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ISHIKAWA DIAGRAM APPLICATION AS A LEARNING MEDIUM FOR QUALITY MANAGEMENT AT A MEATBALL FACTORY IN BANDUNG

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Abstract. *Product quality is not merely a technical issue in the industrial sector but also an essential competency that needs to be understood in quality management education, particularly in vocational education and applied higher education. Contextual and industry-based case learning in quality management is required to enable learners to understand quality control concepts in an applied manner. This study aims to examine the application of the Ishikawa Diagram as a problem-based quality management learning medium through a case study of declining meatball product quality at a manufacturing plant in Bandung, West Java. The research method employs a Quality Control Circle (QCC) approach using the Ishikawa Diagram to identify the root causes of quality problems, supported by Total Plate Count (TPC) testing as empirical evidence. The results indicate that the Ishikawa Diagram is effective not only as an analytical tool but also as a quality management learning medium, as it helps learners systematically understand cause-and-effect relationships within the production process. The main findings reveal that deviations in drying time due to increased production volume were the dominant factor contributing to the decline in meatball quality. This study contributes to the development of quality management learning based on real industrial case studies and strengthens the integration of quality management theory with practical field applications in educational contexts.*

Keywords: *Quality Management, Learning Media, Ishikawa Diagram, meatballs, TPC*

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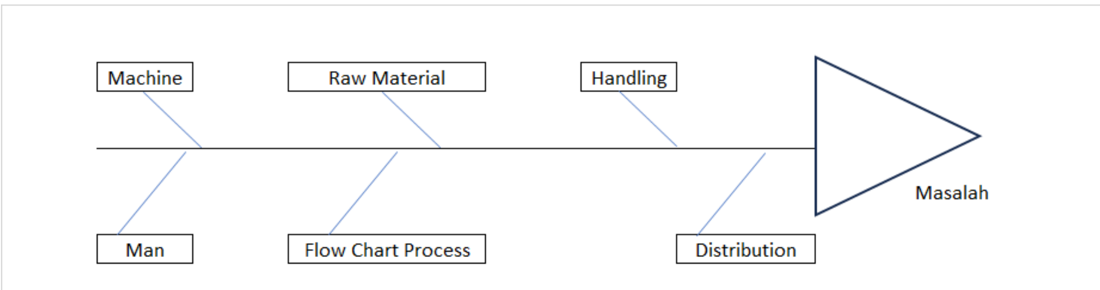
1. INTRODUCTION

Quality management is one of the essential competencies that must be mastered in the field of education, particularly in vocational education, food technology, and industrial management [1]. In the educational context, learning quality management is not only aimed at understanding theoretical concepts but also at equipping learners with analytical skills, problem-solving abilities, and data-driven decision-making competencies [2]. Therefore, contextual and real problem–based learning models are required to make quality management learning more meaningful. One of the main challenges in quality management education is the weak linkage between theoretical concepts taught in the classroom and real-world practices in the field. Learners often understand concepts such as quality, quality control, and risk analysis at a conceptual level, yet experience difficulties when required to apply them to actual industrial cases. This condition highlights the need for practical and applicable learning media, one of which is the use of industrial case studies analyzed through systematic quality management tools.

Meatballs (*bakso*) are one of the most popular meat-based food products and are widely consumed by people of all age groups, including children, adolescents, and adults. Meatballs are generally spherical food products made from a mixture of meat (with a minimum meat content of 50%) and starch or cereals, with or without the addition of other food ingredients and permitted food additives. The nutritional composition of meatballs includes a minimum protein content of 9%, a maximum fat content of 2%, a maximum moisture content of 70%, and a maximum ash content of 3% (SNI 01-3818-1995). This nutritional composition supports microbial growth; therefore, beef meatballs have a relatively short shelf life. Meatballs are high-nutrient meat products with a pH of 6.0–6.5 and high-water activity (Aw > 0.9), resulting in a maximum shelf life of only one day (12–24 hours). Various efforts have been made to extend the shelf life of meatballs, one of which is storage at low temperatures [3].

