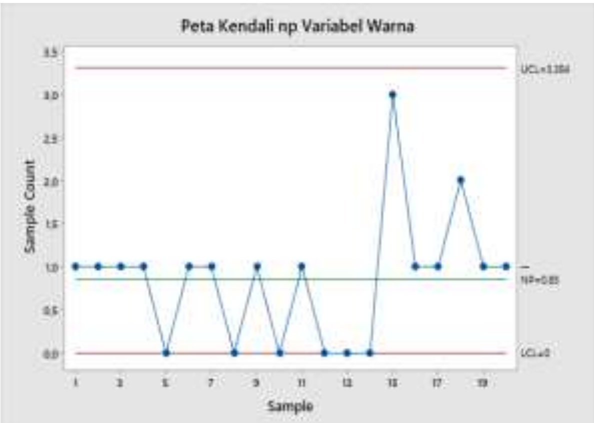
$$LCL = 0{,}8500 - 3\sqrt{0{,}8500(1-0{,}2125)}$$

$$= 0{,}8500 - 3(0{,}8182)$$

$$= -1{,}6045$$

$$= 0$$

4) Plot the defect proportion (percentage) data onto the np control chart



Source: Processed Primary Data (2023)
***Figure* 5**. *Np Control Chart for Color variables*

In the np control chart for the color variable above, it shows that there are no processes that are outside the control limits.

d) Control Chart for Texture Variables

Table 10. Calculation Data of np Control Chart for Texture Variable

No	Texture Test				$\overline{X}$ bar	R
	X1	**X2**	**X3**	**X4**		
1	2,490	2,503	3,326	3,365	2,921	0,875
2	4,700	4,521	1,506	1,578	3,076	3,195
3	4,337	4,299	2,871	2,865	3,593	1,472
4	2,813	2,688	2,642	2,621	2,691	0,192
5	2,670	2,610	2,801	2,807	2,722	0,196
6	4,306	4,354	3,522	3,591	3,943	0,832
7	3,069	3,088	6,329	6,339	4,706	3,270
8	4,443	4,441	4,769	4,667	4,580	0,329
9	4,316	4,204	2,697	2,614	3,458	1,702
10	4,555	4,559	3,218	3,137	3,867	1,423
11	3,823	3,810	3,237	3,243	3,528	0,586
12	8,275	8,307	9,210	9,230	8,756	0,955
13	4,199	4,280	5,209	5,202	4,722	1,010
14	4,290	4,279	4,225	4,205	4,250	0,085
15	3,849	3,849	5,493	5,361	4,638	1,644
16	4,582	4,469	6,389	5,669	5,277	1,920
17	5,628	5,726	3,541	3,654	4,637	2,186
18	5,902	6,040	4,458	4,467	5,217	1,581
19	3,388	3,360	3,638	3,466	3,463	0,279
20	6,560	6,569	3,173	3,197	4,874	3,396
Number					84,920	27,126
Average					4,246	1,356

Source: Processed Primary Data (2023)

1) Calculate the average value ($\overline{x}$) and range (R) in each observation

$$\bar{x} = \frac{\sum_{i=1}^{m} x_i}{n}$$

$$\bar{x} = \frac{2,9404 + 2,5032 + 3,3256 + 3,3652}{4}$$

= 2,9211

For further calculations carried out up to the 20th observation.

$$R = x_{maks} - x_{min}$$

$$R = 3,3652 - 2,4904$$

= 0,8748

For further calculations carried out up to the 20th observation.

2) Calculating the average value of the entire ($\overline{x}$) and range (R)

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{m} x_i}{m}$$

$$\bar{\bar{x}} = \frac{84,9196}{20}$$

= 4,2460

CL = $\bar{\bar{x}}$

CL = 4,2460

$$\bar{R} = \frac{\sum_{i=1}^{m} R_i}{m}$$

$$\bar{R} = \frac{27{,}1256}{20}$$

= 1,3563

CL = $\bar{R}$

CL = 1,3563

3) Calculating the control limits on the average control chart ($\bar{x}$)

