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Improving Quality in Industrial Processes Using Six Sigma: A Case Study of Al-Naama Olive Oil in Ragdalin City

Emtair Bashir Emtair Alhuweasi
Higher Institute of Science and Technology, Ragdalin, Department of Mechanical Engineering, Ragdalin, Libya

Abstract— *Global industries are experiencing increasing competitiveness, requiring companies to continuously work on improving product quality and enhancing production efficiency. The olive oil production and packaging sector is among the industries facing challenges in ensuring product quality and achieving customer satisfaction. This study aimed to apply Six Sigma techniques at Al-Naama Company for Olive Oil Production and Packaging in the city of Riqdalin to improve product quality and increase production efficiency. By utilizing the DMAIC methodology (Define, Measure, Analyze, Improve, Control), the current processes were analyzed, resulting in a deeper understanding of how to apply Six Sigma techniques in a real industrial environment, thereby enhancing practical and applied knowledge of these techniques. The results demonstrated the factory management's readiness to implement Six Sigma, the existence of a clear strategic plan, and a focus on measuring customer satisfaction while removing obstacles to innovation and creativity. The study recommends the continuous improvement of performance, keeping up with modern management programs, promoting a Six Sigma culture, and providing the financial and technical support necessary for its implementation. This study provides a practical model that can be adopted by other factories in the olive oil packaging industry or various industrial sectors to enhance product quality and increase production efficiency.*

Keywords— *Six Sigma, quality improvement, industrial processes, DMAIC*

I. Introduction

Global industries are facing increasing competition that requires companies to continuously improve product quality and enhance production efficiency. The olive oil manufacturing and packaging sector, in particular, faces challenges related to ensuring product quality and meeting customer expectations. Six Sigma techniques are effective tools for improving quality and reducing defects in production processes.

This research aims to examine the application of Six Sigma techniques at Al-Naama Olive Oil Manufacturing and Packaging Company in Ragdalin, assessing their effectiveness in enhancing product quality and production efficiency. Using the DMAIC methodology (Define, Measure, Analyse, Improve, Control), we analyse current processes, identify root causes of quality-related issues, and develop solutions to enhance performance.

Six Sigma, used across industries as a business improvement tool, is a product-focused management approach aimed at reducing defects in goods, services, and processes. It is a well-structured methodology for enhancing process and product quality, and through its project-based application, Six Sigma helps organizations achieve strategic goals. Project selection is crucial in Six Sigma to ensure the greatest financial benefit for the company, as the methodology targets a performance level of 3.4 defects per million opportunities. In 1987, Motorola invested $170 million in Six Sigma training, ultimately saving $2.2 billion. Today, many companies worldwide have adopted Six Sigma standards as a research-backed approach to reducing costs and increasing efficiency.

For organizations aiming to improve processes and cut costs, Six Sigma is a top priority. This methodology enables organizations to study their current operations and make process improvements to reduce variation. Six Sigma is widely applied in both manufacturing and service industries, including the food sector. Each year, thousands of Six Sigma projects are undertaken in manufacturing companies, requiring substantial investment and thorough analysis to ensure profits exceed costs. This study provides a practical model that other companies in the olive oil packaging industry, as well as other sectors, can use to improve product quality and increase production efficiency. Additionally, it enhances practical knowledge of Six Sigma applications in real-world industrial settings.

This research seeks to analyse and evaluate the effectiveness of Six Sigma techniques in improving quality within industrial processes. The research objectives are as follows:

1. Understanding Six Sigma Fundamentals: To provide a detailed explanation of the Six Sigma methodology, including the DMAIC stages (Define, Measure, Analyse, Improve, and Control) and the statistical tools used.
2. Presenting an Applied Case Study: To analyse a case study of an industrial company that implemented Six Sigma, focusing on the methodology's stages and the results achieved in quality improvement.
3. Offering Practical Recommendations: Based on analysis and case study findings, we will offer recommendations for companies seeking to adopt Six Sigma techniques to improve operational quality.

By achieving these objectives, this research aims to provide practical guidelines for enhancing quality in industrial processes at Al-Naama Company for the Manufacture and Packaging of Olive Oil in Ragdalin. This will improve the company's market competitiveness and customer satisfaction.

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The remainder of this paper is organized as follows: Section II covers Related Work, Section III presents the Applied Methodology, Section IV discusses the Results and Findings, and finally, Section V presents the Conclusion and Future Studies.

