IMPROVING THE QUALITY OF THE CHOCOLATE PRODUCTION PROCESS AT WAHANA INTERFOOD NUSANTARA COMPANY USING DMAIC METHOD

BY

DOFFIKAR BATUTA

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Kulliyyah of Engineering
International Islamic University Malaysia

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ABSTRACT

A company that prioritises quality will have an advantage in the global market because not all companies can achieve and sustain high levels of quality. Wahana Interfood Nusantara Company is Indonesia's most complete cocoa bean processing company under the SCHOKO brand. The company processes raw cocoa beans to produce high-quality chocolate and cocoa products. One of the products that experienced defects at Wahana Interfood Nusantara Company was the white couverture chocolate product. The problem statement of this study was what types of defects contribute to the poor quality of white couverture chocolate and what factors contribute to the defects. The aim and objectives of this study were to identify and analyse the current quality state of the production process of Product White Couverture chocolate at Wahana Interfood Nusantara company, Analyse the data collected during the production process of Product White Couverture chocolate to come up with root causes and identify the optimum solution, and Identify improvements made because of proposed solutions. This study uses the DMAIC method (Define, Measure, Analyze, Improve, and Control). They obtained 5 Critical to Quality chocolate attributes: broken, cracked, peeled-off, soft, and porous. Regarding the p-chart control calculation, the CL, UCL, and LCL values were 0.024, 0.026, and 0.022. It means the data result is in control. The DPMO value was 4788.49, and the Sigma value was 2.496, which means that the white couverture chocolate production process is in Indonesia's average Sigma value industry. It was found that 80% of the most dominant defects were peeled off (38.5%), cracked (28.7%), and broken (25.3%). The identified factors include workers or employees (people), tools (equipment), the environment (environment), and methods (methods). Suggestions for improvements are given to maintain regular machine maintenance, conduct employee training, and carry out SOPs correctly.

خلاصة البحث

سَتَتَمَتَّعُ الشَّرِكة التي تعطي الأولوية للجودة بميزة في السوق العالمية لأنه ليس لجميع الشركات قدرة لتحقيق مستويات عالية من الجودة والحفاظ عليها. شركة Wahana Interfood Nusantara هي شركة معالجة حبوب الكوكوا (cocoa) الأكثر اكتمالاً في إندونيسيا تحت العلامة التجارية (SCHOKO). تقوم الشركة بمعالجة حبوب الكوكوا الخام لإنتاج الشوكولاتة (chocolate) ومنتجات الكوكوا في الجودة العالية. كان أحد المنتجات التي عانت من عيب في شركة Wahana Interfood Nusantara هو منتجات الشوكولاتة البيضاء (white couverture chocolate) بيان المشكلة في هذه الدراسة هو ما هي أنواع العيوب التي تساهم في رداءة جودة الشوكولاتة البيضاء والعوامل التي تساهم في العيوب. كان الهدف من هذه الدراسة هو تحديد وتحليل حالة الجودة الحالية لعملية إنتاج الشوكولاتة البيضاء في شركة Wahana Interfood Nusantara، وتحليل البيانات التي تم جمعها أثناء عملية إنتاج Product White Couverture Chocolateللتوصل إلى الأسباب الجذرية وتحديد الحل الأمثل، وتحديد التحسينات التي تم إجراؤها كنتيجة للحلول المقترحة. تستخدم هذه الدراسة طريقة DMAIC (التحديد والقياس والتحليل والتحسين والتحكم). لقد حصلوا على 5 نقط حرجة بالنسبة للجودة: مكسورة، متصدعة، مقشرة، ناعمة، ومسامية. هذا يعني أن نتيجة البيانات كانت تحت CL, UC, LCL وكانت قيمة سيجما 0.024,0.026 و 0.022 ، مما يعني أن عملية إنتاج السيطرة. تبلغ قيمة (DPMO) 4788.49، ومتوسط قيمة سيجما (sigma) هي 2.496، مما يعني أن عملية إنتاج الشوكولاتة البيضاء تكون في متوسط صناعة قيمة سيجما في إندونيسيا. وجد أن 80% من العيوب الأكثر انتشاراً كانت مقشرة (38.5%)، متشققة (28.7%)، ومكسورة (25.3%). تشمل العوامل المحددة العمل أو الموظفين(الأشخاص) والأدوات (المدات) والبيئة والطرق. يتم تقديم اقتراحات التحسينات لإجراء صيانة دورية للماكينة، وإجراء تدريب للموظفين، وتنفيذ إجراءات التشغيل الموحدة (SOP) بشكل صحيح.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Manufacturing.

....
Mohamed Abd. Rahman
Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science in Manufacturing.

....
Mohd Radzi Haji Che Daud
Internal Examiner 1

....
Yang Chuan Choong
Internal Examiner 2

This dissertation was submitted to the Department of Material and Manufacturing Engineering (MME) and is accepted as a fulfillment of the requirement for the degree of Master of Science in Manufacturing.

....
Ahmad Zahirani Bin Ahmad Azhar
Head, Department of Manufacturing and Materials Engineering (MME)

This dissertation was submitted to the Kulliyyah of Engineering and is accepted as a fulfilment of the requirement for the degree of Master of Science in Manufacturing.

....
Sany Izan Ihsan
Dean, Kulliyyah of Engineering

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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LIST OF SYMBOLS

σ	Sigma

LIST OF ABBREVIATIONS

DMAIC	Define, Measure, Analyse, Improve, Control
CTQ	Critical-to-Quality
DPMO	Defects per Million Opportunities
DPO	Defects per Opportunities
DPU	Defects per Unit
CL	Center Line
UCL	Upper Control Limit
LCL	Lower Control Limit
SIPOC	Supplier, Input, Process, Output, Customers

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

In this century, consumers, as product users, are becoming more critical and pickier in their product selection due to technological and economic advances in the global market. Competition in the industrial sector and client satisfaction necessitate constant innovation by companies. The quality of a product is just as important to consumers as the quantity. Product quality is a benchmark for assessing the maturity of the manufacturing industry in producing quality products. Consumers will judge a good company if it has covered three aspects of the production process, which include zero defects (no defects), zero breakdowns (no failed processes), and zero accidents (no accidents). However, these three aspects are very difficult to achieve if the control of the production process is not implemented properly (Bakti & Kartika, 2020). The company that prioritizes quality will have an advantage in the global market because not all companies can achieve and sustain high levels of quality. In addition, manufacturing, product development, and service are under intense pressure to become more efficient, effective, and productive. Based on various success stories from other organisations found in the literature, they began implementing the Six Sigma methodology to meet these stringent requirements, which proved to be a successful approach

Quality control aims to is to develop, design, produce and service a quality product that is most economical, most useful, and always satisfactory to the consumer (Ishikawa & ISHIKAWA, 1985). Product defects can have a detrimental impact on a company's bottom line by diminishing customer satisfaction and confidence in a product. Quality control can also be interpreted as an integrated effort within a company to maintain the quality of the goods produced to match the characteristics and specifications of the products produced (Bakti & Kartika, 2020). Moreover, Quality control is an effort to maintain the products' quality to comply with the specifications established based on company policy.

Technically, quality control aims to determine whether it is going according to plan, has been carried out efficiently, and is possible improvements (Nasution & Sodikin, 2018).

1.2 PROBLEM STATEMENT

Quality problems are common in production processes including in the chocolate production process. They also occur in Wahana Interfood Nusantara Company. A company's output is not meeting customer expectations because the white couverture chocolate on the body surface is not very good. It is difficult to achieve zero faults throughout the entire production process. Typically, this cause-and-effect study involves man, method, machines, material, and environment. Therefore, the best way to enhance the process is to minimise errors as much as feasible.

The research will uncover the answer to the following questions:

1. What types of defects contribute to the poor quality of white couverture chocolate in the moulding prosses?
2. What are the factors contributing to the defects?

1.3 AIM AND OBJECTIVES

The study aims to identify the effects of implementing the DMAIC methodology in improving the quality of the chocolate production process at Wahana Interfood Nusantara Company. To achieve the aim, the following objectives are set:

1. Identify and analyse the current quality state of the production process of Product White Couverture chocolate at Wahana Interfood Nusantara company.
2. Analyse the data collected during the production process of Product White Couverture chocolate to come up with root causes and identify the optimum solution.

3. Identify improvements made as a result of proposed solutions.

1.4 SCOPE AND LIMITATION

The study was held at the Wahana Interfood Nusantara Company, Bandung, Indonesia . The study was limited to only one product, the product is white couverture chocolate. The data for improvement purposes was taken from January 2022 until July 2022. The study was limited to investigating the causes of defects from moulding processes and the steps taken for quality improvement in the production area.

