REPUBLIC OF TÜRKİYE

ALTINBAŞ UNIVERSITY

Institute of Graduate Studies

Industrial Engineering

IMPLEMENTATION OF PERFORMANCE MANAGEMENT IN THE PASTRY ASSEMBLY AREA ACCORDING TO LEAN-SIX SIGMA

Salma AKHLIJ

Master's Thesis

Supervisor

Asst. Prof. Dr. Fatih YİĞİT

İstanbul, 2024

IMPLEMENTATION OF PERFORMANCE MANAGEMENT IN THE PASTRY ASSEMBLY AREA ACCORDING TO LEAN-SIX SIGMA

Salma AKHLIJ

Industrial Engineering

Master's Thesis

ALTINBAŞ UNIVERSITY

2024

The thesis titled IMPLEMENTATION OF PERFORMANCE MANAGEMENT IN THE PASTRY ASSEMBLY AREA ACCORDING TO LEAN SIX SIGMA prepared by SALMA AKHLIJ and submitted on 24 /01/ 2024 has been **accepted unanimously** for the degree of Master of Science in Industrial Engineering.

Asst. Prof. Dr. Fatih YIGIT

Supervisor

Thesis Defense Committee Members:

Asst. Prof. Dr. Fatih YİĞİT	Industrial Engineering Department, Altınbaş University	
Asst. Prof. Dr. Engin SANSARCI	Industrial Engineering Department, Altınbaş University	
Asst. Prof. Dr. Ali İHSAN ÖZEROĞLU	International Relations Department, İstanbul Rumeli University	

I hereby declare that this thesis meets all format and submission requirements of a Master´s thesis.

I hereby declare that all information/data presented in this graduation project has been obtained in full accordance with academic rules and ethical conduct. I also declare all unoriginal materials and conclusions have been cited in the text and all references mentioned in the Reference List have been cited in the text, and vice versa as required by the abovementioned rules and conduct.

Salma AKHLIJ

Signature

DEDICATION

In the name of Allah, the Most Gracious, the Most Merciful.

With hearts filled with gratitude, I commence this humble dedication, acknowledging the infinite blessings bestowed upon us by Allah. It is with deep reverence and appreciation for His guidance that we embark on this journey of knowledge and achievement.

I dedicate this significant event in my life to the memory of my father, taken from us too soon. I hope that, from the afterlife that now belongs to him, he appreciates this humble gesture as a token of gratitude from a daughter who has always prayed for the salvation of his soul. May God, the Almighty, have him in His holy mercy.

To my mother, who sacrificed everything for me and my sisters, showered me with her love, and taught me that good things in life don’t come easily. For her unwavering support and constant presence in my life, I express my eternal gratitude through this work, however modest it may be.

Myriam, Hala, and Aya,

In testimony of my fraternal affection, deep tenderness, and gratitude, I wish you a life full of happiness and success. May God, the Almighty, watch over and protect you.

I also wish to express my sincere gratitude to my advisor and thesis supervisor, Fatih YİĞİT. Their insightful guidance, patience, and invaluable support have been fundamental pillars throughout this academic journey. Their contribution has been crucial to the completion of this work. I am grateful for the opportunity to benefit from their expert guidance and benevolent mentorship.

Nouhayla.B, Leila E, Kalid D, Maryam N and all others,

A heartfelt thank you for your unwavering moral support, for the memories steeped in our sincere and profound friendship, and for the enjoyable moments we have shared together. Your presence has been an invaluable source of comfort and joy throughout this journey. The shared laughter, overcome challenges, and celebrated successes will forever be etched in my memory. Each of you has added a special touch to my life, and I am grateful to have such exceptional friends. May our friendship endure and continue to grace our lives with precious moments.

To my dear MEHDI, your love and encouragement have been a constant source of inspiration. Thank you for standing by me and being my pillar of strength. Your presence in my life adds a special warmth to every achievement. I am grateful for your unwavering support and love.

ABSTRACT

IMPLEMENTATION OF PERFORMANCE MANAGEMENT IN THE PASTRY ASSEMBLY AREA ACCORDING TO LEAN-SIX SIGMA

AKHLIJ Salma

M.Sc., Industrial Engineering Department, Altınbaş University

Supervisor: Asst. Prof. Dr. Fatih YIĞIT

Date: January / 2024

Pages: 69

Effective performance management is integral to the success of any business, serving as a linchpin for ensuring operational efficiency and effectiveness. This holds especially true in the realm of pastry assembly, where the intricacies of various production stages demand a meticulous approach to guarantee the timely and cost-effective creation of high-quality products. Within the pastry assembly area, the implementation of a robust performance management system emerges as a critical necessity. This system acts as a guiding force, ensuring that each facet of the production process aligns seamlessly to yield exceptional outcomes. In recent years, the Lean-Six Sigma methodology has garnered increasing attention as an innovative approach to performance management. This dual-pronged strategy integrates Lean principles, emphasizing the elimination of waste and continuous improvement, with Six Sigma methodologies, focusing on reducing defects and variations. The amalgamation of these methodologies not only promises heightened efficiency but also champions a culture of perpetual refinement within the pastry production landscape.

This thesis delves into the exploration of the applicability and impact of Lean-Six Sigma in the pastry assembly context. Through empirical analysis and case studies, the research aims to elucidate the tangible benefits and challenges associated with the adoption of this performance management approach. By shedding light on the practical implications, this study seeks to contribute valuable insights to the broader discourse on optimizing operational performance in the intricate domain of pastry production.

Keywords: Lean Six Sigma, Performance Management, Operational Efficiency, Pastry Assembly, Production.