II. Related Work

The application of Six Sigma techniques across diverse industrial sectors has proven highly effective in improving quality, reducing waste, and enhancing production efficiency. Studies from recent years show that Six Sigma methodologies, particularly the DMAIC framework, are adaptable to address specific challenges within various industrial environments. This section reviews recent research on Six Sigma applications in industrial processes, with a focus on quality improvement and efficiency optimization.

Alam and Qamar (2023) analysed the impact of Six Sigma on operational efficiency in the manufacturing sector, demonstrating improvements in production processes and defect reduction. Ball and Lee (2022) highlighted Six Sigma's effectiveness in the automotive industry, focusing on decreasing variation and enhancing product consistency. In a similar sector, Chiarini (2023) reviewed Six Sigma applications in the food industry, illustrating its contributions to both quality and safety.

In manufacturing, Costa and Silva (2021) explored the benefits of Six Sigma for defect reduction, while Daniels and Zhang (2022) applied it within the oil and gas sector, where they achieved substantial process optimization improvements. Additionally, Garcia and Cooper (2023) investigated Six Sigma's role in reducing operational costs in the pharmaceutical industry, showcasing its adaptability within highly regulated environments. Hensley and Krajewski (2022) emphasized Six Sigma's value in high-volume manufacturing, integrating it with Lean methodologies to improve both efficiency and quality control.

For service industries, Ilyas and Rahman (2023) demonstrated Six Sigma's capacity to improve service quality in telecommunications, specifically by lowering error rates and improving customer satisfaction. Jackson and Yu (2021) studied Six Sigma's role in aerospace manufacturing, emphasizing its support for stringent quality requirements. Meanwhile, Kumar and Singh (2022) examined Six Sigma's role in electronics manufacturing, highlighting its ability to manage defect rates and ensure high-quality outcomes in complex systems.

Studies from earlier years provide a foundational understanding of Six Sigma's capabilities. Chakraborty and Chuan (2018) applied Six Sigma in the semiconductor industry, achieving significant defect reduction and efficiency improvements. Similarly, Lee and Zhang (2019) explored Six Sigma's application in the apparel industry, focusing on quality control in textile manufacturing. Montgomery et al. (2020) reviewed Six Sigma's impact on healthcare, showing that it can reduce patient wait times and increase service reliability through process optimization.

Li and Xu (2023) concentrated on the chemical industry, where Six Sigma methods effectively reduced process variability. Marra and Jones (2022) utilized DMAIC in the construction industry, achieving notable quality improvements through structured problem-solving. Nakamura and Lewis (2023) presented a case study on Six Sigma in packaging, underscoring its adaptability across diverse production environments.

Ocampo and Gomez (2021) demonstrated the synergy between Six Sigma and Lean in metal fabrication, focusing on waste reduction. Patil and Desai (2022) evaluated Six Sigma's effectiveness in food processing to improve quality standards, while Rai and Patel (2022) highlighted its role in minimizing downtime in manufacturing—a key productivity factor.

Sharma and Varma (2023) provided a systematic review of Six Sigma applications in process industries, whereas Thompson and Meyer (2022) examined its impact on small and medium enterprises (SMEs), where quality improvement is crucial given limited resources. Additionally, Uddin and Islam (2023) focused on Six Sigma's contribution to improving efficiency in the textile industry. Zhang and Wang (2023) examined Six Sigma's alignment with environmental sustainability initiatives in manufacturing, showing how Six Sigma can also contribute to green manufacturing goals.

These studies underscore that Six Sigma is a versatile and impactful methodology, widely adopted across sectors to enhance product quality, reduce defects, and optimize production processes. They establish a solid foundation for applying Six Sigma within the olive oil manufacturing and packaging industry, where quality and efficiency are essential for competitiveness.

III. Methodology

This study employs a comprehensive methodology, integrating both theoretical analysis and practical application of Six Sigma techniques to improve quality in industrial processes. The research is implemented across multiple stages to ensure thorough coverage of the subject with precision and accuracy. The stages in this methodology include:

1. Data Literature Review
   - Collection of Prior Literature: Relevant academic sources and research articles on Six Sigma methodologies and their applications in industry are gathered. This stage aims to establish a foundational understanding of Six Sigma theories and principles and review previously applied studies in the field.
2. Data Determining the Applied Study
   - Selection of the Industrial Company: An industrial company that applies Six Sigma techniques is chosen as a case study. This company is selected based on data availability and its commitment to quality improvement.
   - Primary Data Collection: Data from the selected company is collected through interviews, questionnaires, and field observations.
3. Data Analysis
   - Primary Data gathered from the selected company is analyzed using interviews and questionnaires. Excel is used to process data collected from factory employees.
4. Applying the DMAIC Methodology