1.5 ORGANIZATION OF THE DISSERTATION

There are five chapters in the dissertation. The background of the study, the problem statement, the study aims and objectives, scope and organization of the dissertation are all included in the first chapter. The literature review is summarised in the second chapter. The research technique for DMAIC phases and process production is covered in the third chapter. The results and discussion of the research findings and analysis are presented in the fourth chapter. Finally, the fifth concludes the findings and recommends further research and improvement.

CHAPTER TWO

LITERATURE REVIEW

2.1 DEFINITION OF QUALITY

Quality is an essential aspect of the development of the company. Currently, most consumers have started to make quality the main parameter in determining a product or service choice. Moreover, quality is often a means of promotion that aims to increase or decrease the selling value of the company's products. Consumers cannot easily believe various advertisements on the internet, such as social media. On the other hand, consumers can easily believe in someone's testimony about an item's quality. Therefore, quality is currently one of the strategies used to win the competition among the many products on the market. Consumers no longer use price as a standard to buy goods but are more concerned with the durability of the goods they buy. Quality has different meanings; one of the definitions of quality is a product or service that has product characteristics according to the user's wishes and meets the specified requirements (Montgomery, 2020).

The definition of quality control is an effort to maintain the quality of the goods produced by the product specifications determined at the discretion of a company's management. Based on this definition, it can be inferred that quality assurance is a strategy and everyday activities/actions taken to achieve, sustain and increase the quality of goods or services to reach existing requirements and meet customer satisfaction(Assauri, 2016). Quality control is a planned technique and action taken to achieve, maintain and improve the quality of a product to conform to predetermined standards and meet customer satisfaction (Harahap et al., 2018). Moreover, quality control is an effort to maintain the quality of the products produced by the agreed product specifications based on company policy (Nasution & Sodikin, 2018).

2.2 DIMENSIONS OF QUALITY

The quality of a product can be described and evaluated in various ways using the dimensions of quality. The quality dimension has eight components: performance, reliability, durability, serviceability, aesthetics, features, Perceived quality, and compliance with standards. Below is an explanation of the eight components of the quality dimension as follows (Gaspersz, 2007a):

1. Performance is related to product evaluation to determine whether the product is by the specific function and how well the product performs.
2. Reliability is related to the probability of a product failing to perform its function.
3. Durability is related to a product's useful life or how long a product can last to be used.
4. Serviceability relates to how easily a product can be repaired.
5. Aesthetics is related to the beauty of a product that can provide interest by considering factors such as style, color, shape, alternative packaging, and other sensory features.
6. Features relate to the function of a product with more quality than the primary function.
7. Perceived quality is related to the reputation of a product and a company that makes products with the feelings of customers who use the product.
8. Conformance to standards relates to a product produced

Quality directly describes product characteristics such as performance, reliability, ease of use, and aesthetics. Quality can be defined as fitness for use, namely suitability for use. Quality can also be interpreted as quality being inversely proportional to variability. If a product's variability decreases, the product's quality increases. Product quality is a very important criterion for customers to choose a product. Quality is one of the important aspects of guaranteeing and maintaining customer satisfaction (customer satisfaction) for the products and services produced by a company. In addition, Quality has different meanings; one of the definitions of quality is a product or service that has product characteristics according to the user's wishes and meets the specified requirements (Montgomery, 2020). Quality improvement is carried out on the final product and in the work-in-progress process so that defects or errors can still be corrected (Rahman & Perdana, 2021).

2.3 QUALITY IMPROVEMENT USING SIX SIGMA

Six Sigma (σ) is a Greek alphabet that denotes the standard deviation of a process. Standard deviation measures the. Sigma is a statistical measurement unit describing the distribution of each process or procedure's average value (mean). The benchmark for Six Sigma is 3.4 defects per million opportunities. While Six Sigma's primary goal is to eliminate defects, it also emphasizes continuous improvement efforts that are expected to reduce the number of defective products to zero if they are carried out regularly (Zero defects) (Gaspersz, 2007a). Meanwhile, the concept of Six Sigma is often used as an advanced process of quality control. However, companies must be able to provide satisfaction to customers with good product quality to get more significant profits (Rahman & Perdana, 2021).

Six Sigma is a methodology that gives businesses the means to enhance the performance of their business processes. For Six Sigma, the fundamental unit of improvement is a process. A process may be a product or service that a corporation offers to external clients or an internal process, such as a billing or production process. The objective of process improvement in Six Sigma is to increase performance and decrease performance variation. This rise in performance and decrease in process variance will result in a drop in defects, an increase in earnings, improved staff morale, product quality, and ultimately company excellence (Yang & Basem, 2003). Organisations nowadays seek higher manufacturing quality and process capabilities to reach productivity goals such as long-term competitiveness, profit margins, and market share. Six Sigma is a business improvement method employed in various industries. Essentially, it is a technique for enhancing the quality of final products by decreasing defects, minimising variance, and increasing manufacturing capabilities. The goal of the Six Sigma approach is to reduce product defect rates to raise profit margins and improve the financial situation. It improves client retention and happiness while producing the best-in-class product from the best performance (Pyzdek, 2002). Six Sigma differs from other quality efforts in that it applies not only to product quality but also to all elements of business operation by optimising essential processes (Yang & Basem, 2003).

2.4 SIX SIGMA CONCEPT

Basically, customers will be satisfied if they receive something according to what they expect. Suppose the product (goods or service) is processed at a Six Sigma quality level. In that case, the company can expect 3.4 defects per million opportunities (DPMO) or expect that 99.999966 percent of what the customer expects will be in the product. Six Sigma can be used as a target measure of industrial system performance, about the quality of a production transaction between industry and customers. On the other hand, the lower the value obtained, the worse the industrial system's performance will be. The concept of the Sigma Level of quality describes the quality of a process. A high Sigma quality indicates a lesser likelihood of defective goods during the process, whereas a lower Sigma quality level indicates a larger likelihood of defective products. Therefore, Six Sigma can also be considered a strategy that allows companies to improve quality and profit. Six fundamental aspects need to be considered in applying the Six sigma concept (Gaspersz, 2007a), namely:

1. Identify the customers
2. Identify the product
3. Identify needs in producing products for your customers
4. Define the production process
5. Avoid mistakes in the production process and eliminate all existing waste
6. Continuously improve the process toward Six Sigma

2.5 THE DMAIC

The DMAIC is one of the Six Sigma methodologies used to make process improvements to products or ongoing processes. As a problem-solving method, this approach focuses on finding the fundamental causes of a problem, removing, or minimizing the reasons, and maintaining the changes over time (Sibanda & Ramanathan, 2020). DMAIC has five stages in the problem-solving process related to process improvement and product quality (Montgomery, 2020). The following is an explanation of the DMAIC phases:

2.5.1 Define Phase

According to (Montgomery (2020), the 'Define' phase is the stage where processes contribute to problems that ultimately affect product quality. Moreover, quality improvement is significant for the views of customers and companies. In Six Sigma, the voice of the customer (VOC) is the starting point for process improvement because customer satisfaction is one of the ultimate goals of the Six Sigma program.

2.5.2 Measure Phase

The 'Measure' phase is the measurement phase that aims to evaluate and understand the current state of the process. In the 'Measure' phase, data is collected regarding the quality, cost, and production time measures to develop process input variables and process output variables. Data collection can be done by taking from historical data, but historical data does not fully support this stage because there may be incomplete data. As a result, data collection can also be done through direct observation within a specified time (Montgomery, 2020). Some of the tools that can be used at the measuring stage are as follow:

1. Control Chart

   Control charts are grouped into two types of data, namely variable data and attribute data. The explanation of each data is as follows (Freeman et al., 2021):

   - Variable Data

   Variable data is quantitative data, where quality characteristics are measured using measurement. Examples of variable data are diameter, length, width, weight, volume, and product thickness.

   - Attribute Data

   Attribute data is qualitative data, where quality characteristics cannot be measured quantitatively. Examples of attribute data are broken, cracked, dirty, and perforated products.

2.5.3 Analyze Phase

The 'Analyze' phase aims to process the data that has been obtained in the 'Measure' phase. The data is processed to determine causal relationships and understand the various sources of variability. In the 'Analyze' phase, the potential causes of product defects, quality problems, timing, and production process inefficiency will be determined (Montgomery, 2020). Some of the tools that can be used at the analysis stage are as follows:

1) Pareto chart

A Pareto diagram is a tool that can be used to process data; this diagram can validate the root of the problem. The Pareto chart can also identify the most dominant or influential type of disability based on the largest to the minor frequency on the Pareto chart. Pareto diagrams are made based on the data obtained and the principle of the 80/20 rule, which means that 20% of the causes of problems produce 80% of the effects. This Pareto diagram is a starting point for brainstorming the root of the problem (Council Six Sigma, 2018).