The Ishikawa Diagram, which is an application of Quality Control Circles (QCC) and is also known as the fishbone diagram or Cause-and-Effect Analysis [4], is a tool used to identify the root causes of problems in order to determine corrective actions and improvement steps for a product or system. The main advantage of this diagram is that it is easy to read, apply, and understand, which is why many companies continue to use it as a solution for addressing daily operational problems. Internally, the diagram is commonly used by Quality Assurance (QA) and Quality Control (QC) departments to investigate root causes across related departments. The structure of the Ishikawa Diagram is illustrated as follows:



This study was conducted at a meatball manufacturing plant located in West Java due to a recurring decline in product quality that consistently occurred every January each year. This recurring phenomenon raised concerns and was even associated with superstitious beliefs, as the meatballs repeatedly experienced quality deterioration during that month, characterized by unpleasant odor, slimy texture, and the release of milky exudate, eventually leading to swelling and bursting of the packaging. The Sales Department continuously urged the owner to conduct a more in-depth investigation into the issue. Based on consultation with a quality management expert, it was recommended that a comprehensive Quality Control Circle (QCC) analysis be carried out, including the systematic application of QCC tools. The total bacterial count was measured using the Total Plate Count (TPC) method to determine the number of bacteria present in the product. This procedure was conducted by isolating product samples and observing bacterial growth under controlled laboratory conditions [5,6].

2. RESEARCH METHODS

This study employed a qualitative descriptive approach supported by quantitative data, integrated within a case study framework for quality management learning [7]. This approach was selected to examine the application of the Ishikawa Diagram not only as an industrial quality analysis tool but also as a problem-based and context-oriented learning medium for quality management. The research focused on a single case within the food industry, namely a meatball manufacturing plant in Bandung, which experienced periodic declines in product quality. This case study was utilized as a contextual learning medium to enhance understanding of quality control concepts, cause–effect analysis, and managerial decision-making.

The research involved the application of the Ishikawa Diagram in accordance with the actual production processes. The root causes of the quality problem were categorized into several factors, including machinery, raw materials, human resources, production process flowcharts, handling, and distribution. Machinery included both meatball production equipment and storage facilities (cold storage). Raw materials encompassed all primary, supporting, and additional ingredients used in the meatball production process. Human resources consisted of all employees from relevant departments involved in production. The production process flow referred to all operational stages carried out in accordance with the Standard Operating Procedures (SOPs) and work instructions at each stage. Handling referred to the treatment of the meatballs throughout the production process, while distribution involved the delivery of products to consumers, including factors such as refrigerated truck temperature, temperature fluctuations, and loading duration.

Initially, similar treatments were applied across all factors, making it difficult to identify the root cause of the quality problem. Further investigation revealed a significant increase in sales volume during January, when production consistently exceeded 500 kg, compared to approximately 100 kg in other months. This increase led to deviations in the production process, particularly in drying time. While the standard drying time was two hours for 100 kg of meatballs, the same duration was applied to 500 kg of production. As a result, the final product was insufficiently dried, remained moist, and was immediately packaged to meet the 500 kg sales demand. This condition was identified as the key factor contributing to the decline in meatball quality. The production process is illustrated as follows:

Raw Material Weighing
Mixing of Raw Materials in the Bowl Cutter
Meatball Forming Using the Forming Machine at 65°C
Boiling for Cooking at 85°C
Drying and Cooling of Meatballs
Packaging
Delivery Using Refrigerated Truck

The study continued by using TPC test on meatballs that meet the capacity of the drying time of 100kg in 2 hours compared to 500kg meatballs drying 2 hours. The results of the test obtained 500kg meatballs have TPC 860,000,000. Far TPCnya compared to meatballs 100kg 2H drying that TPC only has 5,100. This is what makes the meatballs become slimy, milky and bulging and broken in the end in the packaging of the meatballs.

The research continued by increasing the drying time of the 500kg meatballs to 10 hours. When followed by TPC test results back to 4,600. When the product was sold no more slimy and milky products were found.Test

3. RESULTS

Ishikawa Factor Diagram

A detailed examination of all factors determining the effectiveness of the Ishikawa Diagram was conducted. Problem-solving efforts must consider all relevant departments involved in the production system. As demonstrated in this study, the sales volume during a specific period played a decisive role in causing deviations in the quality of the meatballs sold. Consequently, additional processing time was required for the production volume of 500 kg of meatballs.

Total Plate Count (TPC) Test

The TPC test can be used as empirical evidence to identify the development of microorganisms in a product. This test can be repeated for each production batch and serves as a critical indicator of product quality.