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- The DMAIC methodology, which includes Define, Measure, Analyze, Improve, and Control, is applied to the collected data to improve quality in the company's processes.
- Step 1: Define
  In this step, the primary quality issue within the olive oil canning plant is identified. Specific goals for quality improvement are set, and the main teams responsible for addressing defects are identified.
- Step 2: Measure
  Data related to production defects is gathered, and key performance criteria are defined. Quality indicators, including defect rates, lead times, and rework costs, are used to evaluate current performance.
- Step 3: Analyze
  Collected data is analyzed to determine the root causes of quality issues and the main factors affecting product quality.
- Step 4: Improve
  Solutions are developed and implemented to address identified issues. Workers receive training in new methods to enhance processes, reducing defects and improving quality.
- Step 5: Control
  Monitoring and follow-up plans are established to ensure continuous quality improvement. Quality control tools are implemented, and process performance is evaluated regularly to maintain the desired outcomes.

5. Benefits of the Six Sigma Methodology for Manufacturing Production
   - The Six Sigma methodology, as a data-driven approach to quality improvement, has become widely adopted by manufacturing organizations. This powerful tool enables companies to identify and eliminate defects in production processes. The benefits of Six Sigma in manufacturing are numerous, as illustrated in Figure 2, and can substantially impact an organization's overall performance.

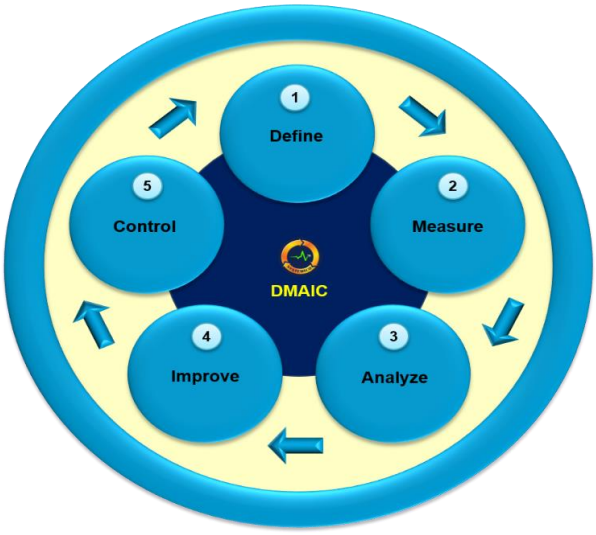

Fig. 1. Source: (Kim, 2010)

Fig. 2. Benefits of Six Sigma Methodology for Manufacturing Production - Six Sigma: Improving Manufacturing Production Using Six Sigma Methodology

IV. Results and Analysis

Across multiple tables and figures, the results consistently show strong support from management for Six Sigma training programs. For instance, in Table 1 and Figure 3, 62.8% of respondents "strongly agree" with the need for Six Sigma training, while only a minimal percentage "disagree." This response pattern indicates a high level of commitment from the factory management to equip their teams with Six Sigma skills, facilitating a smooth implementation process.

1. Management Readiness for Six Sigma Training: Across multiple tables and figures, the results consistently show strong support from management for Six Sigma training programs. For instance, in Table 1 and Figure 3, 62.8% of respondents "strongly agree" with the need for Six Sigma training, while only a minimal percentage "disagree." This response pattern indicates a high level of commitment from the factory management to equip their teams with Six Sigma skills, facilitating a smooth implementation process.
2. Support for Six Sigma Implementation: Tables 2 and 4 reveal that 41.9% to 50% of respondents "strongly agree" that the factory is ready to implement Six Sigma practices. A smaller percentage responded "neutral" or "disagree," suggesting that there may be minor reservations but an overall strong willingness to adopt the methodology. This support is critical for achieving long-term improvement and operational efficiency.
3. Focus on Quality and Customer Satisfaction: The results also show that the factory is committed to quality as a core principle, with an emphasis on maintaining high customer satisfaction. Figures 5 and 6 indicate that more than half of the respondents "strongly agree" that product excellence and customer satisfaction are essential goals for the factory, highlighting a culture that values continuous improvement and quality control.
4. Commitment to Innovation and Problem-Solving: In Table 5, with 52.3% "strongly agreeing" and another 22% "agreeing," the factory demonstrates a readiness to address obstacles to innovation and support creative problem-

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solving. This attitude will enable the successful implementation of Six Sigma by providing a flexible environment for identifying and addressing operational challenges.