TABLE OF CONTENTS

Pages

ABSTRACT .... **vii**

LIST OF TABLES .... **xi**

LIST OF FIGURES .... **xii**

ABBREVIATIONS .... **xiii**

1. INTRODUCTION **1**

2. LITERATURE REVIEW **4**

2.1 LEAN 4

2.1.1 Lean Manufacturing Tools 7

2.2 SIX SIGMA 8

2.3 LEAN SIX SIGMA 10

3. METHODOLOGY **13**

3.1 PERFORMANCE MANAGEMENT 13

3.1.1 Objectives of Performance Management 13

3.1.1.1 Benefits 13

3.1.1.2 Application 14

3.2 LEAN SIX SIGMA 14

3.2.1 Definition 14

3.2.2 Major Lean Objectives 14

3.2.3 Principle of Lean 14

3.2.4 Lean Methods 16

3.3 THE "DMAIC" APPROACH 16

3.4 TOOLS & METHODS 19

3.4.1 Who, What, Where, When, Why, How Method 19

3.4.2 Ishikawa Diagram 19

3.4.3 Pareto Chart 20
3.4.4 Overall Production Effectiveness 21
4. APPLICATION 22
4.1 COMPANY PRESENTATION 22
4.1.1 Paul's History in Morocco 22
4.1.2 Company's Identity Sheet 23
4.1.3 DELI'S Products 24
4.1.3.1 OHC products 24
4.1.3.2 Paul's products 25
4.2 MANUFACTURING PROCESS 26
4.3 QUALITY CONTROL 29
4.3.1 Certifications 30
4.3.1.1 Prerequisite Programs 30
4.3.1.2 HACCP System 30
4.3.1.3 Standard 30
4.3.2 Organoleptic Test 30
4.4 EXPERIMENTAL SECTION 31
4.4.1 The "Define" Phase 31
4.4.2 The "Measure" Phase 34
4.4.3 The “Analyse” Phase 42
4.4.3.1 Analysis and Interpretation of Results: 42
4.4.3.2 Monetary Cost of Losses in the Pastry Assembly Zone: 43
4.4.4 The “Innovate/Improve” Phase 47
4.4.4.1 Skills and Resources 48
4.4.4.2 Awareness meeting 50
4.4.4.3 The 5 S approach 50
5. CONCLUSIONS 53
REFERENCES 55
APPENDIX A 58
APPENDIX B 60

LIST OF TABLES

Pages

Table 3.1: The Eight Core Lean Methods. 16

Table 4.1: Head Quarter's Identity Card. 23

Table 4.2: Factory´s Identity Card. 23

Table 4.3: Lab-Specific Products. 24

Table 4.4: The Specific Raw Materials for Each Laboratory. 27

Table 4.5: Problem Vision Using the WWWWHW Method. 32

Table 4.6: Project Charter. 33

Table 4.7: Product Families. 34

Table 4.8: Timing of Each Product Assembly Step. 36

Table 4.9: Calculated Times for Each Product and Their Assembly Rate. 39

Table 4.10: Calculation of OPE. 41

Table 4.11: Loss Calculation for Each Product. 44

Table 4.12: Losses per Family. 44

Table 4.13: Major Causes of Stoppages. 46

Table 4.14: List of Materials Required. 49

Table 4.15: The 5s. 51

LIST OF FIGURES

Pages

Figure 3.1: The "DMAIC" Process of Six Sigma [22]. 17

Figure 3.2: Ishikawa Diagram. 20

Figure 4.1: The History of PAUL in Morocco from the End of 1998 to the Present. 22

Figure 4.2: Some OHC Products. 25

Figure 4.3: Paul's Pastries and Viennoiseries. 25

Figure 4.4: Manufacturing Circuit Diagram. 26

Figure 4.5: Rotary Oven for Cooking. 27

Figure 4.6: "KOMA" Freezer. 28

Figure 4.7: Conditioning. 28

Figure 4.8: Hermetic Press. 28

Figure 4.9: Working In the Pastry Lab. 32

Figure 4.10: Graphic Representation of the OPE. 43

Figure 4.11: Percentage of Losses for Each Family. 45

Figure 4.12: Ishikawa Diagram. 46

Figure 4.13: Pareto Chart. 47

ABBREVIATIONS

D.M.A.I.C	:	Demand, Measure, Analyse, Improve, Control
FSSC	:	Food Safety System Certification
GFSI	:	Global Food Safety Initiative
ISO	:	International Organization for Standardization
ISO/TS	:	International Organization for Standardization / Technical Specification
OPE	:	Overall Process Efficiency
LSS	:	Lean Six Sigma
10 P	:	10 Persons
5 M	:	Environment, Material, Manpower, Method, Equipment
5 S	:	Seiri, Serton, Seiso, Seiketsa, Shitkonke
PRP	:	Pre-requisite Programms
WWWWHW	:	Who, What, When, Where, How, Why
CTQ	:	Critical to Quality
OHC	:	Out of Home Catering
TMR	:	Minimum Repeatable Time

1. INTRODUCTION

In the contemporary business landscape, the vitality of the production function cannot be overstated. Irrespective of whether an entity operates in the service or manufacturing sector, the prosperity of a business is intricately connected to its prowess in consistently delivering high-quality products while optimizing costs. Any disruption in the orchestration of product manufacturing or delivery can lead to a cascade of consequences ranging from costly rejections to additional expenditures and customer complaints that have the potential to significantly undermine the standing and profitability of the company.

Responding to the evolving challenges posed by organizational complexity and intensifying competition, companies are increasingly gravitating towards a novel philosophy—one that places a premium on the intrinsic value of products. This philosophy seeks to maximize production efficiency by eradicating all forms of waste and non-value-added operations.

Deli's, standing as a cornerstone in the semi-industrial bakery and pastry sector in Morocco, proudly serves as a key supplier to distinguished entities such as the international PAUL supermarket, major Moroccan food corporations, restaurants, and hotels. In the pursuit of fortifying its position and competitive edge, Deli's is unwavering in its commitment to elevating productivity, operational speed, and overall efficiency. The linchpin in achieving this lies in the effective performance management of its workforce, steering performance towards developmental and improvement needs.

At the heart of this endeavour lies the application of the Define, Measure, Analyze, Improve, Control approach from Lean-Six Sigma. This methodology emerges as a crucial tool, empowering Deli's to identify root causes of losses, evaluate them meticulously, and implement tailored actions to mitigate and eliminate them.