2) Cause-and-Effect Diagram

Cause-and-Effect diagram is one of the tools in SPC that looks like a fishbone called fishbone diagram. Fishbone diagrams can be used to find the root cause of the problem that caused the failure. To find the root cause of the problem, brainstorming is carried out to find the reason. Several factors affect the production process, namely Man, Material, Machine, Measurement, Method, and environment (Freeman et al., 2021).

A professor named Kaoru Ishikawa is credited with the creation of fishbone diagram. A cause-and-effect diagram is a visual representation of the relationship between a problem and its possible causes. It is often used in conjunction with the brainstorming activity because it is an effective tool for systematically generating ideas about the causes of problems and presenting these in a structured form. In addition to aiding in discovering root causes and pointing out potential sources of variation, this diagram also provides an organized and simple-to-understand format that promotes group participation while also pointing out potential sources of data collection (Gaspersz, 2007a).

2.5.4 Improve Phase

The 'Improve' phase is the stage that is carried out after the analyze phase is complete, where at this improve phase, changes will be made to produce the desired impact on process performance. The "Improve" phase aims to develop solutions to problems, provide proposed solutions, and implement these solutions (Montgomery, 2020).

2.5.5 Control Phase

The 'Control' phase is the final phase in DMAIC, where this phase is carried out to complete all work and implement the proposed improvements given in the improvement phase to improve the quality of process control (Montgomery, 2020). Table 2.1 lists the activities included in the phases of the DMAIC (Gaspersz, 2007).

Table 2.1 Activities included in the phases of the DMAIC.

DMAIC Phases	Activities
Define (D)	1. Obtain management approval and commitment to implement Six Sigma projects 2. Define customer needs so the Six Sigma project can meet customer satisfaction. 3. Define quality improvement goals 4. Define and define roles and responsibilities to members involved in six sigma projects 5. Define needs and conduct members' training on the Six Sigma methodology. So, members understand to carry out six sigma projects 6. Define resource requirements and existing constraints related to the infrastructure and work environment during the implementation of the Six Sigma project. 7. Define output and service requirements that reflect customer needs. 8. Define the processes in each Six Sigma.
Measure (M)	1. Determine the key of Critical to Quality (CTQ) characteristics requirements related to customer needs which are the scope of the Six Sigma project tasks. 2. Establish a data collection plan, including controlling measurements to obtain accurate data for analysis purposes in the analyse stage of each Six Sigma project 3. Measure the key critical-to-quality (CTQ) characteristics of each process, output, and outcome of the Six Sigma project.
Analyze (A)	Analyse process stability, capabilities, sources, and root causes of quality problems in Six Sigma projects.
Improve (I)	Establish and implement a corrective or improvement action plan in each Six Sigma project to eliminate the root cause of the problem and prevent it from recurring.
Control (C)	1. Document the results of quality improvement and determining the best work practice standards into work procedures to be used as work standards guidelines. 2. Disseminate the results of quality improvement and best practices that standards have determined into work procedures throughout the organization.

2.6 IMPLEMENTATION IN THE FOOD INDUSTRY TO IMPROVE QUALITY

According to Kovach and Cho (2011), using examples from other industries, the authors show how Lean Six Sigma may be successfully implemented in the food business and how this can lead to continual quality improvement. The implementation of the DMAIC method is to help reduce 50% of the cost of the production process by reducing the number of defective products, so that good products increase, and employees' skills increase. This method uses data to reduce or eliminate defective products during manufacturing. Therefore, the DMAIC method is primarily used by the food industry to improve the production process and improve the resulting product (Meena et al., 2022).

2.7 CHOCOLATE VARIETIES

Starting with cocoa beans and transforming them through various transformation processes, the food industry creates various types of chocolate with clearly defined ingredients and characteristics (Figure 1). The sector manufactures different kinds of chocolate, each with its own set of ingredients and qualities (Montagna et al., 2019).

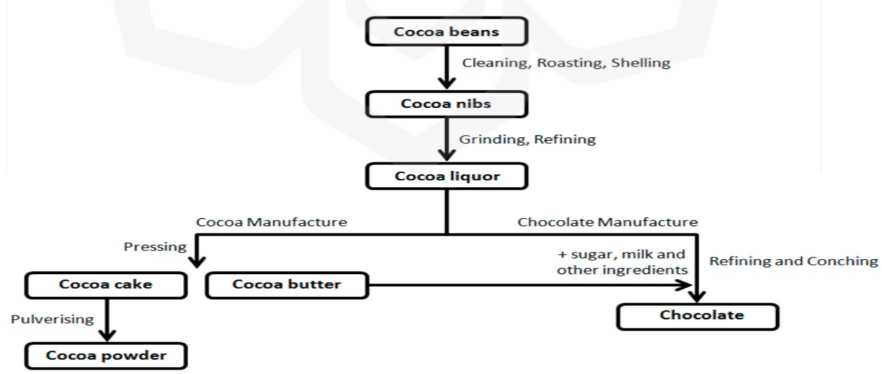

Figure 2.1 Processing of chocolate from cocoa beans (Montagna et al., 2019).

(1) Cocoa butter and cocoa bean solids are the main ingredients in dark chocolate (up to 80 percent of the total weight). It dissolves in the mouth, leaving a delightful, bitter aftertaste, thanks to the powerful, lingering aroma of chocolate. Its quality is determined by the amount of cocoa in it. The majority of the health advantages of chocolate are linked to dark chocolate consumption.
(2) Gianduja chocolate is a brown confection made from hazelnuts, cocoa, and sugar.
(3) Cocoa butter, milk powder, sugar, cocoa, and lecithin (not less than 20–25 percent cocoa) are all found in milk chocolate. It has a dazzling appearance and a robust and lingering aroma, and a sweet, somewhat bitter chocolate flavour.
(4) White chocolate has a sweet, pleasant taste and comprises no cocoa solids in cocoa butter, sugar, and milk.

2.8 CHAPTER SUMMARY

This chapter first introduces the definition of quality and its dimensions. The definition of quality is the characteristics possessed by a product that can satisfy consumer needs. At the same time, the quality dimension is the quality of a product that can be described and evaluated in various ways using the quality dimension. The quality dimension has eight components: performance, reliability, durability, serviceability, aesthetics, features, Perceived quality, and compliance with standards. Furthermore, it explains quality improvement using the concept of Six Sigma and the DMAIC. Six Sigma is a methodology that gives businesses the means to enhance the performance of their business processes. Therefore, Six Sigma can also be considered a strategy that allows companies to improve quality and profit.

Conversely, the DMAIC has five phases: define, measure, analyse, improve, and control. Define is the stage where processes contribute to problems affecting product quality. The measure is the measurement phase that aims to evaluate and understand the current state of the process. Analyze the potential causes of product defects, quality problems, timing, and production process inefficiency will be determined. Improve is to develop solutions to problems, provide proposed solutions, and implement these solutions.

Control is carried out to complete all work and implement the proposed improvements in the improvement phase to improve process control quality. Moreover, it explains the implementation in the food industry to improve quality. It is hoped that this chapter can help researchers in helping them learn about theoretical matters.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter describes how research was conducted. The research begins with identifying problems, determining research objectives, conducting a literature review, and collecting, managing, and analyzing data using the DMAIC method.

3.2 DATA COLLECTION

Data collection aims to obtain relevant information regarding the research question. Research can collect information from existing observations, interviews, documents, and questionnaires. In the study conducted, the data collected is related to the current problems. There are two data types in data collection, namely primary and secondary data. Primary data collection on white couverture chocolate products was carried out by direct methods such as observations, interviews, and questionnaires. At the same time, secondary data collection is done by collecting documents such as company information, historical data on the number of productions, and production defect data from January to July 2022.