It is known that A2 = 0.7290, then:

$$UCL = \bar{\bar{x}} + A_2 \bar{R}$$

$$UCL = 4{,}2460 + 0{,}7290(1{,}3563)$$

= 4,2460 + 0,9887

= 5,2347

$$LCL = \bar{\bar{x}} - A_2 \bar{R}$$

$$LCL = 4{,}2460 - 0{,}7290(1{,}3563)$$

= 4,2460 - 0,9887

= 3,2573

4) Calculate the control limits on the R control chart

It is known that D4 = 2.2820 and D3 = 0 then:

$$UCL = D_4 \times \bar{R}$$

$$UCL = 2{,}2820 \times 1{,}3563$$

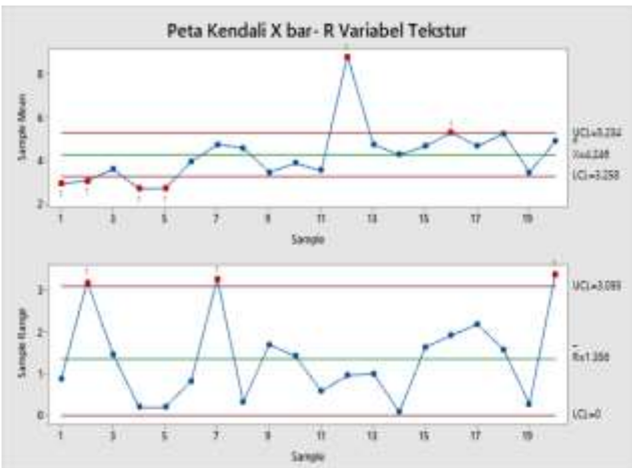
= 3,0950

$$LCL = D_3 \times \bar{R}$$

$$LCL = 0 \times 1{,}3563$$

= 0,0000

5) Plot the average ($\bar{x}$) and range (R) value data on $\bar{x}$ and R control charts



Source: Processed Primary Data (2023)

Figure 6. *X bar-R Control Map for Texture Variables*

In the X bar control chart the texture variable above shows that there are 6 processes that are outside the control limits. Whereas in the control chart R the texture variable shows that there are 3 processes that are outside the control limits.

3. Measurement of Process Capability
   1. Process Capability Value (Cp)
      a) Smell Variable

      It is known that the p bar of the smell variable = 0.0750

      $Cp = 1 - p\ bar$

      = 1- 0,0750

      = 0,9250

      Cp ≤ 1 which means low process capability

      b) Taste Variable

      It is known that the p bar of the taste variable = 0.1125

      $Cp = 1 - p\ bar$

      = 1- 0,1125

      = 0,8875

      Cp ≤ 1 which means low process capability

      c) Color Variable

      It is known that the p bar of the color variable = 0.2125

      $Cp = 1 - p\ bar$

      = 1- 0,2125

      = 0,7875

      Cp ≤ 1 which means low process capability

      d) Texture Variable

      From data processing known value:

      $\bar{R}$ = 1,3563

      USL = 4,9383

      LSL = 3,5820

      It is known that d2 = 2.0590

      $s = \frac{\bar{R}}{d2}$

      $s = \frac{1,3563}{2,0590}$

      = 0,6587

      $$Cp = \frac{USL - LSL}{6s}$$

      $$Cp = \frac{4,9383 - 3,5820}{6(0,6587)}$$

      $$= \frac{1,3563}{3,9522}$$

      = 0,3432

      Cp < 1 which means low process capability

   2. DPMO value

$$DPMO = \frac{\text{total product defects}}{\text{units checked} \times \text{number of characteristic defects}} X\ 1.000.000$$

$$DPMO = \frac{98}{80 \times 4} X\ 1.000.000$$

$$= 0,3063\ X\ 1.000.000$$

$$= 306.300$$

This means that in one million units of white tofu produced there will be a possibility of product failure of 306,300 units.

3. Sigma Value

Sigma Value = NORMSINV ((1000000 – DPMO)/1000000) + 1,5

Sigma Value = NORMSINV ((1000000 – 306300)/1000000) + 1,5

= 2,0064

Based on the results of these calculations, the sigma level at UD Al Jaliil's Tofu Factory was obtained, namely 2.0064 sigma. This shows that the sigma level of 2.0064 includes the average industry or business in Indonesia with a standard sigma value of 2.

d. Analyze

In the analyze stage, an analysis and decomposition of the factors that cause defects in white tofu products at UD Al Jaliil are carried out.