In an era where business dynamics are continually evolving, the imperatives of adaptability and strategic efficiency stand as non-negotiables. The competitive landscape demands not just survival but a commitment to excellence, particularly in industries where precision and quality intertwine seamlessly. Deli's, positioned at the forefront of the semi-industrial bakery and pastry sector in Morocco, bears the torch of this commitment. As a revered supplier to global entities and local gastronomic institutions, its narrative is one of not just delivering products but of crafting experiences and setting benchmarks.

The essence of the modern business paradigm extends beyond profit margins. It encapsulates an intricate dance between quality assurance, operational agility, and resource optimization. In the context of Deli's, this intricate dance plays out daily in its assembly area a critical juncture where raw ingredients metamorphose into delectable creations. It is here that the challenge of balancing efficiency with excellence unfolds, and where the implementation of Lean-Six Sigma performance management becomes not just a strategy but a strategic imperative.

The symbiosis of Lean and Six Sigma principles, encapsulated in the DMAIC approach, promises a paradigm shift in how Deli's approaches performance in its assembly area. This thesis embarks on a journey to unravel the layers of this shift, delving into the intricacies of Lean-Six Sigma implementation within the unique context of a bakery's assembly line.

Beyond the technical nuances, this exploration is a testament to Deli's commitment to continuous improvement. It's a narrative of resilience, adaptability, and an unwavering pursuit of excellence. As the pages unfold, the thesis not only offers a documentation of methodologies and outcomes but also aspires to be a chronicle of lessons learned, challenges surmounted, and the strategic foresight that propels Deli's towards an even more formidable future. Through this exploration, the hope is to contribute not just to the academic discourse on performance management but to offer practical insights for businesses navigating the intricate dance of modern industry dynamics.

Structured into three pivotal segments, this thesis unfolds as follows:

Chapter 1: Literature Review: A dedicated segment that functions as the theoretical backbone of the thesis. It provides an extensive review of the tools deemed indispensable for the successful execution of the project.

Chapter 2: Experimental Part: The heart and soul of the thesis, this segment ventures into the specifics of the project. It meticulously details methodologies employed, outcomes achieved, and proposes strategic corrective actions.

Chapter 3: Results part: To elevate the efficiency of our manufacturing processes, we've opted for the 'DMAIC' approach within the framework of Lean Six Sigma. This systematic methodology provides a robust structure for pinpointing the root causes of inefficiencies, assessing them comprehensively, and executing strategic actions to mitigate these issues. Our project unfolds across distinct phases, namely the 'Define' phase, 'Measure' phase, 'Analyze' phase, and 'Innovate' phase.

Through this multifaceted exploration, the thesis aims not only to document but also to distil insights, analyses, and recommendations derived from the implementation of Lean-Six Sigma performance management in the bakery assembly area. It endeavors to serve as a comprehensive guide, shedding light on the transformative journey undertaken by Deli's and offering valuable lessons for future enhancements in a dynamic business landscape.

2. LITERATURE REVIEW

The genesis of lean thinking can be traced back to (Taiichi Ohno) of Toyota, renowned for pioneering the Toyota Production System (TPS). This system emerged as a strategic response to the constraints posed by limited resources, aiming to revolutionize production processes. The concept of lean thinking, while widely recognized, is multifaceted, with its definitions adapting to different contexts. The absence of a singular and definitive description of lean can be attributed to its continual evolution over time [1] At its core, lean thinking harbors the fundamental objective of optimizing both the production and delivery of products and services. This optimization is achieved through the meticulous minimization of costs and time, effectively curtailing waste in the operational processes.

Despite the global recognition of lean principles, their effective application in developing countries faces unique challenges. The journey toward lean practices in these contexts is still in its infancy. One of the primary hurdles is the resistance to change deeply embedded in established work cultures. Additionally, traditional work practices prevalent in many developing countries pose formidable barriers to the seamless integration of lean methodologies (Douglas et al., 2017). As industries grapple with the dynamic landscape of globalization, understanding and overcoming these challenges become imperative for the successful implementation of lean thinking, fostering efficiency and sustainability in diverse economic settings.

2.1 LEAN

Lean management is a set of principles aimed at improving processes by eliminating non-value-added steps and reducing waste. Originally developed for the automotive industry, it has found widespread application in various fields. [2] Emphasizes the basic principles of Lean management, provides examples of its implementation, and equips physicians with practical tools to identify and eliminate wasteful processes. Overall, Lean management has the potential to enhance safety enable a reduction in lead times, and improve quality, stability, and customer satisfaction and experience.

Also**,** in accordance with [3], the bakery industry holds significant economic and social significance in Medellin, with a majority of companies being small and characterized by high levels of informality, low value-added, and productivity. Lean Manufacturing has emerged as a widely adopted approach for waste elimination in both the industrial and service sectors. Its practice has shown substantial benefits in terms of improving quality and organizational productivity. The bakery industry is located in the early stages of the implementation of lean manufacturing techniques, but taking into account they don´t have formal knowledge about lean, in an empirical way, they have implemented some of the topics of the improvement tools, especially related to product quality and productivity.

In other study conducted by (Gładysz, Buczacki, & Haskins 2020) food waste is a significant issue in food services, necessitating organizational improvements to reduce waste and costs. While lean management has been applied in service businesses, its specific application in the food services domain is limited, particularly regarding food waste elimination. This study examines the feasibility of using lean management methods in food services to achieve efficient operations and reduce food waste. Through a literature review and three case studies from Poland, it demonstrates the effectiveness of lean management in decreasing food waste and operational costs. The findings provide insights and recommendations for food service organizations to streamline their processes using lean management practices. Overall, this study contributes to the theory and practice of sustainable restaurant management.

The use of lean management tools in operating activities can potentially contribute to the reduction of food waste. Ongoing research aims to explore this further by applying systems dynamics modelling. This modelling approach will simulate the relationships between various lean tools and their corresponding impacts on different indicators that influence final food waste in food service organizations. By studying these relationships, the research aims to provide valuable insights into optimizing lean practices for effective food waste reduction.