3.3 FLOWCHART OF METHODOLOGY

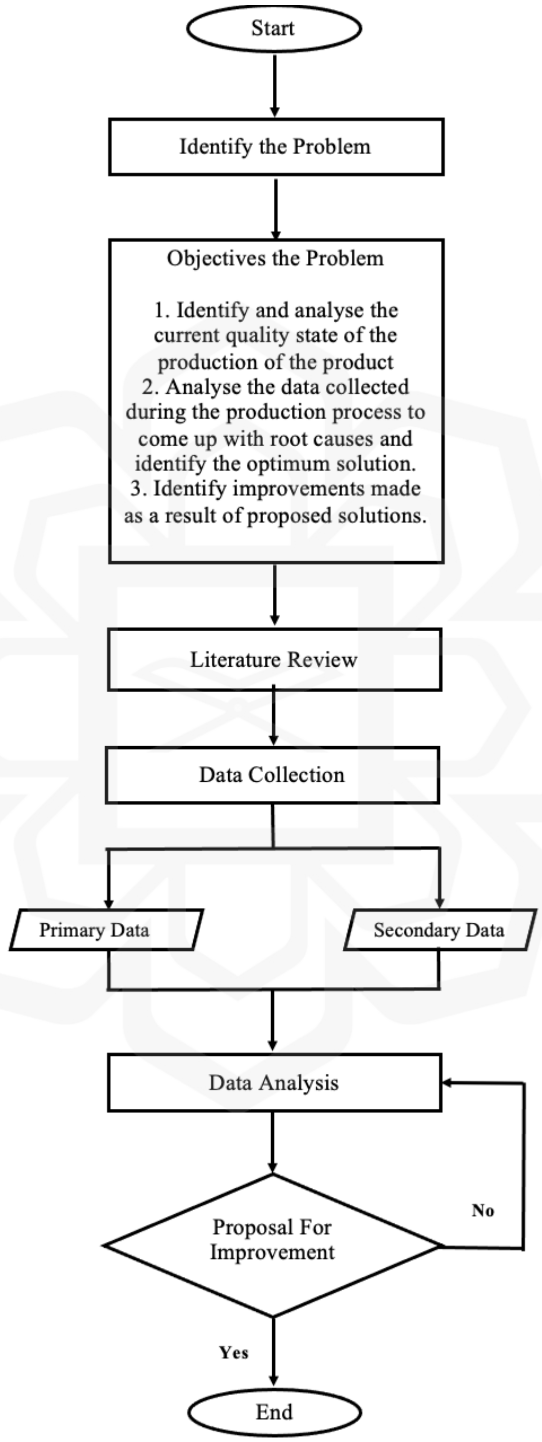

Figure 3.1 Flowchart of Methodology.

The above flowchart shows the methodology applied to carry out the case study at the Wahana Interfood Nusantara Company:

a). The author interviewed the QC manager about the activities involved in the production process. Qualitative interviews were conducted to obtain direct information about certain situations and conditions, complete a scientific investigation, and receive data. Meanwhile, the purpose of observation is to provide a realistic picture to the author of a behaviour or event related to the activity of the research object. For example, to gain insight into the activities, procedures, and processes involved in the types of defects caused by the manufacturing process.

b). Collect data to identify and analyse the current quality state of the production process of Product White Couverture chocolate. Moreover, analyse the data collected to come up with root causes, determine the optimum solution, and Identify improvements made because of proposed solutions.

c). There are two types of data collection: primary and secondary. Primary data was collected to determine how much white couverture chocolate was produced, how many of those products had defects, and what kinds of defects those white counter chocolate products had. From January through July of 2022, the secondary data is taken from the production history. From January to July 2022, they have access to the historical data on the number of production records.

d). The DMAIC Six Sigma problem-solving approach is used for data analysis.

e). Despite the brainstorming and investigation sessions' suggestions and preventative measures, the number of defects has not decreased. Additional investigations and analyses are being conducted to determine the root cause in the production area.

3.4 RESEARCH APPROACH

This chapter presents information on the methodology of the study. It is based on the DMAIC model of Six Sigma. This model has five phases: Define, Measure and Analyse, Improve and Control. Each phase is described below and applied to improve the quality of the white couverture chocolate production process in the Wahana Interfood Nusantara Company.

3.4.1 Define Phase

The first stage carried out in Six Sigma is the define stage. The 'Define' stage aims to find the process that contributes most to the cause of product defects. In this 'Define' stage, information was collected regarding the problems that often occur in white couverture chocolate products. This 'Define' stage consists of several steps, namely:

1. Determination of the critical quality characteristics of white couverture chocolate.

   They were conducted to determine the quality characteristics of white couverture chocolate products. In this case, the quality characteristics used are the results of interviews with the Quality division manager. Based on the results of interviews that have been conducted, there are three types of defects found in white couverture chocolate products.

2. Determination of Critical to Quality (CTQ)

   At this stage, it is determined the critical-to-quality (CTQ) using a Pareto diagram to describe the percentage of defects that occur in the production process. Making a Pareto diagram is done to determine the most dominant type of defect (80% of the total number of defects) to see which types of defects are very influential and need to be repaired.

3. Making SIPOC (Supplier-Input-Process-Outputs-Customers) diagrams.
   The purpose of making a SIPOC diagram is to know the flow of the process of making white couverture chocolate from raw materials to the final product. Below is the meaning of Supplier-Input-Process-Output-Customer (SIPOC):
   • Supplier – is a person or group that provides materials or resources to the company
   • Inputs – everything provided by the supplier to the company.
   • Process – a processing activity consisting of several sub-processes/
   • Outputs – are products resulting from a process.
   • Customers – are groups or individuals who receive the results of the outputs.

3.4.2 Measure Phase

The data obtained from the 'Define' stage was calculated at the measurement stage. This measurement was carried out to determine the performance of the moulding process and the number of defective products that occurs. This 'Measure' stage was carried out in several steps, namely:

1. Defect data retrieval
   Defect data taken is a product of white couverture chocolate that has gone through the moulding process every month from January 2022 until July 2022.

Table 3.1 Production Data of White Couverture Chocolate.

Month	Total of Productions (pcs)	Total of Defects (pcs)
Jan	49,598	1,244
Feb	32,987	778
Mar	53,520	1,232

Month	Total of Productions (pcs)	Total of Defects (pcs)
Apr	50,745	1,241
May	56,725	1,377
Jun	28,410	644
Jul	26,564	632
TOTAL	298,549	7,148

2. Calculation of control p chart attribute

   Making a p control chart is done to determine the central limit of defects in the resulting product and whether the production results are still within normal limits. The data collection includes the number of production and defects taken from January 2022 until July 2022. The steps in making the p control chart are as follows:

   1. Production and defect data are collected from January 2022 to July 2022.
   2. Calculation of control p chart attribute

   $$CL = \bar{p} = \frac{\text{Total of Defects}}{\text{Total of Production}}$$

   3. Calculation of the UCL.

   $$= \bar{p} + 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$$

   4. Calculating of the LCL

   $$= \bar{p} - 3\sqrt{\frac{\bar{p}\,(1-\bar{p})}{n}}$$

3. Calculation of DPU (Defect per Unit)

   A size that reflects all types of the average number of defects against the total units produced. The data needed in calculating the DPU stage is the number of defects that occur and the total number of units.

   $$DPU = \frac{\text{Defect}}{\text{Unit}}$$

4. Calculation of DPMO (Defect per Million Opportunities)

   Defect Per Million Opportunities (DPMO) is a method used to measure the defect level in a product implemented in Six Sigma. The DPMO value will be used to determine the capability of the production process and the sigma level of the process. To calculate the value of DPMO and sigma level, the Defects per Unit (DPU) and Defects per Opportunities (DPO) are calculated first.

   $$\text{DPMO} = \frac{\text{Number of Defect}}{\text{Number of Unit x Opportunities per unit}} \text{ x } 1.000.000$$

5. Calculation of Sigma Level

   Calculation of the conversion of sigma values from Defects Per Million Opportunities (DPMO) to sigma values is carried out using Microsoft Excel with the formula for calculating the conversion of Defects Per Million Opportunities (DPMO) as follows:

   $$\text{Normsinv}\left(\frac{1000000-\text{DPMO}}{1000000}\right) + 1.5 =$$

3.4.3 Analyze Phase

The third stage of the DMAIC method is the 'analyze' stage. The analysis stage aims to process the data obtained from the measuring stage. At this stage, the Pareto diagram analyses and identifies 80% of the most dominant defects in white couverture chocolate products during the moulding process. After that, analysis and identification of the factors that cause the product to be defective in the moulding process are carried out using a fishbone diagram. The analysis involves several factors, including human factors, materials, methods, machines, and the environment.

3.4.4 Improve Phase

In the improvement stage, brainstorming is carried out based on the results of 'Measure' and 'Analyze' phases, which will be used to formulate improvement proposals to improve the quality of the product and reduce the defect rate of white couverture chocolate products. There will be changes made by the company as suggested. The proposed revisions can't be fully implemented because of the Covid 19 pandemic and the limited implementation time available.

3.4.5 Control Phase

After the proposed improvement, the next step is to propose controlling the moulding process so that problems in the process do not occur again. After the DMAIC stage is carried out, then an analysis of each stage is carried out, namely:

1. Analysis at the Define stage.
   In the define stage, an analysis of the critical-to-quality (CTQ) of white couverture chocolate products is carried out. From these several CTQ, key CTQ were obtained as the basis for improving the quality of white couverture chocolate products.
2. Analysis at the Measure stage.
   The analysis carried out at the measuring stage is an analysis of the results of the DPMO calculation. This analysis explains the magnitude of the defects that occur in white chocolate products and explains the sigma level.
3. Analysis at the Analysis stage
   After the measuring stage, the analysis is carried out at the analysis stage. This analysis is carried out using the Pareto diagram and fishbone diagram.
4. Analysis at the Improve stage,
   At this stage, an analysis of the proposed product quality improvement is carried out. This analysis aims to reduce how likely the proposals made can improve the quality of white couverture chocolate products.

