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

BY

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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 الشَّركة 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.

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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.