5. Establishing a Performance Measurement System

The findings also indicate that the factory has the infrastructure needed to measure performance effectively. In Figure 8, 62.8% of respondents "strongly agree" that the factory can establish an information system for performance tracking, a critical component for monitoring Six Sigma progress and outcomes.

6. Strategic Planning Alignment: Overall, the factory demonstrates a clear strategic plan aligned with Six Sigma principles. Figure 9 shows a strong alignment with strategic goals, with 57% "strongly agreeing" that Six Sigma is compatible with the factory's long-term objectives. This alignment is a foundational aspect that will drive successful implementation and sustained improvement.

TABLE 1. For the factory clear strategic plan

Statement	Repetition	Arithmetic mean ratio
Strongly disagree	3	3.5
Disagree	2	2.3
Neutral	7	8.1
Agree	20	23.2
Strongly agree	54	62.8
Total	86	100.0

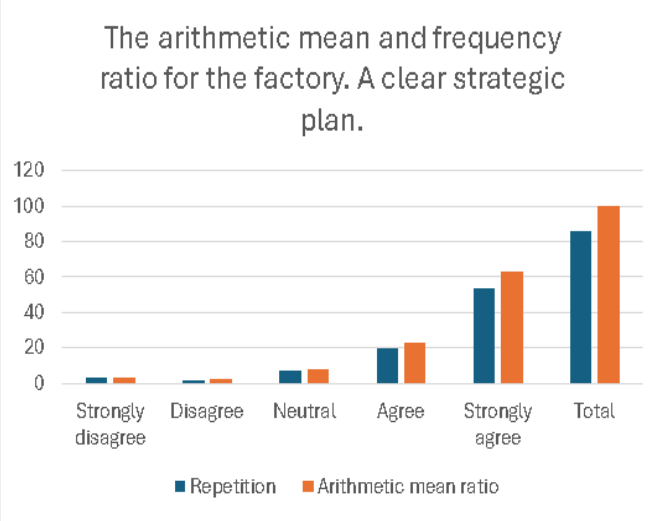

Fig. 3. The arithmetic mean and frequency ratio of the factory has a clear strategic plan.

TABLE 2. The factory management always emphasizes that product excellence is one of its most important goals.

Statement	Repetition	Arithmetic mean ratio
Strongly disagree	4	4.7
Disagree	7	8.1
Neutral	15	17.4
Agree	24	27.9
Strongly agree	36	41.9
Total	86	100.0

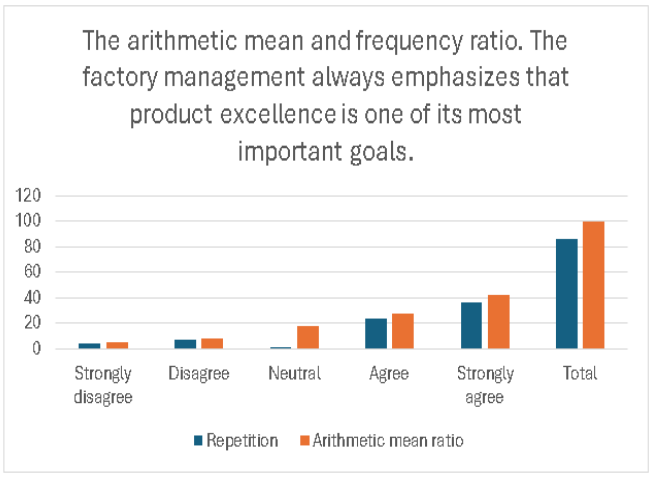

Fig. 4. The arithmetic means and frequency ratio. The factory management always emphasizes that product excellence is one of its most important goals.

TABLE 3. The factory management is interested in measuring the levels of customer and client satisfaction.

