

Quality Control Analysis on White Crystal Sugar Products Using Statistical Processing Control and Seventools Methods at PT. XYZ

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ABSTRACT

Objective: PT. XYZ is a manufacturing company that produces white crystalline sugar, which is a natural sweetener from sugarcane raw materials used as raw materials for households and the food industry. At PT. XYZ has a problem, namely the number of defects exceeds the standard in the company, namely in June amounted to 52,702 (Ku), July 64,282 (Ku), August 69,741 (Ku), while the number of defects in June amounted to 304.5 (Ku), July amounted to 357.5 (Ku), and August amounted to 39 (Ku) with a defect percentage in 3 months of 0.6%. **Method:** From these data, it shows that these conditions exceed the established standard (Zero Defect) and improvement must be carried out. The solution to this problem uses the methods of Statistical Processing Control and Seven Tools. **Result:** The results of the data calculation are the highest defects in refined sugar by 51%, gravel sugar by 40%, and sapon sugar by 9%, this is due to the production process not being maximized because of the lack of supervision by superiors during the production process. **Novelty:** This study provides an applied approach in identifying and analyzing production defects using Statistical Processing Control and Seven Tools to support quality improvement and minimize product defects, offering a practical contribution to continuous improvement in the sugar manufacturing industry.

INTRODUCTION

All companies have an obligation to pay attention to the quality of the products they produce. This is certainly beneficial for the company [1]. Quality is a way of satisfying customers by meeting their needs and desires [2]. The importance of quality is prioritized for business continuity, including improving product quality, price, and service time in order to increase the company's competitiveness [3].

Quality control is an activity to improve product quality so that it meets the standards set by the company [4]. Quality control is the process of identifying whether the products manufactured meet the standards set by the company [5]. The purpose of quality control is to increase sales and reduce costs incurred due to poor quality [6].

PT. XYZ is a manufacturing company that produces sugar in the form of White Crystal Sugar (GKP), which is a natural sweetener from sugar cane raw materials for use as raw materials for households and the food industry [7]. Quality control is prioritized to ensure that the products produced are in accordance with the MBS (Sweet, Clean, Fresh) slogan. The sugarcane milling capacity in 2023 will reach up to 3000 Ton Cane Day (TCD). Sugar is supplied from sugarcane originating from areas such as Malang, Tuban, Gresik, Mojokerto, Pasuruan, and Sidoarjo [8]. The People's Sugar Cane Partnership (TRK) is a program that provides farmers with easy access to credit, while the Independent People's Sugar Cane (TRM) is a program for companies and farmers

without easy access to credit. It is hoped that through this program, progress in agriculture can become a program that enriches farmers [9].

Continuous production activities have a negative impact, namely a large amount of sugar defects caused by machine errors, human fatigue, and temperature factors that affect the results and raw materials [10]. Based on observations, PT. XYZ refers to the Government's SNI by setting a zero defect rate. Production data from the company in 2023 for White Crystal Sugar (GKP) products in June was 52,702 (Ku), July 64,282 (Ku), August 69,741 (Ku), while the number of defects in June was 304.5 (Ku), in July it was 357.5 (Ku), and in August it was 390 (Ku) with a defect percentage in 3 months of 0.6%. These data show that the condition exceeds the established standard of Zero Defect and improvements must be made to reduce the number of defects in White Crystal Sugar. If product defects are not controlled, product quality will decline, incurring additional costs for reproduction and decreasing consumer confidence, which will ultimately reduce company revenue [11].

Based on these issues, this research began with field studies, problem formulation, problem limitations, and research objectives. Data was then collected by interviewing employees. The data collected included company profiles, production data, and production defects. Once the data was collected, it was processed using Statistical Process Control (SPC) and the Seven Tools method. These methods were used because they are related to quality control and recommend appropriate improvements to reduce product defects [3].

This study differs from previous studies in that it combines two methods, namely statistical process control (SPC) to find the causes of product defects and Seventools, a quality tool used to help companies solve problems and improve quality.

Research Objectives: (1). To identify the factors causing defects in sugar at PT. XYZ. (2). To provide recommendations for improvements to increase sugar product productivity.

Statistical Processing Control (SPC)

Statistical Processing Control is the application of statistical methods to control various processes used to ensure that processes meet standards [12]. Statistical Processing Control is a method used to ensure that the production process complies with the quality standards set by the company. The purpose of Statistical Processing Control is to monitor the process in order to produce products and achieve a controlled process [13]. Research by Susetyo [4] This study discusses quality control in sugar using the statistical processing control (SPC) method to determine the causes of product defects in white crystal sugar, which is used to maintain and improve product quality in accordance with company standards.

Seventools

Seventools is a method for overcoming production failures and reducing product defects [14]. Seventools is a method for solving problems that is useful for improving the production process. The objectives of Seventools are to identify problems, minimize problems, analyze the causes of defects, and make improvements to defective products

[15]. Permono's research [16] This study discusses the application of the Seventools method for controlling sugar product quality, where the researcher's objective is to determine the number of defects, identify the factors causing defects, and determine improvement proposals to maintain and improve product quality.