As stated in the literature review written by [5] In recent years, Lean Manufacturing (LM) and Lean Six Sigma (LSS) have been increasingly adopted in academic and administrative processes within universities. This implementation has been driven by factors such as cost reductions, quality improvements, increased competition, enhanced process efficiency, and stakeholder satisfaction.

In terms of academic management processes, the literature highlights the benefits of Lean implementation, including improved study plans and enhancements to teaching processes at various education levels. On the other hand, the application of Lean in administrative management processes has shown more diverse outcomes, ranging from improvements in library book cataloguing to personnel hiring processes. The literature also suggests that there is a greater volume of research on Lean in administrative management compared to academic management.

Key facilitators for successful Lean implementation in universities include senior management commitment, proper selection and training of improvement teams, understanding customer needs, motivating employees through change, and the involvement of facilitators or consultants. Additionally, many problems encountered in universities can be categorized as different types of lean waste, demonstrating the wide range of areas where waste can be eliminated or minimized through Lean practices.

In this context a comparative study was done by [6] to explore the impact of implementing lean manufacturing (LM) in both developing and developed countries manufacturing sectors. The research addresses a gap in the existing literature by providing a comprehensive review of the effects of LM implementation in these different contexts. The findings of this study are valuable for manufacturing managers seeking insights into the implications of LM in both developed and developing nations. Moreover, it offers guidance to developing countries interested in adopting LM to improve their operations.

The study reveals that LM adoption can lead to operational improvements in both developing and developed countries. In the developing world, organizations have experienced benefits such as enhanced customer satisfaction through the timely delivery of high-quality products. The research also identifies the primary drivers and barriers faced by manufacturing organizations when implementing LM in both contexts. Notably, small and medium-sized enterprises (SMEs) encounter difficulties during LM implementation, leading to hesitancy in adopting this philosophy. The study further highlights that manufacturing organizations in both developing and developed countries have employed LM tools selectively, depending on the specific types of waste they aim to address.

2.1.1 Lean Manufacturing Tools

The introduction of lean and green production in the western manufacturing industry aimed to eliminate waste and improve competitiveness. However, some companies have faced failures due to misapplication of lean and green tools and improper implementation order. To determine the most effective lean tools for waste reduction, a study was conducted by [7] among lean companies. This study aimed to identify the best lean toolbox for each waste category and determine the appropriate sequential order of tool implementation. The stepwise multiple regression model revealed that Total Productive Maintenance, Poka-Yoke, Kaizen, 5S, Kanban, Six Big Losses, Heijunka, Takt Time, Andon, OEE, SMED, and KPIs are the best waste management techniques. Specifically, 5S, Kaizen, Kanban, Poka-Yoke, and TPM were highly recommended as the starting point for any lean manufacturing initiative.

This work identified the most frequent and significant lean tools for waste elimination among lean practitioners. By examining the occurrence of lean tools in different implementation stages, the study provided insights into the lean experts' way of thinking. It is important for organizations to investigate best practices in their industry and adapt the lean framework to their specific needs. Management must have a deep understanding of organizational waste and knowledge of the lean toolbox for successful implementation. Using lean tools that target multiple types of waste as initial steps can have a statistically significant positive impact on waste reduction. Each lean tool has its own impact on waste reduction, and management should prioritize their implementation based on organizational needs. However, it should be noted that lean implementation is a continuous process, and other factors besides lean tools influence its success and sustainability.

[8]'s paper focuses on the use of Visual Management tools to enhance the efficiency and value of construction projects. The study employed a structured survey to collect data on the usefulness and importance of 12 lean tools and techniques identified from the literature review. A total of 153 valid responses were analysed using Excel spreadsheets and SPSS 23 software. Reliability analysis, relative importance index, and cluster analysis were performed on the collected data. The findings revealed that the most significant and important lean tools and techniques for construction projects were big rooms, 5S, Last

Planner System (LPS), and Building Information Modelling (BIM), with relative importance index values of 92%, 91%, 90%, and 88%, respectively. These findings highlight the effectiveness of Visual Management tools in improving construction project outcomes.

2.2 SIX SIGMA

In other research carried out by (Nallusamy et al., s. d. 2018) aims to implement the DMAIC phases of Six Sigma to improve the rejection rate in a manufacturing industry. The global market's focus on achieving zero defects, equivalent to 3.34 defectives per million parts, highlights the importance of Six Sigma in eliminating product and process defects to maximize profits and industry value. The study utilizes various tools such as process flow analysis, Pareto chart, and fishbone diagram to identify the root causes of defects and critical factors for control and improvement. The implementation of DMAIC resulted in a significant reduction in the rejection rate from 5.3% to 1.2% in the selected manufacturing industry.

The successful implementation and increasing organizational interest in the Six Sigma method have experienced significant growth in recent years. Factors that contribute to the success of Six Sigma projects include management involvement, organizational commitment, project management and control skills, cultural change, and continuous training.

[10] Did a study with an objective to provide a comprehensive review of the benefits and challenges associated with the implementation of Lean Six Sigma (LSS) in business organizations. Additionally, this study aims also to examine the extent of LSS literature across different sectors, research methodologies, and journals. By exploring these aspects, the study aims to contribute to a deeper understanding of the application and dissemination of LSS in various contexts.

[11] Examines the implementation of Six Sigma in Indonesia and provides a summary of current evidence on its effectiveness in various sectors. Their literature study focused on the implementation of Six Sigma in Indonesia between the years 2016-2020. The study found that Six Sigma offers significant advantages in terms of improving operations, quality, productivity, cost reduction, and safety in various types of companies and organizations in Indonesia. However, the application of Six Sigma in small and medium-sized enterprises

(SMEs) faces challenges due to cost limitations, lack of personnel skills, and the time-consuming nature of Six Sigma projects. As a result, SMEs in Indonesia often prefer simpler improvement tools like kaizen and PDCA. The study suggests that future research should explore the integration of Six Sigma with the Industry 4.0 concept to further enhance its implementation.