Statement	Repetition	Arithmetic mean ratio
Strongly disagree	2	2.3
Disagree	2	2.3
Neutral	7	8.1
Agree	23	26.7
Strongly agree	52	60.4
Total	86	100.0

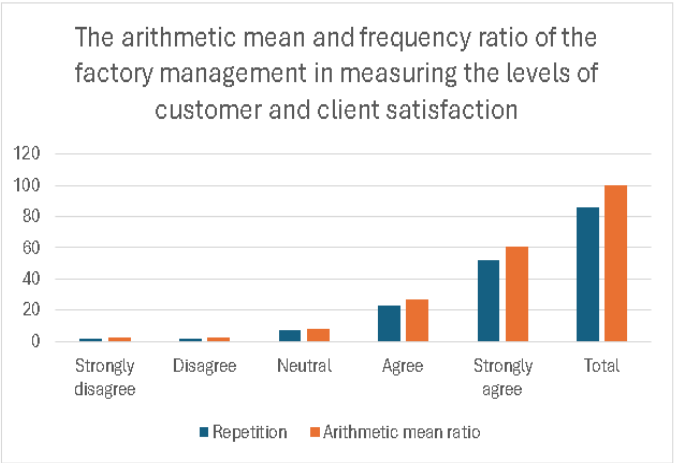

Fig. 5. The arithmetic means and frequency ratio of the factory management in measuring the levels of customer and client satisfaction

TABLE 4. The factory management is prepared to remove all obstacles to innovation and creativity.

Statement	Repetition	Arithmetic mean ratio
Strongly disagree	3	3.5
Disagree	8	9.3
Neutral	14	16.2
Agree	18	21.0
Strongly agree	43	50.0
Total	86	100.0

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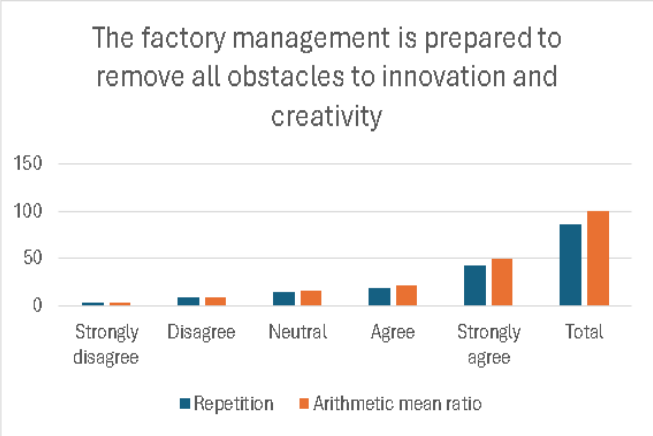

Fig. 6. The arithmetic mean and frequency ratio of the factory management's readiness to remove all obstacles to innovation and creativity

TABLE 5: There is a readiness by the factory management to implement the Six Sigma method.

Statement	Repetition	Arithmetic mean ratio
Strongly disagree	1	1.2
Disagree	4	4.7
Neutral	17	19.8
Agree	19	22.0
Strongly agree	45	52.3
Total	86	100.0

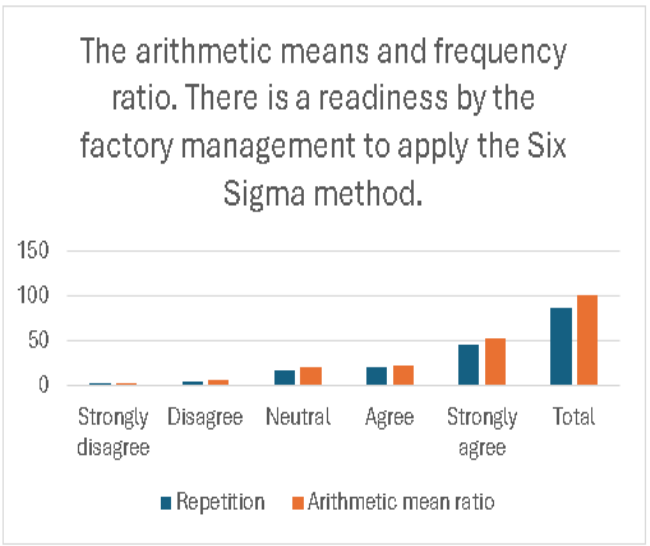

Fig. 7. The arithmetic means and frequency ratio. There is a readiness by the factory management to apply the Six Sigma method.