RESEARCH METHOD

A. Time and Place

The time and place of this research was from May to October 2023 at PT. PG Candi Baru – Sidoarjo, a sugar processing facility in Sidoarjo Regency. Located at Jl. Raya Candi No.10, Candi Jaya, Candi, Kec. Sidoarjo, Sidoarjo Regency, East Java 61271.

B. Data Collection

The stages of primary and secondary data collection are as follows:

Primary Data: At this stage, data collection was carried out for 1 month on the company description, production volume, and number of sugar defects at the company, which would later be used for research.

Interviews: Interviews were conducted to gather information through questions and discussions with various Quality Assurance Supervisors at the company. In this case, information could be obtained directly from field supervisors for analysis to determine the causes of defects and reduce their number.

Secondary Data: Secondary data is collected by searching for information related to the research topic. The materials used were books and journals about White Crystal Sugar, Statistical Process Control (SPC) Methods, and Seventools that had been researched previously.

C. Research Flow

The research flow diagram shows the stages of the research to be conducted. The following is an explanation of the research flow diagram, which can be seen in Figure 1:

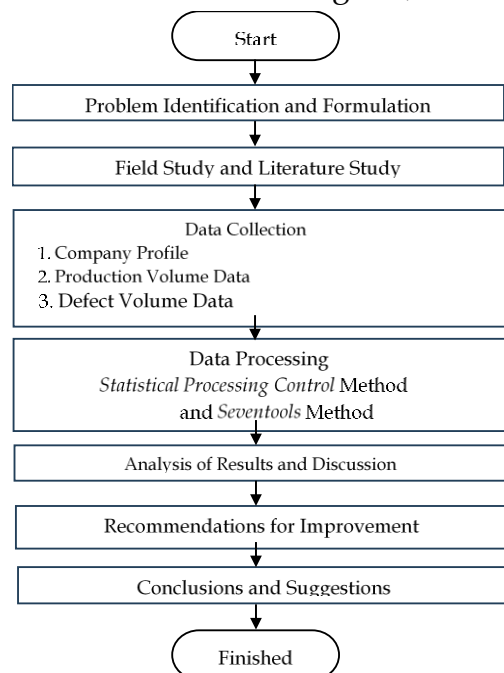


Figure 1. Research Flow Chart.

Research Steps:**A. Statistical Processing Control (SPC)**

Statistical Processing Control is the application of statistical methods to control various processes used to ensure that processes meet standards [12], where this method involves calculations such as the formula below:

1. Calculating the *Percentage of Defects*

$$P = \frac{np}{n} \dots\dots\dots(1)$$

Source: [4]

Explanation:

np = Number of *Defective* Products

n = Number of Production

2. Determining the *Center Line*

$$CL = \frac{\sum np}{\sum n} \dots\dots\dots(2)$$

Source: [4]

Explanation:

$\sum np$ = Number of *Defective* Products

$\sum n$ = Number of Production

3. Determining the Upper Control Limit

$$UCL = \bar{p} + 3 \left(\frac{\sqrt{\bar{p}(1-\bar{p})}}{n} \right) \dots\dots\dots(3)$$

Source: [4]

Explanation:

$\bar{p}$ = Average Number of *Defects*

n = Number of Production

4. Determining the Lower Control Limit

$$LCL = \bar{p} - 3 \left(\frac{\sqrt{\bar{p}(1-\bar{p})}}{n} \right) \dots\dots\dots(4)$$

Source: [4]

Explanation:

$\bar{p}$ = Average Number of *Defects*

n = Number of Production

B. Seventools

Seventools are used to identify problems, minimize problems, analyze the causes of defects, and make improvements to defective products [15]. There are 7 tools to solve problems using this method, and the 7 tools are explained as follows:

1. Check Sheet

A check sheet is a collection of data on the production process that can be obtained from the company.

2. Control Chart

Control Charts are a control process that will be widely used to quickly investigate causes to find the cause and effect.

3. Histogram

A Histogram is a method for displaying graphical data with a certain range of values.

4. Pareto Diagram

A Pareto Diagram is a method for determining the highest to lowest number of defects in the production process at a company.

5. Scatter Diagram

A Scatter Diagram is a method used to see the relationship between two variables.

6. Cause-and-Effect Diagram (Fishbone Diagram)

A Cause-and-Effect Diagram is a method used to identify the factors that cause high product defects.

7. Stratification

Stratification is a method used to classify problems into smaller groups or categories [17].

RESULTS AND DISCUSSION

Results

A. Seventools Method

Check Sheet

The following data is the defective product data for White Crystal Sugar for 3 months from June 2023 to August 2023. The data includes the production quantity and defect quantity based on the direct results from PT. XYZ during the research period. The research data is as follows.