Six Sigma, initially developed at Motorola in the mid-1980s, is a business improvement initiative created by engineer Bill Smith. [5] The term "Six Sigma" refers to the level of variability in a process, with a goal of achieving 3.4 defects per million opportunities. The main objective of Six Sigma is to identify and eliminate causes of defects or mistakes in business processes, focusing on customer-critical outputs. A key factor in the success of Six Sigma is the DMAIC methodology, which stands for Define, Measure, Analyse, Improve, and Control. DMAIC provides a structured roadmap for improvement, and it involves the systematic use of various tools throughout the project. As individuals gain expertise in these tools and engage in more projects, they develop proficiency in scientific problem-solving approaches. Ongoing research in the field aims to further enhance the understanding and application of Six Sigma principles and methodologies.

As indicated in Technology, Agility and Transformation: Emergent Business Practices the implementation of the DMAIC methodology, a key Six Sigma tool, in an ABC Led Organization to address the issue of higher rejection percentages during the production of a new product. The aim of this study was to identify and analyse the causes of rejection in order to enhance product quality and reduce financial losses and customer complaints. Through the DMAIC approach, the rejection rate was reduced from 5.8% in June 21 to 2.8% in October 21, resulting in significant cost savings and a decreased likelihood of consumer complaints regarding quality defects. This highlights the tangible benefits of implementing Six Sigma, such as improved product quality, reduced costs, shorter process turnaround times, and increased customer satisfaction. This case study demonstrates the practical implementation of the Six Sigma DMAIC methodology in the food manufacturing industry to minimize process variation and reduce rejection rates. The study not only achieved a reduction in rejection percentage but also provided valuable insights into the benefits of using statistical tools within the Six Sigma framework.

Six Sigma has an important role in reducing process variation and improving revenue while minimizing food waste in the meat processing industry per [12] It serves as a valuable benchmark for other organizations within the industry looking to implement Six Sigma. The structured approach of Define, Measure, Analysis, Improve, and Control phases outlined in the study provides a practical template for food manufacturers to follow and apply similar methods and tools. The findings of the study suggest that managers in the food industry, particularly in meat processing, can benefit from adopting the DMAIC approach to identify and address organizational problems and variations. This comprehensive understanding of root causes enables them to implement targeted improvement actions and mitigate or eliminate such issues. The DMAIC framework can be applied in other sectors and the wider meat processing industry to address organizational challenges. Additionally, training and awareness programs can enhance the competencies of the workforce, leading to improved operational productivity and environmental performance. The theoretical implications of this study contribute to the broader application of Six Sigma methods in the food industry, deepening our understanding of how it can bring benefits to the sector.

2.3 LEAN SIX SIGMA

Lean Six Sigma is a data-driven and fact-based philosophy that focuses on preventing defects and improving quality. By reducing waste, process variation, and cycle time, organizations can achieve customer satisfaction and gain a competitive advantage. Lean Six Sigma combines the principles of Lean, which aims to eliminate waste, with Six Sigma, which targets process variation reduction. The involvement of all employees is crucial for successful implementation. Numerous studies have empirically investigated the effectiveness of Lean Six Sigma in enhancing process efficiency and quality. Makwana et Patange (2019)

According to [3], the bakery industry holds significant economic and social significance in Medellin, with a majority of companies being small and characterized by high levels of informality, low value-added, and productivity. Lean Manufacturing has emerged as a widely adopted approach for waste elimination in both the industrial and service sectors. Its practice has shown substantial benefits in terms of improving quality and organizational productivity. The bakery industry is located in the early stages of the implementation of lean manufacturing techniques, but taking into account they don´t have formal knowledge about lean, in an empirical way, they have implemented some of the topics of the improvement tools, especially related to product quality and productivity.

In [14]’s paper he investigates the adoption of Lean Six Sigma (LSS) practices and their impact on performance improvement in the food industry. The study finds that LSS is relevant and effective in this sector, positively influencing performance outcomes. The level of experience of individual companies moderates the adoption of LSS practices, particularly in terms of financial gains and product quality. The sector's characteristics, such as mandatory cleaning practices, restrict the adoption of certain LSS practices like set-up time reduction. Additionally, practices requiring financial resources and statistical knowledge, such as Six Sigma role structure and Statistical Process Control, are less commonly adopted in the food industry due to low margins and complexity. The study suggests that increasing managerial awareness of the benefits of LSS practices can encourage employees to gain experience and utilize the tools effectively for performance improvement in the food industry.

Lean Six Sigma (LSS) has gained recognition as an effective business improvement methodology for minimizing variations and enhancing efficiency. However, its implementation in the food industry has been limited compared to other manufacturing sectors. [15] Addressed in their paper the gap in the literature by focusing on the pre-implementation stage of LSS in food manufacturing settings. The study aims to identify the factors that influence the readiness for LSS implementation in this industry. Semi-structured interviews were conducted with twelve food industry practitioners involved in quality management.

The primary objective of this study is to identify the factors that need to be considered when preparing for Lean Six Sigma (LSS) deployment in the food industry. The study identifies the most commonly cited LSS readiness factors, starting with management support and leadership, followed by organizational culture readiness, employee involvement, project management, process management, and external factors. A causal map illustrates the interrelationships among these factors and their impact on LSS implementation preparedness in the food manufacturing industry. It is recommended to test the grounded hypothesis to further refine the constructs.

Furthermore as stated by [16] today's complex market and business environment, organizations must prioritize meeting customer needs such as high product quality, competitive costs, and faster delivery. To effectively manage these requirements, a comprehensive approach and methodology are essential. The article focuses on the integration of Six Sigma tools and techniques with lean manufacturing principles to enhance process efficiency and product quality in the industry. This combination, known as Lean Six Sigma (LSS), is a highly effective tool that can significantly impact processes and improve customer/stakeholder satisfaction within an organization.