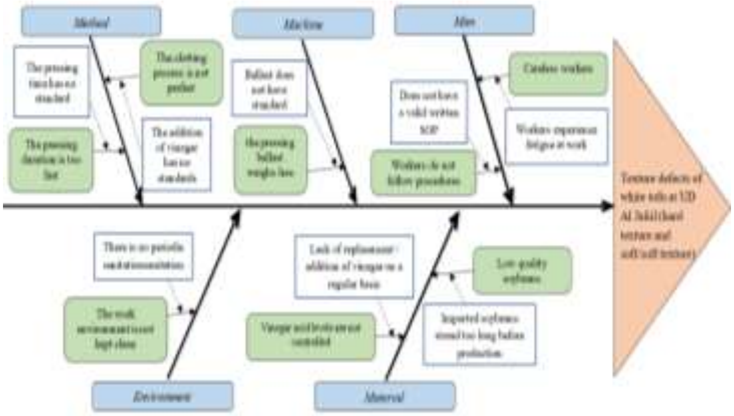
1. Determination of Repair Priorities
2.

Source: Processed Primary Data (2023)

Figure 7. *Pareto Chart of Defects of White Tofu Products*

Based on the Pareto chart above, it shows the highest to lowest types of defect. The highest type of defect is the type of texture defect of 67.35% or as many as 66 pieces, then the type of color defect is 17.35% or as many as 17 pieces, then the type of taste defect is 9.18% or as many as 9 pieces, while the type of defect is the lowest namely the type of smell disability of 6.12% or as many as 6 pieces. Based on these results it can be seen that the most common defects found are texture defects. This means that priority improvement efforts are on texture variables with hard and soft texture defects.

3. Tracing the Root Causes of the Problem



Source: Processed Primary Data (2023)

Figure 8*. Cause and Effect Diagram of Texture Defects in White Tofu*

Table 11. Observation Results of the Root Causes of White Tofu Texture Defects

Cause	Main factor	Root Causes of Problems
Man	Workers do not follow procedures	Does not have a valid written SOP
	Careless workers	Workers experience fatigue at work
Machine	Pressing ballast weighs less	Ballast does not have standard weights
Method	The clotting process is not perfect	The addition of vinegar has no standards
	The pressing duration is too fast	The pressing time has no standard
Material	Low quality soybeans	Imported soybeans stored too long before production
	Vinegar acid levels are not controlled	Lack of replacement / addition of vinegar on a regular basis
Environment	The work environment is not kept clean	There is no periodic sanitation

e. Improve

In the improve stage, several proposals for quality improvement plans for white tofu products were determined at UD Al Jaliil. The improvement plan is prepared by applying the 5W+1H question concept. Below are some suggested fixes to fix and address the root cause of the problem:

1. Man

a) Does not have a written SOP

Table 12. Proposed Problem Fixes Does not have a Written SOP

No	5W+1H	Explanation
1	What	Make SOP for white tofu production process flow which is written in a simple way
2	Why	So that each stage of the production process has clear and the same procedures and conditions
3	Where	At UD Al Jaliil and written SOPs can be posted in the production area so workers can read the SOPs easily
4	When	As soon as possible
5	Who	Owner with competent workers

6	How	UD Al Jaliil needs to make an SOP for the white tofu production process flow which is written and known by the workers so that it is used as a reference in carrying out the white tofu production process so that the process can be more orderly and in accordance with the standards set by the company.

b) Workers Experiencing Work Fatigue

Table 13. Proposed Actions to Correct the Problem of Workers Experiencing Work Fatigue

No	5W+1H	Explanation
1	What	Implement a shift work system
2	Why	So that workers do not experience excessive fatigue due to the production process that continues from morning to evening
3	Where	At the UD Al Jaliil tofu factory
4	When	The shift system can be carried out every day divided into 2 shifts, namely the morning-afternoon shift and the afternoon-afternoon shift
5	Who	Workers at UD Al Jaliil
6	How	UD Al Jaliil can implement a shift work system where workers who initially all work full time from morning to evening can then apply a shift system where later they will work alternately according to the distribution determined by the company.

2. *Machine*

a) Ballast Does Not Have Standard Weight

Table 14. Proposed Actions to Correct the Ballast Problem Does Not Have Standard Weight

No	5W+1H	Explanation
1	What	Using a ballast that has a standard weight of 30 kg.
2	Why	So that the weight used is more constant and does not change
3	Where	In place of pressing white tofu
4	When	During the process of pressing white tofu
5	Who	Workers in the pressing process
6	How	UD Al Jaliil can replace ballast in the form of a tub filled with water to use a tool that has a constant weight of 30 kg. The weights that can be used are weights made of stone or other solid materials, so that the weight is always the same for each pressing of 30 kg and don't stack too many tofu boards during the pressing process, a maximum of 5 tofu boards. If therer are sufficient funds, UD Al Jaliil can also mechanize the pressing process by presenting a pressing machine with a hydraulic working system where the tool utilizes the pressure exerted by the liquid to press the tofu pulp so that it can be pressed..