Table 1. Production Volume and Defect Volume Data.

No	Month	Production Volume	Defect Type			Total Defects
			Fine Sugar	Granulated Sugar	Sapon Sugar	
1	June	52.702	180	121,5	29	330,5
2	July	64.282	175	141,5	31	347,5
3	August	69.741	181	157	32	370
	Total	186.725	536	420	92	1048

Source: Internal Data PG. Candi Baru

As can be seen in the Production Volume and Defect Volume data above, June had a defect volume of 330.5 quintals, July had a defect volume of 347.5 quintals, and August had a defect volume of 370 quintals. It can therefore be concluded that August had the highest defect volume compared to the other months. The reason for the highest number of defects in August was because the machine was overloaded with raw materials, causing the machine to wear out easily and resulting in a large production volume. This is because the production volume and the number of defects are interrelated.

Histogram

A histogram is a tool similar to a bar chart that aims to show frequency distribution. The following table shows the data obtained from the types and percentages of defects in White Crystal Sugar products.

Table 2. Types of Defects in White Crystal Sugar.

Month	Type of defect		
	Fine sugar (Ku)	Grainy sugar (Ku)	Sapon sugar(Ku)
June	180	121,5	29
July	175	141,5	31
August	181	157	32
Total	536	420	92

As seen in the histogram, the total number of defects in fine sugar over a 3-month period was 540 quintals. Grainy sugar had a total of 420 quintals, and sapon sugar had a total of 92 quintals. After determining the number of defects, a histogram diagram can be created based on the type of defect. This can be seen in the following graph.

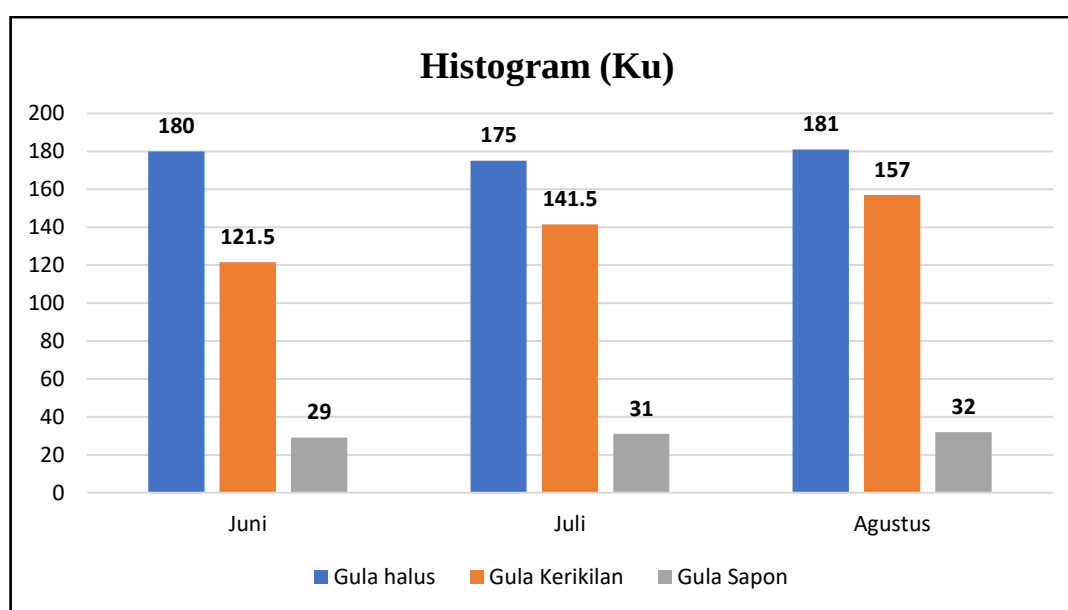


Figure 2. Histogram of the Percentage of Defects in White Crystal Sugar from June to August 2023.

The histogram above shows that the number of defects in fine sugar from June to August was 540 quintals, the number of defects in gravel sugar from June to August was 420 quintals, and the number of defects in sapon sugar from June to August was 92 quintals. Defects in fine sugar are caused by excessive cooking time, which causes the sugar to clump together. Gravel sugar defects are caused by temperature instability during the crystallization process, which forms gravel sugar. Sapon sugar is caused by good sugar production that is scattered and mixed with impurities such as dust, etc., making the sugar unfit for consumption.

Pareto Diagram

The Pareto Diagram aims to identify the most dominant defects in White Crystal Sugar products at PT. PG Candi Baru. The data obtained on the types and percentages of defects can be seen in the following table:

Table 3. Pareto Diagram of Quality Control Priorities.

No	Defect Type	Number of Defects (Ku)	Presentas e	Kumulatif	Prioritas
1	Fine Sugar	536	51%	51%	1
2	Gravel Sugar	420	40%	91%	2
3	Sapon Sugar	92	9%	100%	3
	Total	1048	100%		

From the table above, it can be seen that the type of defect in Fine Sugar products has a percentage of 51%, Granulated Sugar has 40%, and Sapon Sugar has 9%. So it can be concluded that Fine Sugar should be prioritized for improvement, followed by Granulated Sugar and Sapon Sugar. After obtaining the percentage values, a percentage graph was created to make it easier to understand.