In another hand a study was done which examines the readiness factors of Lean Six Sigma (LSS) implementation in the food manufacturing industry [17]. Through interviews with quality practitioners and case studies of food companies, the study identifies twenty-eight factors categorized into six readiness factors: management support and leadership, organizational culture readiness, process management, project management, employee involvement, and external relations. The findings provide a diagnostic tool for food business managers to assess their readiness for LSS implementation, aiding in decision-making and investment planning. The proposed framework enables self-assessments of readiness levels and contributes to the successful and sustainable implementation of LSS practices in the food manufacturing industry. The identified readiness factors enhance understanding and facilitate organizational transformation, leading to improved LSS implementation and outcomes in food businesses.

3. METHODOLOGY

3.1 PERFORMANCE MANAGEMENT

Performance management is a vital tool used by managers to oversee and assess the work of employees. The primary objective of performance management is to establish a conducive environment where individuals can effectively leverage their skills and contribute to the organization's overarching objectives. This practice is extensively applied in both the private and public sectors [18]

3.1.1 Objectives of Performance Management

Performance management aims at building a high-performance culture for both the individuals and the teams so that they jointly take the responsibility of improving the business processes on a continuous basis and at the same time raise the competence bar by upgrading their own skills within a leadership framework. Its focus is on enabling goal clarity for making people do the right things in the right time. It may be said that the main objective of a performance management system is to achieve the capacity of the employees to the full potential in favour of both the employee and the organization, by defining the expectations in terms of roles, responsibilities and accountabilities, required competencies and the expected behaviours.[19]

3.1.1.1 Benefits

A performance management program offers numerous advantages. Firstly, it enables organizations to better communicate their common and operational goals. Additionally, it aids in mobilizing and empowering employees by clearly defining their objectives and roles.

Indeed, when performance reaches its peak, the company can reap several benefits. These may include increased organizational revenue, improved interpersonal relationships among team members, and streamlined managerial tasks through the implementation of a control system. Furthermore, when a company significantly increases its revenue, it becomes evident that all its members can reap the rewards. In this perspective, employees are encouraged to contribute more to the company's success, which, in turn, allows the organization to benefit from this enhanced performance.

3.1.1.2 Application

Applying performance management in an organization is an effective method for aligning employees' personal goals with those of the company in order to achieve organizational objectives. To ensure the performance of its team, the organization must establish a performance management system that aligns with its goals and values.

To apply a performance management system, we have implemented the DMAIC approach of Lean Six Sigma.

3.2 LEAN SIX SIGMA

3.2.1 Definition

Lean Six Sigma is a synergistic blend of established methodologies for eliminating waste and enhancing processes, specifically drawing from the strengths of Lean Manufacturing and Six Sigma. As noted by Spector R. (2006), Lean Six Sigma proves most potent in refining processes and is extensively adopted by high-performing organizations. While originating in manufacturing, it has successfully transitioned into service sectors. In the words of Ronald D. Snee (2010), Lean Six Sigma stands as a meticulously structured, theory-driven approach geared towards augmenting performance, cultivating effective leadership, ensuring customer satisfaction, and bolstering overall bottom-line results.[20]

3.2.2 Major Lean Objectives

The primary aim of Lean is to optimize quality, costs, and delivery times while actively engaging employees through a participatory approach. These refined aspects of performance collectively lead to achieving industrial excellence. Industrial excellence hinges on accomplishing three core objectives:

a. The highest quality of manufactured products.

b. The lowest cost.

c. The shortest delivery time or manufacturing process performance.

3.2.3 Principle of Lean

Lean methodology aims to eliminate the 8 forms of waste: (« Document (1).pdf », s. d.)

a. Defects: Production of products, components, or services that do not meet specified requirements, leading to issues such as scrap, rework, replacements, exceeding production timelines, and/or the use of defective materials.

b. Waiting: Delays caused by factors such as out-of-stock situations, processing delays, equipment downtime, and bottlenecks in competence.

c. Unnecessary Processing: Steps in the process that are not essential for product production.

d. Overproduction: Manufacturing surplus items without corresponding orders.

e. Movement: Unnecessary or strenuous human motions and the transportation of work-in-process (WIP) over long distances.

f. Inventory: Excessive stocks of raw materials or finished goods.

g. Unused Employee Creativity: Failure to harness employees' suggestions for process improvements.

h. Complexity: Incorporating excessive parts, intricate process steps, or requiring more time than necessary to meet customer demands.

From the above, it can be said that Lean Management solves three types of constraints: quality, costs and deadlines:

a. Quality objectives:

Increasing the quality level of the work process results in fewer errors, rework, and rejects. This leads to a more efficient use of company resources and, consequently, a reduction in the total cost of operations.

b. Cost Objectives:

At the entrance of a production facility, you'll find human resources, infrastructure, and raw materials. At the exit, you have finished products. Productivity increases when the same resources at the entrance generate a greater number of finished products at the exit, or when, for the same volume of finished products, the input factors decrease.

c. Time Objectives:

Reducing lead time: Lead time is defined as the time interval between the receipt of raw materials and the receipt of payment for sold products by the company. Reducing this interval means producing more products in the same time, improving resource turnover, and enhancing responsiveness and flexibility in meeting.

3.2.4 Lean Methods

The concepts and tools extended to Lean are very numerous. The list is obviously not complete, but it is sufficiently exhaustive to give an idea of the richness of Lean tools:

Table 3.1: The Eight Core Lean Methods.

Cellular Manufacturing / One-piece Flow Production Systems	Kaizen
5S	Kanban
Just-in-time Production	Six Sigma
Total Productive Maintenance (TPM)	Pre-Production Planning (3P)

In our case, we proceeded with the DMAIC approach, which is a basic component of the six-sigma methodology.

3.3 THE "DMAIC" APPROACH

In order to improve the performance of our manufacturing area, we have chosen the "DMAIC" approach of Lean Six Sigma. This is a rigorous methodology that will help us identify the causes of losses, evaluate them, and implement the most appropriate actions to reduce them. To do this, our project will be divided into several phases, namely: the "Define" phase, the "Measure" phase, the "Analyze" phase, and the "Improve" phase.

"DMAIC is the problem-solving method that enables the achievement of Lean Six Sigma goals, founded on data analysis to optimize and then stabilize company processes. It is an organized and rigorous methodology used in performance improvement.