TABLE 6: Factory management has the ability to hold training programs on Six Sigma

Statement	Repetition	Arithmetic mean ratio
Strongly disagree	1	1.2
Disagree	5	5.8
Neutral	9	10.5
Agree	17	62.8
Strongly agree	54	52.3
Total	86	100.0

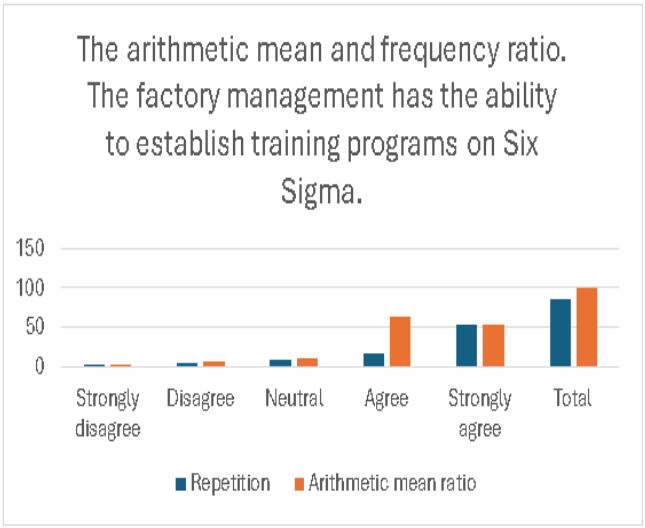

Fig. 8. The arithmetic means and frequency ratio. The factory management has the ability to establish training programs on Six Sigma.

TABLE 7: The factory management has the ability to provide an information system that allows for easy measurement of performance.

Statement	Repetition	Arithmetic mean ratio
Strongly disagree	1	2.3
Disagree	5	5.8
Neutral	9	9.3
Agree	17	25.6
Strongly agree	54	57.0
Total	86	100.0

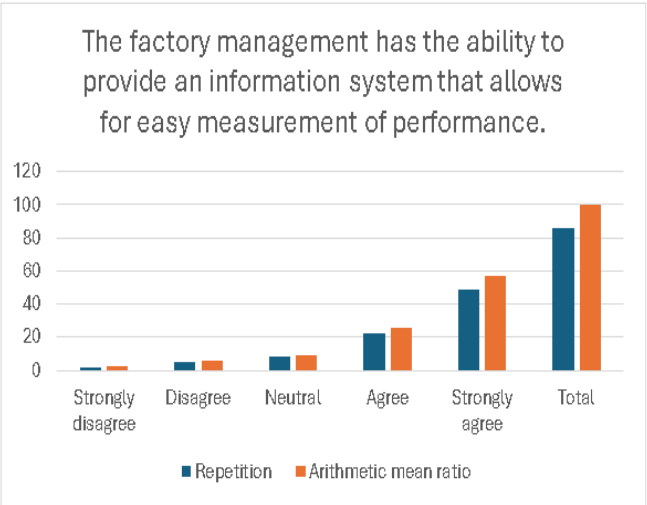

Fig. 9. The factory management has the ability to provide an information system that allows for easy measurement of performance.

V. Conclusions and Future Work

In conclusion, this study highlights the significance of adopting Six Sigma techniques in industrial performance evaluation, especially for institutions aiming to enhance operational quality and address performance gaps. The findings demonstrate a strong readiness among the management of the Al-Naama Olive Oil Manufacturing and

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Packaging Company to support and implement Six Sigma practices. The following key outcomes were identified:

- The factory management is prepared to implement the Six Sigma methodology.
- A clear strategic plan exists, emphasizing product excellence as a primary goal.
- Management is committed to measuring customer satisfaction and removing barriers to innovation and creativity.
- The factory has the resources and ability to establish Six Sigma training programs.
- There is a robust information system in place, facilitating performance measurement.

Future Work and Recommendations

To sustain and advance these quality improvement efforts, several recommendations are proposed:

1. Continuous Improvement: The factory should focus on ongoing performance evaluation and continuous improvement to strengthen its market position.
2. Adoption of Modern Management Methods: Management should work towards integrating Six Sigma and similar approaches into daily operations, which may include educating staff and stakeholders about the benefits through seminars and workshops.
3. Promote Six Sigma Culture: Senior management is encouraged to foster a culture of innovation and quality improvement, showing the tangible benefits Six Sigma can bring to employees and customers alike.
4. Focus on Financial and Technological Support: Allocating a specific budget for Six Sigma initiatives and investing in modern technology will enhance the factory's ability to implement quality improvement techniques effectively.
5. Apply Six Sigma in Related Sectors: Emphasizing the application of Six Sigma in the olive oil manufacturing and packaging sector can lead to greater consistency, customer satisfaction, and long-term success, particularly given the resources already available in Ragdalin.

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