5. Analysis at the Control stage

   The analysis at the control stage aims to determine whether the proposal does not occur again so that it can improve the quality of white couverture chocolate products.

3.5 CHAPTER SUMMARY

This study uses qualitative research methods and the DMAIC in this chapter to obtain the findings discussed. A flowchart explains the process steps carried out by the author in conducting the research. So that it becomes easier for everyone to understand. The first process is identifying the problems in Wahana Interfood Nusantara and determining its objectives. After that, it is assisted by searching for literature reviews in the hope that the problem will stay on the right track. Retrieve data from the period Jan-July 2022. There were two types of data taken, primary and secondary data. After the data is obtained, analysis and calculations are carried out using the DMAIC method. Eventually, after getting the analysis results, the author submitted a proposal for improvement to the Wahana Interfood Nusantara Company for consideration.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter presents data collected and data processing from the DMAIC stages (define, measure, analyze, improve, and control) to solve problems in the moulding process of white couverture chocolate products at Wahana Interfood Nusantara Company. The Define and Measure stages explain the data collection and calculate data. On the other hand, the Analysis, Improve, and Control stages explain data processing and analysis so that can provide suggestions to company can improve its performance to be better in the future. The steps and results of data collection and processing will be described below.

4.2 DEFINE PHASE

In the 'Define' stage, the critical-to-quality (CTQ) is determined with the aim of knowing what the physical quality characteristic of white couverture chocolate is, then it will be described using a SIPOC (supplier-input-process-output-customer) diagram. It is used to identify problems that occur in the process of making white couverture chocolate. Critical-to-quality CTQ determination is also carried out at this defined stage using the Pareto diagram.

4.2.1 Physical Defects Condition of White Couverture Chocolate

Conditions of white couverture cholate defects that have occurred so far include peeled off, broken, cracked, soft and porous. This condition is a problem that occurs in the process of moulding white couverture chocolate products. These five defects conditions will later be used in determining critical-to-quality (CTQ).

4.2.2 Identification of Critical-to-Quality (CTQ)

Wahana Interfood Nusantara Company sets quality criteria for each product produced to suit its customers' needs and wishes. The CTQ identification stage aims to identify the quality attributes of White Couverture Chocolate goods determined by the customer's preferences. The quality features of White Couverture Chocolate products are identified by CTQ identification by identifying those quality characteristics categorized as excellent and those classified as inadequate or faulty as good quality characteristics.

1. Good Quality Characteristics of White Couverture Chocolate Products.

   The products produced by Wahana Interfood Nusantara Company do not tolerate defects in terms of attributes because this can reduce the quality of the product itself. Product White Couverture Chocolate is classified as good if it meets the following characteristics:

   1. There are no broken parts on the product.
   2. There is no dirt on the product resulting from the production process.
   3. There are no scratches on the product.
   4. No product parts are peeled off due to the production process.
   5. There are no wavy marks due to the production process.

Figure 4.1 White Couverture chocolate.

2. Defective White Couverture Chocolate Product Quality Characteristics.

Several products have defects in producing the White Couverture Chocolate product, so they are classified as defective. Product quality characteristics identified from interviews with the factory and direct observation obtained three types of defects. The types of defects that occur in White Couverture Chocolate products are as follows:

1. Broken

Products included in the "Broken" category are chocolate products damaged during the production process. Inconsistent moulding machine temperatures cause the chocolate to crumble from the inside. When entering certain hours, such as 10 am-02 pm, the air temperature outside the factory increases its temperature to 35 degrees Celsius and above. Therefore, the room temperature also becomes hot and forces the moulding machine to work hard to cool the moulding machine temperature to keep it within 24 degrees Celsius. Thus, the moulding machine overworks hard, making the temperature of the moulding machine inconsistent. Furthermore, the moulding machine experiences a decrease in temperature and causes the chocolate to freeze, and breaks occur during the production process.

Figure 4.2 Broken type defect on white couverture chocolate.

2. Crack

Products included in the "cracked" category are when parts of the chocolate product are cracked during production. Inconsistent moulding machine temperature causes the chocolate to crumble from the inside. When entering certain hours, when the engine temperature increases, it becomes cold, causing the chocolate to freeze, which causes the chocolate to crack during the production process.

Figure 4.3 Crack type defect on white couverture chocolate.

3. Peeled off

Products that fall into the "peeled" category are when parts of the chocolate product are damaged during the production process. The wind in the moulding machine is sometimes inconsistent, making the air blow too hard and putting pressure on the melted chocolate mixture that has just been added. The strong pressure causes the chocolate mixture to stick to the pan. When the chocolate has finished the moulding process, operator error when prying the chocolate that sticks to the pan causes the chocolate to peel.

Figure 4.4 Peeled-off type defect on white couverture chocolate.

4. Soft

Products that fall into the "soft" category are when parts of the chocolate product are damaged during the production process. The temperature in the moulding machine is sometimes inconsistent because the moulding machine adjusts the temperature of the hot surroundings. Thus, the air blows too hard and puts pressure on the melted chocolate mixture that has just been added. This pressure changes the melted chocolate dough's structure before solidifying in the middle of the moulding process.

Figure 4.5 Soft type defect on white couverture chocolate.

5. Porous

Products included in the "Porous" category are chocolate products damaged during the production process. The inconsistent temperature around the moulding machine makes the moulding machine temperature also sometimes inconsistent. Thus, the temperature is a factor that causes the inside of the chocolate to become porous because it is not ripe, and only the outside of the chocolate is ripe.

Figure 4.6 Porous type defect on white couverture chocolate.

4.2.3 SIPOC (Supplier-Input-Process-Output-Customers)

The SIPOC diagram aims to see what factors influence the manufacture of white couverture chocolate and describe the relationship between suppliers, inputs, processes, outputs, and customers. Making a SIPOC diagram starts from receiving raw materials from suppliers to becoming a product, then delivered to the customer or temporarily stored in the warehouse. Below is the table from SIPOC:

Table 4.1 Table of SIPOC

Supplier	Input	Process	Output	Customers
PT. Bumi Tangerang Mesindotama	Raw Material	Receiving Raw Material	White Couverture Chocolate	PT. JCO Donuts & Coffee
PT. Makmur Sejati Internusa		Material Weighing Process		
PT. Jala Bumi Persada		Grinding Process (Mixing and Refining Temperature = 35-45^0C, timer = 3 hours)		
PT. Unijaya Pratama		Moulding		
PT. Mitra Dunia Pangan		Cooling (Temperature = 4-10^0C)		
		Packaging and Labeling		

4.3 MEASURE PHASE

This is the second step in applying the Six Sigma methodology. The data obtained from the define stage is calculated at the measurement stage. This measurement is carried out to determine the performance of the moulding process and the number of defective products that occur. This measurement stage is carried out in several steps, namely:

1. Data Collection

The data collected is on white couverture chocolate products that have undergone the moulding process. The following is the total production of white couverture chocolate from January 2022 to July 2022.

Table 4.2 Production Data of White Couverture Chocolate.

Month	Total of Productions (pcs)	Types of Defects					Total of Defects (pcs)
		Peeled off	Cracked	Broken	Soft	Porous	
Jan	49,598	335	284	514	96	15	1,244
Feb	32,987	220	145	341	64	8	778
Mar	53,520	312	310	521	73	16	1,232
Apr	50,745	391	388	395	54	13	1,241
May	56,725	409	356	512	82	18	1,377
Jun	28,410	201	171	225	41	6	644
Jul	26,564	183	154	241	47	7	632
TOTAL	298,549	2,051	1,808	2,749	457	83	7,148

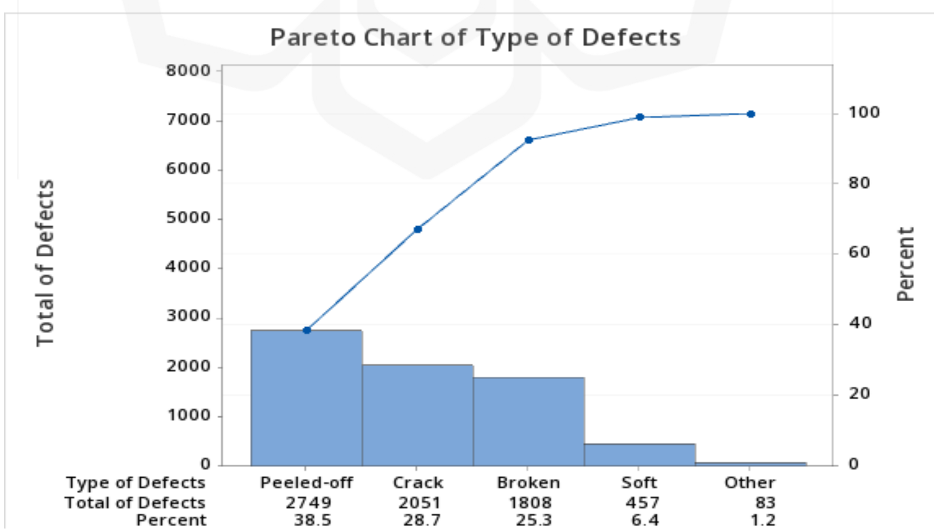

Figure 4.7 Pareto chart of types of defects.