Each letter of the acronym refers to a specific step in the process, as shown in Figure 1.

Figure 3.1: The "DMAIC" Process of Six Sigma [22].

i. Define the problem, improvement activity, opportunity for improvement, the project goals, and customer (internal and external) requirements.

a. Project charter: This document outlines the focus, scope, direction, and motivation for the improvement team.

b. Voice of the customer: This involves understanding feedback from current and future customers, including their needs, preferences, and any factors that satisfy, delight, or dissatisfy them.

c. Value stream map: This tool provides an overview of an entire process, starting from the initial customer contact and ending at the final customer delivery. It analyzes what is required to meet customer needs, identifying areas for improvement and optimization.

ii. Measure process performance**:**

a. Process map: This is a visual representation used to record the activities performed as part of a process. It helps in understanding the flow and steps involved in a process.

b. Capability analysis: This is conducted to assess the ability of a process to meet specified requirements or specifications. It provides insights into whether the process is capable of producing products or delivering services within desired limits.

c. Pareto chart: This graphical tool is employed to analyze the frequency of problems or causes within a process. It helps in identifying and prioritizing the most significant issues that need attention.

iii. Analyze the process to determine root causes of variation and poor performance (defects):

a. Root cause analysis (RCA): This method is used to uncover the underlying causes of issues or problems within a process. It delves deep into the root causes of variations and defects.

b. Failure mode and effects analysis (FMEA): FMEA is employed to identify possible failures that may occur in products, services, or processes. It assesses the impact of these failures and their likelihood.

c. Multi-vari chart: This tool is utilized to detect different types of variation within a process. It helps in understanding the sources of variation and their effects.

iv. Improve process performance by addressing and eliminating the root causes:

a. Design of experiments (DOE): DOE is used to solve complex problems in processes or systems where multiple factors influence outcomes. It helps in understanding how various factors interact and affect the results.

b. Kaizen event: A Kaizen event focuses on rapid change by concentrating on a specific, narrow project. It involves the active participation and ideas of the individuals directly involved in the work.

v. Control the improved process and future process performance:

a. Quality control plan: This plan documents the requirements and procedures needed to maintain an improved process at its current level of performance.

b. Statistical process control (SPC): SPC is used for monitoring and controlling process behaviour. It involves the use of statistical techniques to ensure that a process remains within specified limits.

c. 5S: 5S is a methodology for organizing the workplace to make it suited for visual control. It involves Sort, set in order, Shine, Standardize, and Sustain.

d. Mistake proofing (poka-yoke): Poka-yoke techniques are applied to make errors impossible or immediately detectable in a process, reducing the likelihood of defects or mistakes.

vi. Standardize/Follow-Up:

This is an additional phase that we can incorporate to conclude the approach. It ensures that the project endures over time and that proven solutions continue to be correctly implemented within the company.

This method employs numerous tools such as the "Five Whys," the Ishikawa diagram, the Pareto diagram, and the Five S method.

3.4 TOOLS & METHODS

3.4.1 Who, What, Where, When, Why, How Method

This method is a structured approach used to gather and organize information by asking a series of questions related to these six key aspects. It is often employed to ensure a comprehensive understanding of a subject or situation.

i. Who? - Concerned, actor, responsible.

ii. What? - Object, action, phase, operation.

iii. Where? - Location, distance, step.

iv. When? - Moment, schedule, duration, frequency.

v. Why? - Motivations for carrying out such an action, following such a procedure.

vi. How? - Material, equipment, necessary means, methods, modalities, procedures.

3.4.2 Ishikawa Diagram

An Ishikawa diagram is a diagram that shows the causes of an event and is often used in manufacturing and product development to outline the different steps in a process, demonstrate where quality control issues might arise, and determine which resources are required at specific times.

i. An Ishikawa diagram is used to show the causal factors that go into some final outcome, often related to a production or design problem.

ii. They are named after Japanese engineering professor Kaoru Ishikawa in the 1960s, who helped apply them to manufacturing processes.

iii. Shaped somewhat like a fish, these charts are sometimes called fishbone or "Ishikawa" diagrams.

iv. Ishikawa diagrams often follow the "Six M's": manpower, machinery, methods, materials, measurement, and Mother Nature.

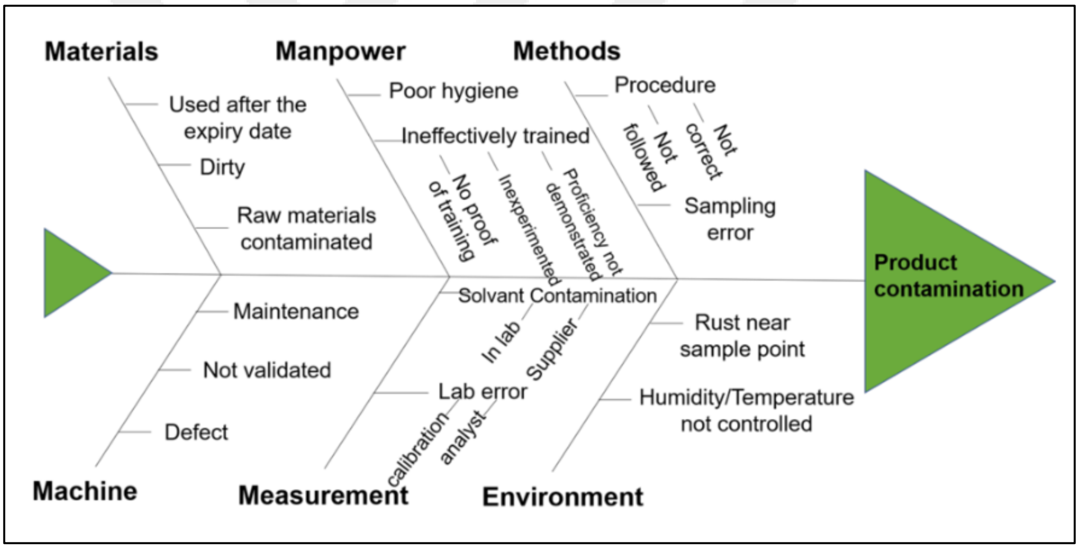

Figure 3.2: Ishikawa Diagram.