3. *Method*

a) Addition of Vinegar Has No Standard

Table 15. Proposed Actions to Correct the Problem of Adding Vinegar Does Not Have a Standard

No	5W+1H	Explanation
1	*What*	UD Al Jaliil needs to determine the standard for adding vinegar to the clumping process
2	*Why*	In order for the added vinegar to have a standard size/dose that is certain not only based on worker assumptions
3	*Where*	In place of the clumping process of white tofu
4	*When*	During the clumping process of white tofu
5	*Who*	Workers in the clumping process
6	*How*	UD Al Jaliil can determine the amount of vinegar added in one cooking process. The ideal addition of vinegar is 74 ml per 0.5 kg of soybeans. if in one cooking at UD Al Jaliil that is equal to 14 kg then ideally vinegar is added as much as 2,184 ml or 2,184 liters.

b) Pressing Time Has No Standard

Table 16. Proposed Action to Correct the Problem Pressing Time Does Not Have a Standard

No	5W+1H	Explanation
1	What	UD Al Jaliil needs to determine the standard pressing time in the pressing process
2	Why	In order for the pressing to be carried out to have a definite time standard, it is not only based on worker assumptions
3	Where	In place of the process of pressing white tofu
4	When	During the process of pressing white tofu
5	Who	Workers in the pressing section
6	How	UD Al Jaliil can determine how long the pressing process takes. It is better to press for 15 minutes so that the water from the tofu has completely stopped dripping and the texture is more integrated and not too soft.

4. *Material*

a) Imported soybeans are stored too long

Table 17. Proposed Actions to Correct the Problem of Imported Soybeans Stored Too Long

No	5W+1H	Explanation
1	What	Using local soybean raw materials and arranging soybean purchase schedules
2	Why	So that the quality of soybeans is better and contains more protein if you use local soybeans and in the process of buying soybeans, it is scheduled so that soybeans do not accumulate
3	Where	At the UD Al Jaliil tofu factory
4	When	During the white tofu production process

5	Who	The owner of the tofu and UD Al Jaliil workers
6	How	UD Al Jaliil can replace imported soybeans with local soybeans by conducting partner relations with farmers directly and in the process of purchasing these raw materials must be considered with the existing stock so that there is no accumulation of soybean raw materials.

b) Lack of Periodic Addition of Vinegar

Table 18. Proposed Actions to Correct the Problem of Lack of Periodic Addition of Vinegar

No	5W+1H	Explanation
1	What	Measure the coagulation PH and schedule regular additions of vinegar
2	Why	So that the level of vinegar acid can be controlled
3	Where	In the process of clumping white tofu
4	When	During the clumping process of white tofu
5	Who	The workers in the clumping department
6	How	UD Al Jaliil can arrange a schedule for adding vinegar periodically, which is once every three or four months. Prior to the addition process, you can measure the level of acetic acid with a coagulation pH ranging from 4.5 to 4.6 using a vinegar acidity measuring instrument, namely a PH meter. Then the addition of vinegar is done by adding the old vinegar liquid with the new vinegar liquid so that the acid level of the vinegar can increase again so that the resulting tofu is not easily crushed/soft.

5. *Environment*

a) Lack of Periodic Sanitation

Table 19. Proposed Actions to Correct the Problem of Lack of Periodic Sanitation

No	5W+1H	Explanation
1	*What*	Perform periodic sanitation every week
2	*Why*	To keep the work environment clean
3	*Where*	At the UD Al Jaliil tofu factory
4	*When*	Once every week
5	*Who*	All workers at the factory know UD Al Jaliil
6	*How*	UD Al Jaliil can carry out periodic sanitation by cleaning the work environment. Sanitation that can be done is ensuring that the water used is clean, cleaning the factory floor, cleaning dirty milling machines, cleaning the holding tanks/buckets, cleaning the boiling tanks, washing the cloth used for filtering, cleaning the tofu molds, etc.