Based on the Pareto diagram above, it is known that peeled-off defects have the most significant percentage value compared to crack, broken, soft, and porous in the moulding process of white couverture chocolate products. Therefore, improvements must be made to eliminate or reduce the five types of defects in white couverture chocolate product process moulding.

4.3.1 Control Chart Calculation

1. p control chart calculation

Making a control chart determines whether a production process is within the control limits. The control chart p is based on the proportion of defective products from the White Couverture Chocolate product from January 2022 to July 2022. Because the monthly production number varies, each calculation method's CL, UCL, and LCL calculations differ.

1. Calculation of the CL or the process average:

$$CL = \bar{p} = \frac{\text{Total of Defects}}{\text{Total of Production}} = \frac{7148}{298549} = 0.024$$

2. Calculation of the UCL.

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

$$= 0.025 + 3\sqrt{\frac{0,024\,(1-0,024)}{49598}}$$

$$= 0.026$$

3. Calculating of the LCL

$$= \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$= 0.024 - 3\sqrt{\frac{0,024\,(1-0,024\,)}{49598}}$$

$$= 0.022$$

The results of the calculation of data for p control charts in other months can be seen in the table below:

Table 4.3 Data recapitulation of CL, UCL, and LCL.

No	Month	Total of Productions	Total of Defects	% Defects	CL	UCL	LCL
1	January	49,598	1,244	0.025	0.024	0.026	0.022
2	February	32,987	778	0.024	0.024	0.026	0.021
3	March	53,520	1,232	0.023	0.024	0.026	0.022
4	April	50,745	1,241	0.024	0.024	0.026	0.022
5	Mei	56,725	1,377	0.024	0.024	0.026	0.022
6	June	28,410	644	0.023	0.024	0.027	0.021
7	July	26,564	632	0.024	0.024	0.027	0.021
TOTAL		298,549	7,148				

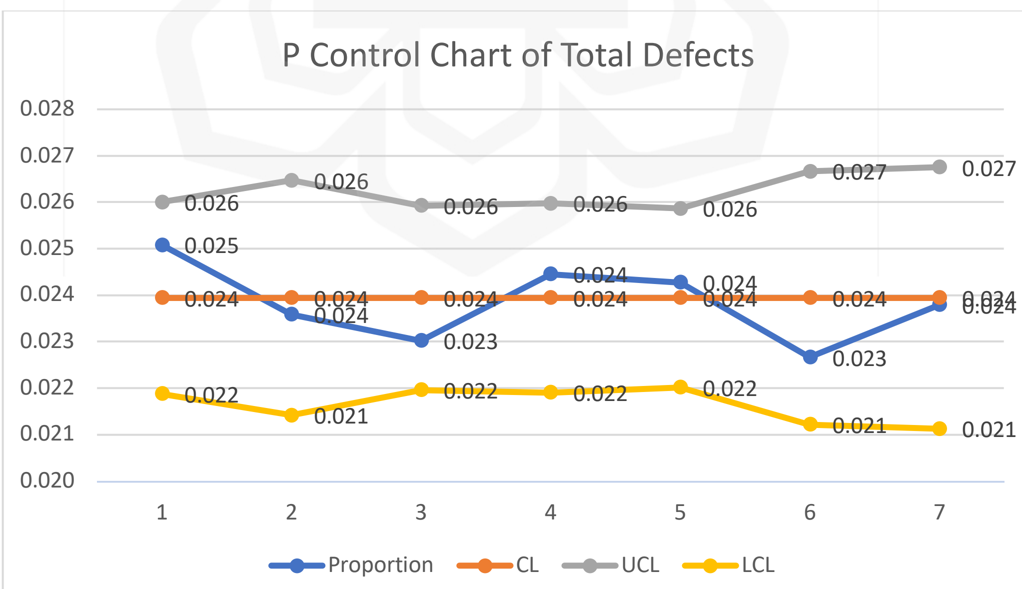

Figure 4.8 p Chart of Total Defects.

Regarding the calculation of the p chart control in table 4.3, it can be seen that the results of the CL, UCL, and LCL values are 0.024, 0.026, and 0.022. Meanwhile, the calculation of the control chart p above using Microsoft Excel in Figure 4.8 shows that all data results were in control. It can be seen that no data is out of control. Furthermore, the calculation of DPMO (Defect Per Million Opportunities) and the sigma level of the white couverture chocolate product moulding process is carried out.

4.3.2 Six Sigma Level Calculation

The next measurement phase measures the level of sigma and Defect Per Million Opportunities (DPMO). DPMO aims to calculate the sigma of the white couverture chocolate production process.

- Calculate DPU (Defect Per Unit)

  $\text{DPU} = \frac{\text{Defect}}{\text{Unit}} = \frac{7148}{298549} = 0.024$

- DPMO (Defect Per Million Opportunities)

  $= \frac{\text{Total of Defects}}{\text{Total of Units x CTQ}} \text{ x } 1000000$

  $= \frac{7148}{298549 \text{ x } 5} \text{ x } 1000000$

  $= 4788.49$

After calculating the DPMO value, the DPMO value was 4,788.49. The DPMO value will be used to calculate the sigma level in the white couverture chocolate product moulding process. The sigma level calculation below was obtained by converting the DPMO value to the sigma level.

- Sigma Level

  $\text{Normsinv}\left(\frac{1000000-\text{DPMO}}{1000000}\right) + 1.5 = \left(\frac{1000000-4788.49}{1000000}\right) + 1.5 = 2.495$

Table 4.4 DPMO and Sigma level.

A. ALL Values Required to Calculate Sigma Level			
Defects	7148	DPMO	4788.49
Units	298549	Sigma Level	2.495
Opportunities Per Unit	5		
B. Enter only the known Defects Per Million Opportunities			
Enter DPMO	4788.49	Sigma Level	2.495

Based on the calculation of the value of DPU (Defect Per Unit), DPMO (Defects per million opportunities), and the level of Sigma that has been carried out, the results show that the DPU value was 0.024, which means that the probability of the white couverture chocolate product having defects was 2.4% for each unit. The DPMO value was 4788.49, and after being converted to a sigma level value, the result was 2.495 Sigma. The DPMO value of 4788.49 means that in one unit of White couverture chocolate product, there is an average opportunity to fail from this defect, which was 4788.49 failures for every one million opportunities. The Sigma level value was 2.495 Sigma which means that the production process of white couverture chocolate is in the average Sigma value for industry in Indonesia and is below the average sigma value for industry in the United States because the average sigma value for industry in the United States that is above 4 Sigma (Gaspersz, 2007).

The sigma value is still far from achieving a perfect sigma value of 6, so it is still necessary to identify and analyze the causes of the process that causes the product to become defective.

Table 4.5 Sigma Level, DPMO, and Description (Gaspersz, 2007).

Sigma Level	DPMO	Description
1σ	690.000	Very uncompetitive
2σ	308.000	Indonesian industry average
3σ	66.800	Indonesian industry average
4σ	6.210	American Industry average
5σ	320	American Industry average
6σ	3.4	World Class Industry

4.4 ANALYSE PHASE

This is the third step in applying the Six Sigma methodology. At the analyse stage, an analysis of the relationship between cause and effect and failures from a production process is carried out. After that, an analysis is carried out to determine the most potential failure of a case regarding product quality.

1. Pareto chart types of defects

Table 4.6 White Couverture Chocolate Product Defects Data.