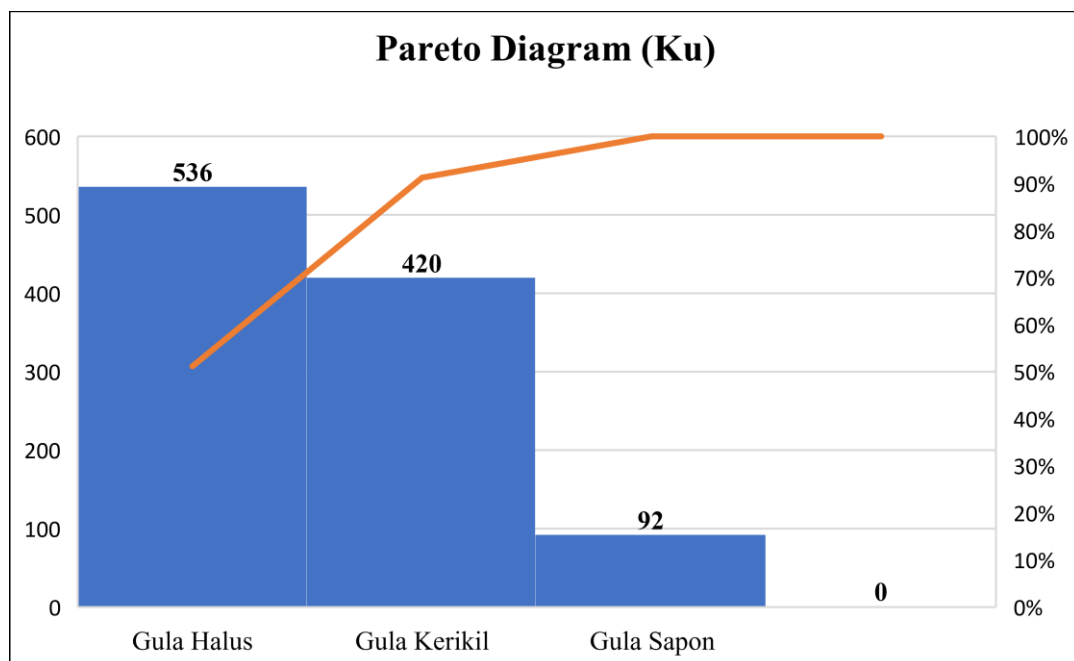


Figure 3. Defect percentage graph on a Pareto diagram.

The defect percentage graph on the Pareto diagram above shows that the percentage of defects in Fine Sugar is 540 quintals, Granulated Sugar is 420 quintals, and Sapon Sugar is 92 quintals. The cause of the large number of defects in Fine Sugar is due to

Scatter Diagram

A Scatter Diagram is used to show the correlation or relationship between one factor and another characteristic. The Scatter Diagram data can be seen in the following table.

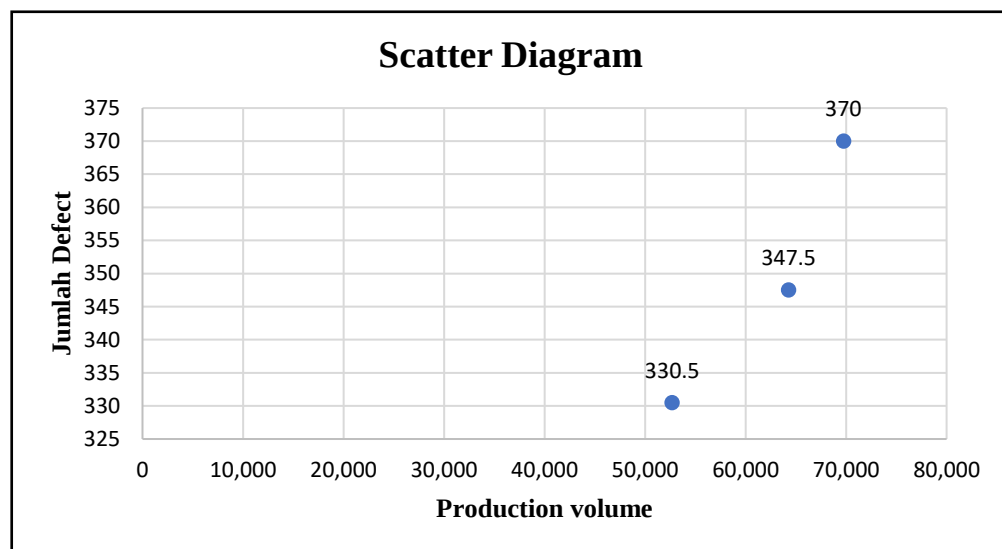
Table 4. Scatter Diagram of the Relationship between Production Volume and Defects.