Ishikawa Diagram as a Quality Management Learning Medium

The results of implementing the Ishikawa Diagram at the meatball manufacturing plant in Bandung indicate that this tool is capable of systematically identifying the root causes of product quality deterioration through a cause–effect approach. The contributing factors to quality problems were classified into several main aspects, including machinery, raw materials, human resources (employees), production process flowcharts, handling, and distribution. In the educational context, these findings demonstrate that the Ishikawa Diagram functions not only as an industrial quality analysis tool but also as an effective learning medium for quality management based on real industrial case studies. Learners are able to understand that quality problems are not singular in nature but arise from the interaction of multiple interrelated factors within a production system.

The findings further show that the Ishikawa Diagram is effective as a contextual and applicative quality management learning medium. The visualization of cause–effect relationships facilitate learners' understanding of the complexity of production systems and enhances their ability to develop systems thinking skills. This aligns with educational management learning principles that emphasize the integration of theory and practical field applications [8]. Through real industrial case studies in the meatball industry, quality management learning becomes less abstract and more contextual and relevant to workplace demands. Learners can therefore develop analytical, collaborative, and problem-solving skills that are essential in industrial settings.

Root Cause Identification as a Problem-Based Learning Process

Further analysis revealed that, at the initial stage, all production factors appeared to receive similar treatment, making it difficult to identify the primary cause of quality deterioration. However, in-depth investigation revealed a significant increase in production volume during January, rising from an average of 100 kg to 500 kg per production cycle. This increase in volume was not accompanied by adjustments to the drying time, which remained fixed at two hours. As a result, large batches of meatballs remained moist and were immediately packaged to meet distribution demands. These findings confirm that the mismatch between production capacity and Standard Operating Procedures (SOPs) constituted the main root cause of the quality problem.

From an educational perspective, this identification process reflects the implementation of problem-based learning in quality management education, where learners are trained to analyze problems systematically, critically, and based on empirical data rather than assumptions or perceptions. The findings also emphasize that quality issues often arise due to inconsistencies between production policies and field-level implementation. In educational contexts, this provides an important lesson that quality management is not solely related to technical procedures but also involves managerial decision-making, capacity planning, and consistent adherence to established standards [9,10]. Case-based learning, as demonstrated in this study, can therefore serve as an effective instructional model in quality management, operations management, and quality control courses by training learners to analyze real-world problems comprehensively.

Strengthening Empirical Evidence through Total Plate Count (TPC) Testing

The TPC test results revealed a highly significant difference between meatball products produced with different production volumes and drying times. Meatballs produced in a 500 kg batch with a drying time of two hours showed a TPC value of 860,000,000, which was substantially higher than that of meatballs produced in a 100 kg batch with the same drying duration, which exhibited a TPC value of only 5,100. After adjusting the drying time to 10 hours for the 500 kg batch, the TPC value decreased drastically to 4,600, and no further cases of slimy texture, milky exudate, swelling, or packaging rupture were observed. These results confirm that appropriate control of the production process has a direct and significant impact on product quality.

In the learning context, the use of TPC testing as supporting data strengthens evidence-based learning, where learners not only analyze problems conceptually but also understand the importance of laboratory data in quality management decision-making. The application of the Ishikawa Diagram in this study therefore has strong pedagogical implications for vocational education and applied higher education. This tool can be utilized as a collaborative learning instrument in classrooms, quality management simulations, and industry-based learning projects. Furthermore, the integration of TPC test data into learning activities enhances learners’ data literacy and scientific understanding, ensuring that graduates not only comprehend quality management concepts but are also capable of making decisions based on scientific evidence [11,12]. Consequently, the findings of this study reinforce the position of the Ishikawa Diagram not only as an industrial quality control tool but also as an effective, contextual, and industry-relevant learning medium for quality management.

4. CONCLUSIONS

The existence of a detailed production process must always be controlled in every existing process. Because every difference in treatment will produce different products. Drying factor and length of time become a point of things that should be a concern in the process of making meatballs. In addition to providing solutions to product quality problems in the food industry, this study confirms that the application of Ishikawa diagrams has strategic value in the context of education and educational management, especially as a learning medium for Quality Management based on real case studies. The use of Ishikawa diagrams supported by empirical data through the TPC test allows Learning participants to systematically integrate conceptual understanding with field practice. This shows that quality management learning will be more effective if it is designed contextually, problem-based, and oriented to data-based decision making. Thus, this study recommends the use of Real Industry case studies as part of learning strategies in vocational education and applied higher education in order to improve the analytical competence, systemic thinking, and readiness of graduates to face the challenges of the world of work.

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