No	Name of Defects	Count of Defects	%	Cumulative %
1	Peeled off	2,749	38.5	38.5 %
2	Cracked	2,051	28.7	67.2 %
3	Broken	1,808	25.3	92.4 %
4	Soft	457	6.4	98.8 %
5	porous	83	1.2	100 %
TOTAL		7,148		

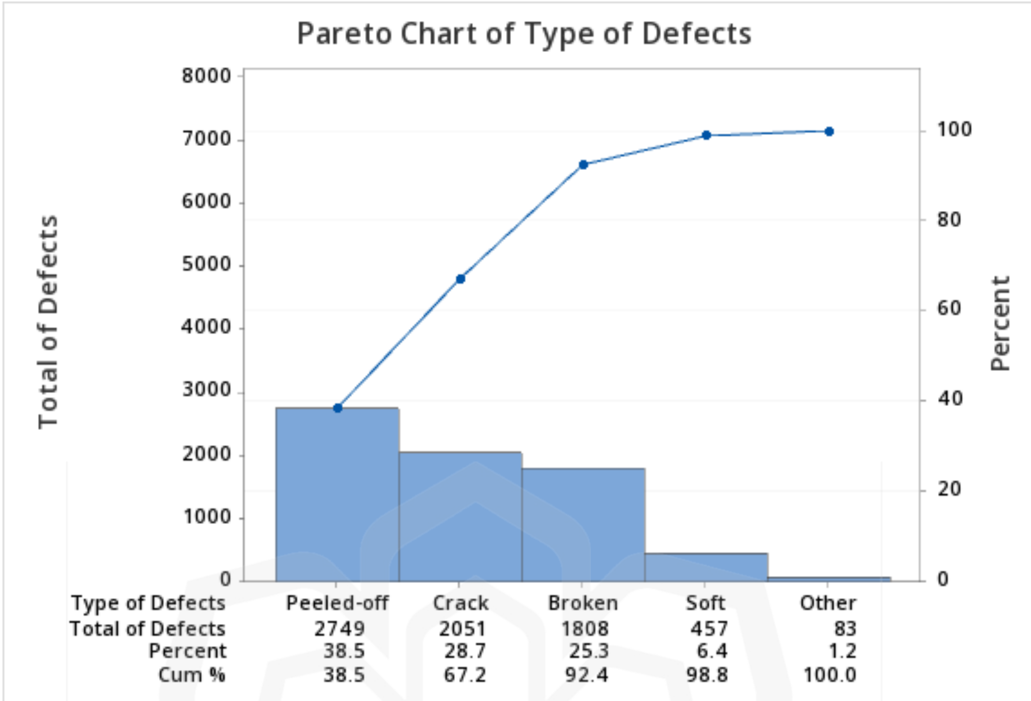

Figure 4.9 Pareto Chart of Types of Defects.

According to the Pareto diagram above, the most dominant types of defects can be seen by their cumulative values. Following the Pareto principle, which states the 80/20 rule, which means that 80 per cent of quality problems are caused by 20 per cent of the causes of defects. So that the selected types of defects with a cumulative value of up to 80% with the assumption that 80% can represent all types of defects that occur. It can be seen that the types of defects are peeled off (38.5 %), cracked (28.7 %), and broken (25.3 %). The three types of defects will be prioritized in handling this problem. The three defects that exist are from the moulding process. So, to overcome these defects, the process must be investigated to make improvements to the process so that defects that occur due to the process can be reduced. If the three types of defects are handled, then 80% of the problems will be resolved so that the three types of defects are a priority that must be addressed first.

2. Fishbone of Defects

In the analysis process, a cause-and-effect diagram is used (Fishbone Diagram), which is a diagram to identify the factors that influence and cause the product to experience defects in the production of white couverture chocolate product moulding process. The identified factors include workers or employees (people), tools (equipment), the environment (environment), and methods (methods).

Brainstorming Causes of Defects:

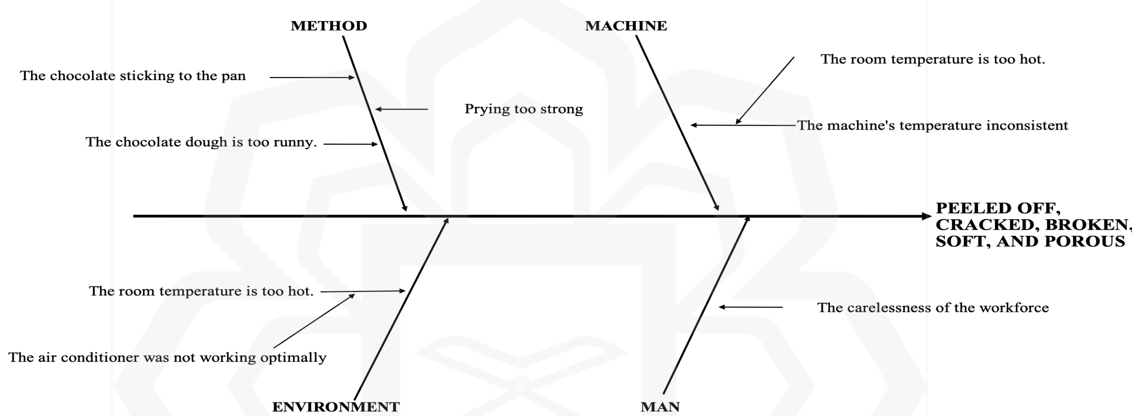

Figure 4.10 Fishbone of Types of Defects.

1. Man

   Factors causing defects in white couverture chocolate products are human factors. Factors caused by humans are due to the carelessness of the workforce. This carelessness can be caused by employees talking to each other so that employees do not focus on their work. Carelessness is caused by a lack of supervision and fatigue.

2. Method

   Improper application of the method can result in the chocolate mixture sticking to the pan when the moulding process is complete. Thus, requires operator assistance to pry it out with a hook. The harder it sticks, the stronger the operator's pry will cause the chocolate to peel when pinched.

3. Machines

   The factor that causes broken, cracked, and peeled-off defects were the machine that is not regularly maintained. This can cause the machines to experience damage, such as the moulding machine's temperature is not stable at a particular time. Carrying out maintenance on machines, such as maintenance optimally and regularly, will make the machines work optimally.

4. Environment

   Environmental factors significantly affect the performance of workers and machines because a comfortable environment will make it easier for workers to work. Changes in room temperature during the day can affect the stability of the machines in the room. The machine will have an inconsistent temperature when the room temperature is hot and will change the machine temperature when the production process is carried out. The instability of the room temperature will make it difficult for workers to supervise the machine. The work environment has a significant role in creating a good product.

4.5 IMPROVE PHASE

The 'Improve' stage was carried out after the 'Analyze' stage was completed. This stage provides suggestions for improvements that aim to improve the quality of white couverture chocolate products. This proposed improvement can also reduce the level of defects in the product and increase the value of the sigma level in the process. The improvement proposals given are based on identifying potential failure causes using tools at the Define, Measure, and Analyse stages, namely Pareto Diagrams, P, and Fishbone Diagrams. This improvement proposal is based on brainstorming with the factory. This brainstorming was carried out by discussing the proposed improvement options in more detail regarding the existing problems, hoping that the proposed improvements could improve product quality and reduce defects in white couverture chocolate products.

1. Description of the proposed improvements to the failure mode factor machine
   After observing and analysing a fishbone diagram, it was found that 1 factor that cause of inconsistent machine failure was the unstable machine temperature during the day. The room temperature causes this to be not cold, so the moulding machine has an inconsistent temperature. Proposed improvements to schedule maintenance on the moulding machine. This is necessary to minimise temperature changes in the moulding machine during production. Moulding machine temperature that is too cold can cause chocolate to break and crack during production.

2. Description of the proposed improvements to the failure mode factor environment.
   After observing and analysing using a fishbone diagram, one factor was obtained from the cause of environmental failure. Namely, the temperature of the room temperature was too hot during the day. This is due to the position of the moulding room on the 2nd floor of the building, and the room's roof cannot withstand the sun's heat during the day. The temperature that has been set ranges from 20 degrees Celsius to 24 degrees Celsius and can change during the day. Proposed improvements by checking the room temperature periodically and moving the moulding room on the 1st floor. This is necessary to minimise the occurrence of sudden changes in the temperature of the moulding room temperature. Too hot room temperature will cause the moulding machines to experience overheat.

3. Description of the proposed improvements to the failure mode factor method.
   After observing and analysing fishbone diagrams, it was found that 3 factors caused the failure of the method: the chocolate sticking to the pan, prying too strong, and the chocolate dough is too runny. Of the three factors, the chocolate is not cooked evenly when the moulding process is complete. The undercooked chocolate will stick to the pan, forcing the operator to pry the chocolate out of the pan. The process of picking too hard chocolate will cause the chocolate to peel. The proposed

improvement is to let the chocolate sit for 3 minutes before being put into the moulding machine. This is necessary to minimise the chocolate dough that sticks to the pan when the moulding process is complete.

4. Description of the proposed improvements to the failure mode factor man.
After observing and analysing fishbone diagrams, it was found that 1 factor was the cause of man's failure, namely less skill in supervision. This is because the operator is less skilled in regulating the room temperature and the temperature of the moulding machine and less skilled in picking chocolate in the pan. Dense work activities and operators who are in a hurry to work are the cause. The improvement proposal given to the problem is to make operator training so that the operator on duty can operate the moulding machine must have high accuracy, especially in regulating the moulding machine's temperature and room temperature and taking responsibility for the work.

4.6 CONTROL PHASE

At this stage, it is explained how to control the improvements that have been made at the repair stage so that defects that occur in the moulding process of white couverture chocolate products can be minimized. Control is carried out as follows:

The implementation of maintenance on moulding machines and air conditioners is carried out every 3 months. The form of control that is carried out is to unify the implementation of maintenance by creating a form check sheet containing the maintenance results. The form is filled out by the maintenance officer and then given to the head of maintenance to be checked and signed. The next step is to control the improvements that have been made using tools such as check sheets and documentation to be carried out.