Month	Production Volume	Defects
June	52.702	330,5
July	64.282	347,5
August	69.741	370

Source: Internal Data from PG. Candi Baru

From the data for the three months, it can be seen that August had the highest number of defects, namely 370.5, followed by July with the second highest number, namely 347.5, and finally June with the lowest number of defects, namely 330.5. This is because the production volume at the beginning of the month was low, resulting in a low number of defects at the beginning of the month, while the production volume at the end of the month was high, resulting in a high number of defects. The reason August had the highest number of defects is because the production volume was also high, as production volume and defect count are interrelated.

From the following table, a Scatter Diagram can be created. This can be seen in the following image.

**Figure 4.** Scatter Diagram of the number of defects (Scatter Diagram).

The Scatter Diagram above shows a strong positive correlation, meaning that there is a relationship between (Production Volume) X and (Number of Defects) Y. Higher production volumes will result in a higher number of defects in white crystal sugar.

B. Statistical Process Control

Control Chart

On the P Control Chart, the proportion of white crystal sugar will be calculated to determine whether the product defects are still within the control limits required by the company.

Table 5. Production Volume and Product Defect Proportion (Quintals).

Month	June	July	August
Production Volume	52.702 (Ku)	64.282(Ku)	69.741(Ku)
Number of Defects	330,5 (Ku)	347,5(Ku)	370(Ku)
Defect Percentage	0,6%	0,6%	0,6%

1. P Control Chart (P Chart)

$$\text{Mei} = \frac{330,5}{52,702} = 0,0062$$

$$\text{Juni} = \frac{347,5}{64,282} = 0,0054$$

$$\text{Juli} = \frac{370}{69,741} = 0,0053$$

2. Determining the Center Line

$$\frac{1048}{186.725} = 0,0056$$

3. Determining the Upper Control Limit (UCL)

$$\begin{aligned} \text{UCL} &= \bar{p} + 3 \left(\frac{\sqrt{\bar{p}(1-\bar{p})}}{n} \right) \\ &= 0,0056 + 3 \left(\frac{\sqrt{0,0056(1-0,0056)}}{186.725} \right) \\ &= 0,0056 + 3 \left(\frac{\sqrt{0,0056(0,9944)}}{186.725} \right) \\ &= 0,0056 + 3 \sqrt{\frac{0,0055}{186.725}} \\ &= 0,0056 + 3 \sqrt{0,00000003} \\ &= 0,0056 + 3 (0,00018) \\ &= 0,0056 + 0,006 \\ &= 0,0062 \end{aligned}$$

4. Determining the Lower Control Limit (LCL)

$$\begin{aligned} \text{LCL} &= \bar{p} - 3 \left(\frac{\sqrt{\bar{p}(1-\bar{p})}}{n} \right) \\ &= 0,0056 - 3 \left(\frac{\sqrt{0,0056(1-0,0056)}}{186.725} \right) \\ &= 0,0056 - 3 \left(\frac{\sqrt{0,0056(0,9944)}}{186.725} \right) \\ &= 0,0056 - 3 \sqrt{\frac{0,0055}{186.725}} \\ &= 0,0056 - 3 \sqrt{0,00000003} \\ &= 0,0056 - 3 (0,00018) \\ &= 0,0056 - 0,006 \\ &= 0,0050 \end{aligned}$$

Table 6. Proportion of White Crystal Sugar Products.

Month	Production Volume	Fine Sugar	Defect Type Granulated Sugar	Sapon Sugar	Defect Volume	Proportion	CL	UCL	LCL
June	52702	184	121,5	29	334,5	0,0063	0,0056	0,0062	0,0050
July	64.282	175	141,5	31	347,5	0,0054	0,0056	0,0062	0,0050
August	69.741	181	157	32	370	0,0053	0,0056	0,0062	0,0050
Total	186725	540	420	92	1048	0,0056	0,0056	0,0062	0,0050

Source: PG Internal Data. Candi Baru

The table above shows that the Center Line (CL) has a value of 0.0056, the Upper Control Line (UCL) has a value of 0.0062, and the Lower Control Line (LCL) has a value of 0.0050. After obtaining the values for the Center Line (CL), Upper Control Limit (UCL), and Lower Control Limit (LCL), a control chart was created using Excel calculations as follows.