V. Conclusion

a. Based on the results of quality control using the Six Sigma method at UD Al Jaliil, it can be concluded that of the four variables studied, namely smell, taste, color and texture, it is known that the type of defect that most influences the quality of white tofu at UD Al Jaliil is tofu texture. The process at UD Al Jaliil is also not fully under control. This can be seen through the DMAI stages and the results obtained are that at the Define stage, 4 CTQs (smell, taste, color & texture) are determined. In the Measure phase, a process stability calculation was carried out with the result that the smell & texture variables were out of control because it was found that the process was outside the control limits while the taste and color were controlled, the process capability calculation obtained the result that all variables had $Cp \leq 1$ (low capability), Sigma level of 2 .0064 Sigma. The Analyze phase determines the priority for repairing the highest defect, namely texture at 67.35% and determines the root cause of the problem. The Improve phase is determined by suggestions for improvement to address the root cause of the problem.
b. The DPMO value is 306,300 which means that in one million units/processes of white tofu products produced there will be a probability of product failure of 306,300 units/processes. The Sigma level is 2.0064 Sigma. This shows that the sigma level of 2.0064 from UD Al Jaliil is the average sigma level of the Indonesian industry.
c. Factors that cause white tofu products to have texture defects, namely the human factor include not having written SOPs, workers experiencing fatigue. The machine factor, namely the ballast, does not have a standard weight. Method factors include the addition of vinegar does not have a standard, the pressing time does not have a standard. Material factors include imported soybeans that are stored too long before production, lack of regular addition of vinegar. The environmental factor is the absence of periodic sanitation. So suggestions for improvement to address the root cause of the problem include making production process flow SOPs, implementing a shift work system, using ballast that has a standard weight of 30 kg or applying a hydraulic pressing system, determining the ideal addition of vinegar, which is as much as 2,184 ml or 2,184 L, determining the length of the process pressing for 15 minutes, changing imported soybeans to local soybeans by conducting partner relations with farmers, arranging schedules for adding vinegar periodically, and carrying out periodic sanitation by cleaning the work environment.

References

V. Gaspersz, Pedoman Implementasi Program Six Sigma Terintegrasi dengan ISO 9001:2000, MBNQA, dan HACCP. Jakarta: Jakarta: Gramedia Pustaka Utama, 2002.

Sarwono dan Y. P. Saragih, Membuat Aneka Tahu. Depok: Depok: Penebar Swadaya, 2001.

D. Dinas Perindustrian dan Perdagangan, Data Penyebaran Agroindustri Tahu. Kabupaten Jember, 2010.

H. Tannady, Pengendalian Kualitas, Cetakan 1. Yogyakarta: Yogyakarta: Graha Ilmu, 2015.

A. Syukron dan M. Kholil, Six Sigma Quality for Business Improvement, Cetakan 1. Yogyakarta: Yogyakarta: Graha Ilmu, 2013.

H. C. Wahyuni, W. Sulistiyowati, dan M. Khamim, Pengendalian Kualitas: Aplikasi pada Industri Jasa dan Manufaktur dengan Lean, Six Sigma dan Servqual. Yogyakarta:

Graha Ilmu, 2015.
I. Irwan dan D. Haryono, Pengendalian Kualitas Statistik (Pendekatan Teoritis dan Aplikatif). Bandung: Bandung: Alfabeta, 2015.
B. Badan Standardisasi Nasional, “Standar Nasional Indonesia tentang Tahu,” Sni 01-3142-1998, hal. 1, 1998.
D. N. Midayanto dan S. S. Yuwono, “Penentuan Atribut Mutu Tekstur Tahu untuk Direkomendasikan sebagai Syarat Tambahan dalam Standar Nasional Indonesia,” Pangan dan Agroindustri, vol. 2, no. 4, hal. 259–267, 2014.
D. I. Bunta, A. S. Naiu, dan N. S. Yusuf, “Pengaruh Penambahan Tepung Tulang Ikan Tuna terhadap Karakteristik Hedonik Kue Bagea Khas Gorontalo,” J. Ilm. Perikan. dan Kelaut., vol. 1, no. 2, hal. 81–88, 2013, [Daring]. Tersedia pada: http://ejurnal.ung.ac.id/index.php/nike/article/viewFile/1225/974
P. Nugroho, B. Dwiloka, dan H. Rizqiati, “Rendemen, Nilai pH, Tekstur, dan Aktivitas Antioksidan Keju Segar dengan Bahan Pengasam Ekstrak Bunga Rosella Ungu (Hibiscus sabdariffa L.),” J. Teknol. Pangan, vol. 2, no. 1, hal. 33–39, 2018.
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