1. Check Sheet

This control stage is expected to involve operators recording product defect data in their respective areas. Check Sheet is a data collection and analysis tool presented in table form which aims to simplify the process of data collection and analysis, as well as to find out problem areas based on the frequency of types or causes and make decisions to make improvements or not. This is done by recording the frequency of appearance of the characteristics of a product related to its quality. The data is used as a basis for analyzing quality problems.

PT. WAHANA INTERFOOD NUSANTARA Tbk. Cocoa & Chocolate Confectionery				**WAHANA INTERFOOD NUSANTARA COMPANY**			
				Jl. Dadali no. 16, Bandung, 40184, West Java, Indonesia			
				Machines Inspection Form			
No	Date	Shift		Machines	Operator's	Temperatures	Operator Signature
		A	8AM				
		B	11AM				
		C	2PM				
		A	8AM				
		B	11AM				
		C	2PM				
		A	8AM				
		B	11AM				
		C	2PM				
		A	8AM				
		B	11AM				
		C	2PM				
Supervisor Signature							

Figure 4.11 Check Sheet Form.

2. Documentation

It is necessary to do documentation to create a new standard in the implementation. This is an effort to prevent the tendency of a new system to return to the old system or work pattern. Documentation serves as valid, actual, and official evidence. Documentation helps gain a better understanding of what an organization can achieve. In addition, the function of the documentation is to provide information about the contents of the document to those who need it to prepare evidence. Documentation is also helpful to help making decisions, planning, and supervise. Besides that, it can also be used as evidence and historical reference.

4.7 CHAPTER SUMMARY

This chapter calculates and investigates the existing data in more detail. Five categories of defects were found in white couverture chocolate's moulding process: cracks, soft, broken, peeled off and porous. After knowing the type of defects in the product, calculations were performed using a Pareto chart to determine the percentage of each defective product. The following were the percentage values, peeled off (38.5%), cracked (28.7%), broken (25.3%), soft (6.4%) and porous (1.2%). Furthermore, calculations are carried out using the P control chart to determine whether the data is still in control, and the result is that the data is in control. After completing the p control chart calculation, analyses are conducted to determine the value of DPMO and Sigma levels in white couverture chocolate products. The DPMO value is 4788.49, and the Sigma level value is 2.495. thus, the sigma value is still in the average industry value in Indonesia. In addition, it identified the factors that influence the occurrence of defects in white couverture chocolate products using a fishbone diagram. The following were the factors influencing the occurrence of defects in white couverture chocolate products: machine, method, man, and environment. Eventually, in the final stage, the study makes suggestions for improvement and control to reduce the defects.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Based on observations and investigations at Wahana Interfood Nusantara Company. The following conclusions are obtained:

1. From the calculation of the p-value of the control chart, the CL, UCL, and LCL values were 0.024, 0.026, and 0.022. meanwhile, calculating the p-control chart using Microsoft Excel shows that all data results were in control. It can be seen that none of the data got out of hand. Furthermore, the result calculation of the value of DPU (Defect Per Unit), DPMO (Defects per million opportunities), and the level of Sigma that has been carried out, the results show that the DPU value was 0.024, which means that the probability of the White couverture chocolate product having defects was 2.4% for each unit. The DPMO value was 4788.49. After being converted to a sigma level value, the result was 2.495 Sigma. In addition, the Sigma level value was 2.495 Sigma which means that the production process of white couverture chocolate is in the average Sigma value for industry in Indonesia and was the average sigma value for industry in the United States because the average sigma value for industry in the United States that is above 4 Sigma.
2. There are types of defects in the moulding process of white couverture chocolate products. The defects were often broken, peeled off, cracked, soft, and porous. Factors that cause defects were human, method, machine, and environmental. This study is limited to the moulding area.
3. The proposed improvement to the failure mode factor machine is to create a schedule for maintenance on the moulding machines. The proposed improvements to the failure mode factor man are to make operator training so that the operator on duty can operate the moulding machine must have high accuracy and taking responsibility for the work. In addition, the proposed improvements to the failure mode factor method are to let the chocolate sit for 3 minutes before being put into the moulding machine. Moreover, the

proposed improvements to the failure mode factor environment are checking the room temperature periodically and moving the moulding room on the 1st floor.

5.2 RECOMMENDATION

From the studies that have been done, many other factors contribute to the occurrence of defects in the moulding process of white couverture chocolate products. Even though the Sigma level is at the average quality of the industry in Indonesia, it would be better if more optimal improvements were made.

Employee training is highly conducted and should be based on needs. Moreover, employee training aims to improve employee skills and a sense of responsibility towards the company. All employees must follow the company's training to understand the SOPs that apply to the company.

The selection of the production room layout is also essential in this case. Inconsistent temperature dramatically affects the performance of the moulding machine and its surroundings. Hot temperatures will cause employees not to focus on work and increase the defects produced by employees.

The DMAIC method should be applied in all departments in the company, such as the purchasing department. The purchasing department can help reduce errors in receiving raw materials, resulting in increased costs and raw material inventory levels. Therefore, it can be concluded that the application of DMAIC can be adopted for various types of business, provided that people in the organisation are given training in the methodology.

It is suggested that further research can be developed by considering and observing the production process apart from the molding area.

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APPENDIX A

SAMPLE INTERVIEW TRANSCRIPTION

R – RESEARCHER
P – PARTICIPANT

The following was the result of an interview with Mrs Riri as the Quality Control Manager. She discussed the white couverture chocolate product's moulding process at Wahana Interfood Nusantara Company. This interview aims to identify the factors that cause defects in the moulding process of white couverture chocolate products. Furthermore, the results of this interview will be translated into a fishbone diagram.

Discourse Unit (DU)	Researcher ® / Participant (P)	Transcription
1.	R	Assalamualaikum Warahmatullahi wabarakatuh.
	P	Walaikumsalam Warahmatullahi Wabarakatuh.
2.	R	Are any defects often appearing during the moulding process for white couverture chocolate products?
	P	Usually, several types of defects appear when the moulding process is complete.
3.	R	What were the types of defects?
	P	Types of defects that occur include broken, crack, soft, porous, and peeled-off
4.	R	May you please explain what the five types of defects were like?
	P	Chocolate included in the category of broken defects was the texture of chocolate that breaks when the moulding process is completed. Chocolate in various crack defects was a chocolate texture that cracks when the moulding process is completed. Meanwhile, the soft defect type was a chocolate texture that was not hard when the moulding process was completed. Moreover, chocolate classified as a porous defect

Discourse Unit (DU)	Researcher ® / Participant (P)	Transcription
		was a type of chocolate with a non-solid and porous texture. Furthermore, the chocolate included in the peeled-off type of defect was the chocolate texture that sticks to the moulding process.
5.	R	For the room temperature of the moulding process, is there a standard for how many degrees Celsius?
	P	For the room temperature of the moulding process, the company's standard is 25 degrees Celsius
6.	R	How many months is the air conditioner maintenance schedule?
	P	Air conditioner maintenance is carried out every six months every year
7.	R	For the temperature of the moulding machine temperature, is there a standard?
	P	The moulding machine has a standard temperature of about 5-6 degrees Celsius.
8.	R	Every how many months of machine moulding maintenance?
	P	Every 3-4 months in 1 year.
9.	R	Does the company provide training to employees?
	P	Of course, training is carried out every six months a year.

APPENDIX B

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Improving the Quality of the Chocolate Production Process at Wahana Interfood Nusantara Company Using DMAIC Method

Doffikar Batuta[1], Mohamed Abd Rahman[2]
International Islamic University Malaysia[1,2]
Jalan Gombak, Kuala Lumpur, 53100, Malaysia
Correspondence Email: doffikar@gmail.com
ORCID ID: 0000-0001-8873-2502

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ABSTRACT

In this century, consumers, as product users, are becoming more critical and pickier in their product selection due to technological and economic advances in the global market. Wahana Interfood Nusantara Company is Indonesia's most complete cocoa bean processing company under the SCHOKO brand. The study aims to identify the effects of implementing the DMAIC methodology in improving the quality of the chocolate production process at Wahana Interfood Nusantara Company. This study uses the DMAIC method (Define, Measure, Analyze, Improve, and Control). They obtained 5 Critical to Quality: broken, cracked, peeled-off, soft, and porous. The DPMO value was 4788.49, and the Sigma value was 2.496, which means that the white couverture chocolate production process is in Indonesia's average Sigma value industry. It was found that 80% of the most dominant defects were peeled off (38.5%), cracked (28.7%), and broken (25.3%). Suggestions for improvements are given to carry out regular machine maintenance, conduct employee training, and carry out SOPs correctly.

Keywords: Chocolate, DMAIC, Manufacturing, Quality Control, Six Sigma