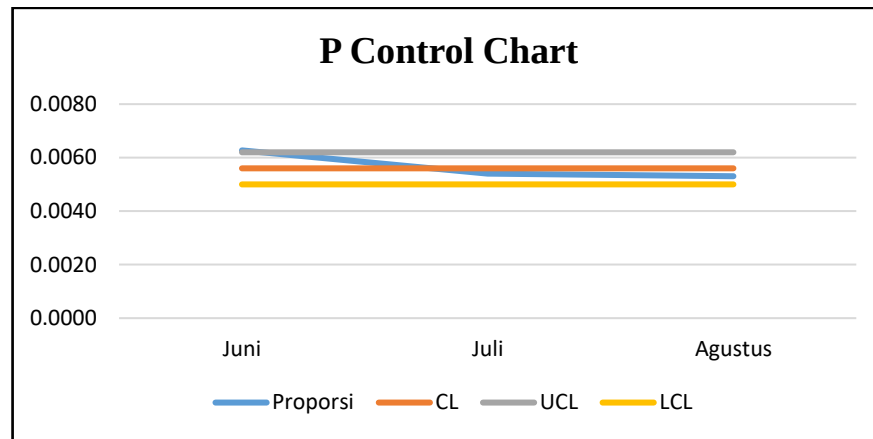


Figure 5. P Control Chart.

From the results of the p control chart analysis above, the calculations using Excel show that there are 10 points outside the control limits and 80 points within the control limits. Therefore, it can be concluded that the production process for White Crystal Sugar is fairly well controlled, but it still needs to be improved so that the points outside the control limits do not increase.

Table 7. After Improvement.

Month	Production Volume	Fine Sugar	Defect Type Granulated Sugar	Sapon Sugar	Defect Volume	Proportion	CL	UCL	LCL
June	52.702	155	121,5	29	305,5	0,0058	0,0056	0,0062	0,0050
July	64.282	175	141,5	31	347,5	0,0054	0,0056	0,0062	0,0050
August	69.741	181	157	32	370	0,0053	0,0056	0,0062	0,0050
Total	186.725	511	420	92	1023	0,0056	0,0056	0,0062	0,0050

Source: PG Internal Data. Candi Baru

After making adjustments and obtaining new Center Line (CL), Upper Control Limit (UCL), and Lower Control Limit (LCL) values, a control chart was created using Excel calculations as follows:

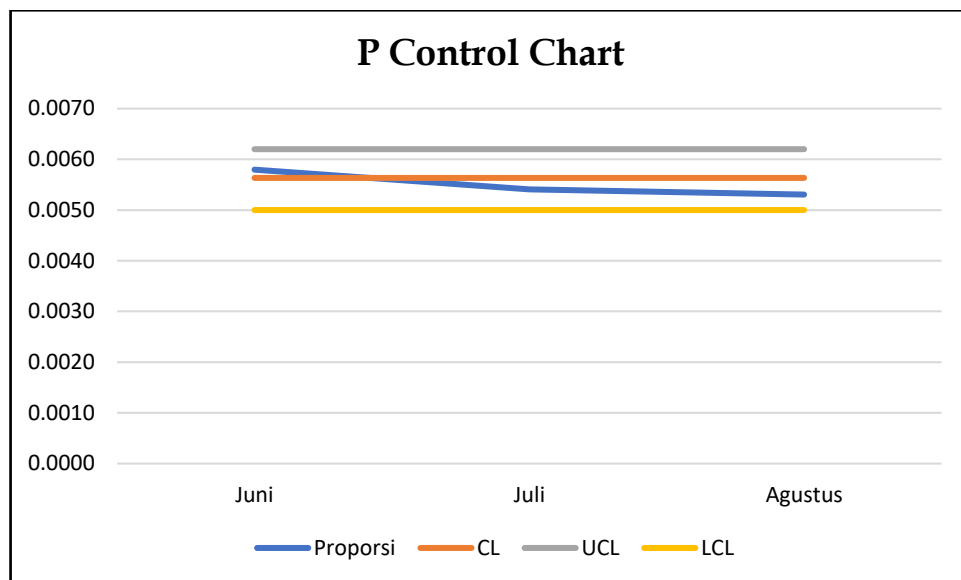


Figure 6. P Control Chart After Improvement.

The data in the graph above shows that the values on the P control chart are now all within control limits. None of the values exceed the control limits.

Fishbone Diagram

A Fishbone Diagram (Cause and Effect) or Fishbone Diagram is a diagram used to analyze the factors causing product defects. The factors causing defects in White Crystal Sugar products are as follows. These cause-and-effect factors will be explained in the Fishbone Diagram. The following are the results of the fishbone diagram.

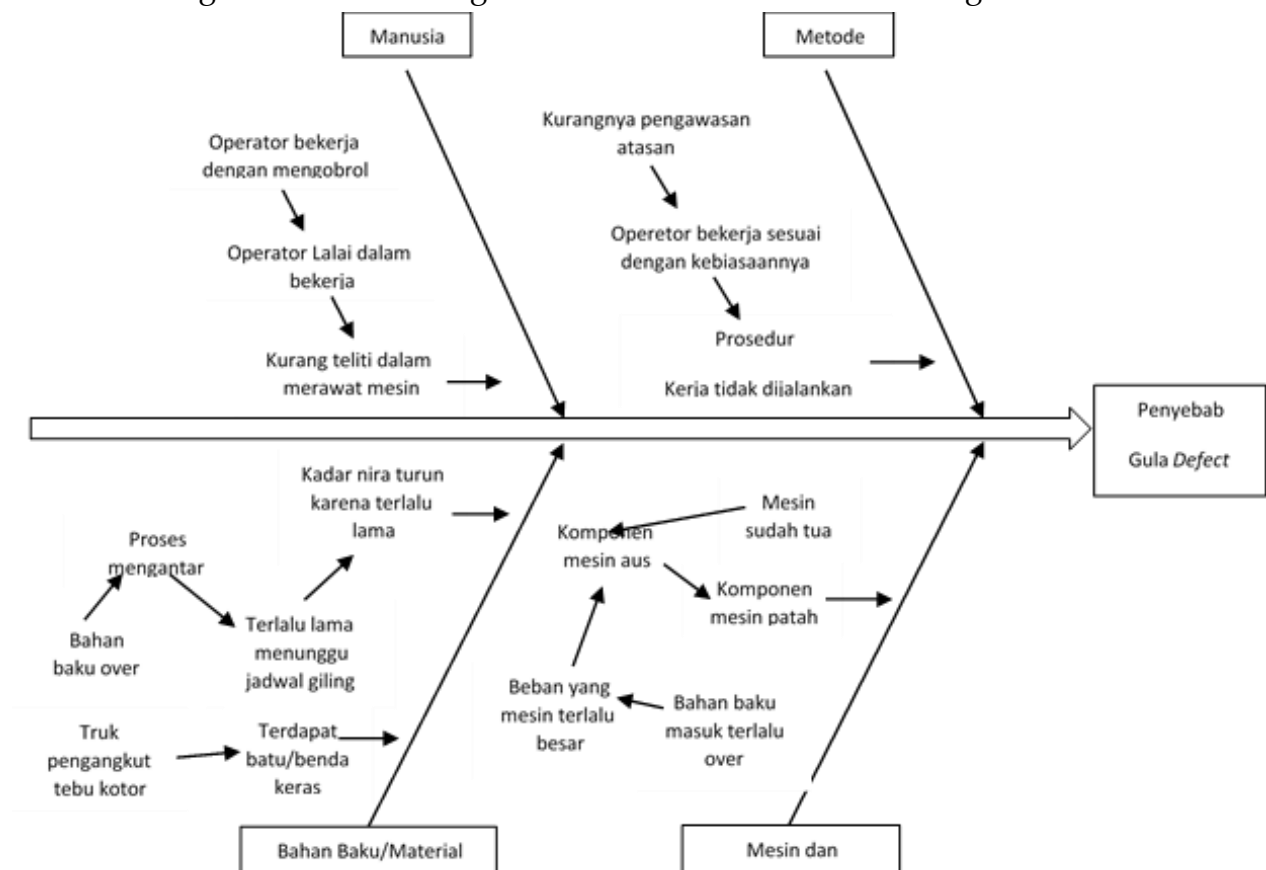


Figure 7. Fishbone Diagram of the causes of sugar defects.

The fishbone diagram shows that the causes of sugar defects consist of human negligence at work, methods that are not properly implemented by operators because they work according to their habits, poor quality materials, and old and damaged machines that need to be repaired.

Stratification

Stratification is Quality Management, which is the division and grouping of data into smaller categories with similar characteristics. The following is a stratification data table.

Table 8. Stratification.

No	Type of Defect	Number of Defects	Percentage	Priority
1	Fine Sugar	536	51%	1
2	Granulated Sugar	420	40%	2
3	Sapon Sugar	92	9%	3
	Total	1048	100%	

The stratification table above shows that fine sugar has a defect percentage of 51%, granulated sugar has a defect percentage of 40%, and sapon sugar has a defect percentage of 9%. Therefore, it can be concluded that fine sugar should be prioritized for improvement, followed by granulated sugar and sapon sugar. After obtaining the percentage values, a percentage graph was created to make it easier to understand.

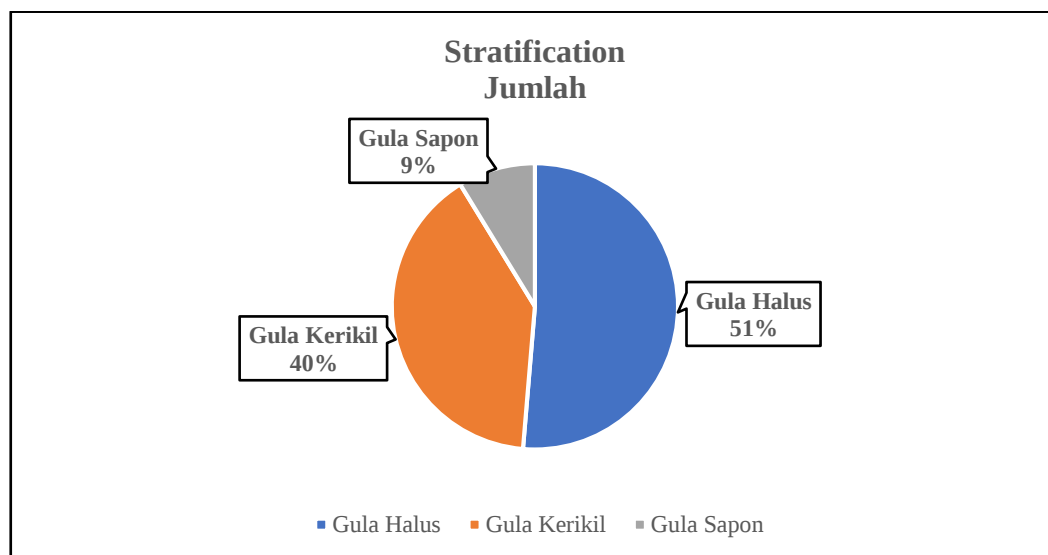


Figure 8. Pie Chart of Defect Percentage Stratification.

From the chart above, it can be seen that the defect percentage for sugar is 51% for fine sugar, 40% for granulated sugar, and 9% for sapon sugar. From this data, it can be concluded that fine sugar has the highest number of defects and must be improved.

Improvement Proposals using the 5W – 1H method**Table 9.** Improvement Proposals using the 5W – 1H method.

No	Factor	What	Why	Where	When	Who	How
1	People	Operators chatting, operators being careless, operators lacking attention to detail	Low skills and motivation due to lack of training	May – September 2023	Production Process Department	Production Team	Tighten supervision and provide training to the production team to improve workers' skills. Establish strict company SOPs for the sugar production process to ensure work is carried out according to procedure. Collaborate with smart farmers to improve sugarcane quality, Conduct sorting of incoming or delivered sugarcane. Conducting regular maintenance, Increased supervision from superiors to the production team.[18]
2	Method	Procedures not followed by operators	Operators are negligent and work according to habit	May – September 2023	Production Process Section	Production Team	
3.	Material	Declining material quality	Declining sugar content in sugarcane	May – September 2023	Production Process Section	Production Team	
4.	Machinery/ Equipment	Machine components are worn out,,	Lack of machine maintenance, workers are negligent in carrying out work procedures	May – September 2023	Production Process Section	Production Team	

Discussion

Based on data from June – August 2023, PT. XYZ experienced a defect rate exceeding the company standard of 0.6% of the Zero Defect company standard, The following data processing results using the Statistical Processing Control (SPC) and Seventools methods obtained values on the Pareto Diagram, namely Fine Sugar at 51%, Granulated Sugar at 40%, and Sapon Sugar at 9%. On the Scetter Diagram, there is a strong positive relationship (Positive Correlation), which means that there is a relationship between (Production Quantity) X and (Number of Defects) Y, the higher the

production volume, the greater the impact on the number of defects in White Crystal Sugar. The Control Chart shows 10 points outside the control limits and 80 points within the control limits, requiring improvement. In the statistical processing control and seventools methods, there are factors that cause product defects due to human error because the operator is not careful because the operator is chatting, causing errors during the production process. The method is due to the work procedures not being carried out by workers due to a lack of supervision by superiors. material, because the sugar content in the cane decreased due to the long delivery process and long waiting time for grinding due to excess raw materials, machine, because machine components broke due to the machine being old and worn out, so repairs must be carried out. Improvements were proposed using the 5W-1H method, namely that supervisors must tighten supervision and provide training to the production team so that workers' skills improve, and methods must establish strict company SOPs for the sugar production process so that work can be carried out according to procedure. Materials must collaborate with smart farmers to improve sugarcane quality, conduct sorting of incoming or delivered sugarcane, and machines must undergo regular maintenance with increased supervision from management to the production team.

CONCLUSION

Fundamental Finding : Calculations using the Statistical Processing Control (SPC) method on White Crystal Sugar products obtained a CL value of 0.0056, a UCL of 0.0062, and an LCL of 0.0050, as can be seen in the Control Chart diagram for white crystal sugar products in June, which exceeded the control limits and therefore required improvement. Meanwhile, calculations using the Seventools method for White Crystal Sugar can be seen in the Pareto chart, which shows the number of defects in fine sugar at 540 quintals, granulated sugar at 420 quintals, and sapon sugar at 92 quintals. Therefore, the high number of defects in fine sugar requires improvement. The improvement can be seen in the 5W-1H method. **Implication :** The purpose of this study is to reduce the number of defects to meet company standards and maintain good product quality, ensuring production consistency and minimizing waste. **Limitation :** This study only focuses on White Crystal Sugar products and the observation period from June to August, so the results may not fully represent variations in other production months or product types. **Future Research :** Future research should include a longer observation period and apply advanced quality improvement methods, such as Six Sigma or Lean Manufacturing, to evaluate process optimization and continuous improvement in the sugar production industry.

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the opportunity to conduct research at the company. The researcher hopes that this article will be useful for readers and serve as input and motivation for further education and research.

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