3.4.3 Pareto Chart

A Pareto chart is a type of chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line. The chart is named for the Pareto principle, which, in turn, derives its name from Vilfredo Pareto, a noted Italian economist.

The approach to create a Pareto diagram is as follows:

a. Establish data lists.

b. Rank the values of the studied criterion in descending order.

c. Calculate the cumulative of these values.

d. Calculate the percentage for each cumulative.

e. Represent the chart of cumulative percentages.

3.4.4 Overall Production Effectiveness

Overall Equipment Effectiveness (OEE) is a hierarchy of metrics that assess and indicate how efficiently a manufacturing operation is utilized. It is the ratio of actual production to maximum potential production.

Its measurement is expressed in units produced per unit of time. The units produced can be quantities, weights, distances or lengths, volumes, amounts of heat, etc.

To calculate OEE, we can apply the relationship 3.4.4

$$OPE = \frac{Units\ produced\ per\ hour}{Rate\ of\ product\ per\ hour} \tag{3.1}$$

OEE is used when a workstation primarily incurs labour costs (no machinery involved), or when it's an overcapacity station. It's also employed when there's a desire to understand the gap compared to best practices and to improve upon them.

4. APPLICATION

4.1 COMPANY PRESENTATION

4.1.1 Paul's History in Morocco

PAUL is a family-owned company that started in 1889 as a small bakery in Croix, France. It has been passed down for five generations and has since expanded to become an international brand. Francis Holder, who joined the family business in 1953, took over the bakery after the death of his father-in-law and has since played a significant role in its growth and innovation, including the installation of a wood-fired oven and bakery in full view of customers in 1972. The company launched its first cake range in the 1950s and later incorporated cafes or restaurant areas into some of its bakeries. In 1993, the company refreshed its brand by introducing iconic black shop fronts and artisan specialty breads made using sustainably produced winter wheat.

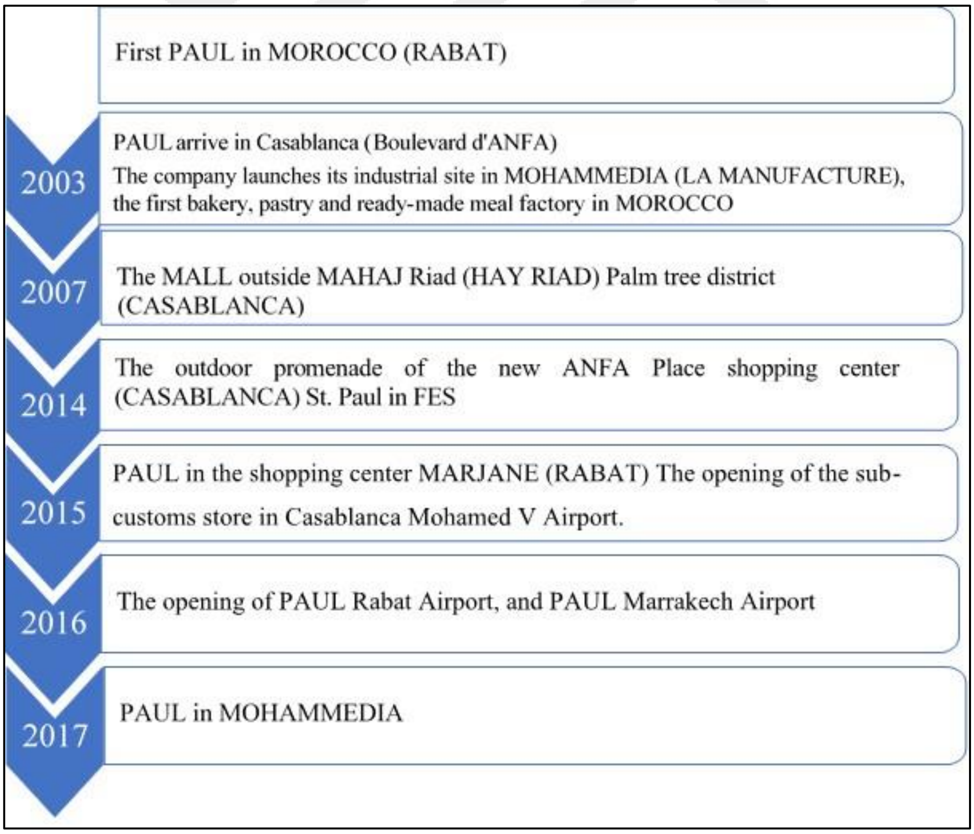

Figure 4.1: The History of PAUL in Morocco from the End of 1998 to the Present.

4.1.2 Company's Identity Sheet

Table 1 represents the headquarters profile, and Table 2 is for the factory.

Headquarter:

Table 4.1: Head Quarter's Identity Card.

	DELI'S
Legal form	Limited company
Address of the Headquarter	9, Rue Al Khatawate-Valmont-Agdal, Rabat, Morocco.
Phone	(212) 0537 67 57 67.
Fax	(212) 0537 77 23 50.
Share capital	23.000.000 DHs.

Factory:

Table 4.2: Factory´s Identity Card.

Address of the factory	Lot 26, 27 - New Industrial Zone - Mohammedia.
Phone	(212) 0523 31 33 33 / 22 22.
President General Manager	Y. BAHRAOUI.
Workforce	200
Annual production	About 2500 tons.
Main customers	• PAUL Stores: 11 • Hotel Group: Accor, Royal Mansour, Club Med, Mazagan, Ryad Mogador, Barcelo, Amphitrite, Hayatt Regency, Novotel, Sofitel... • Supermarchés : Marjane, Acima, Carrefour. • Restaurant groups : McDonald's, Pizza Hut, Pomme de pain...
Market served	Local

4.1.3 DELI'S Products

DELI'S manufactures several ranges of products through its different laboratories.
The table below shows the different specific products for each laboratory:

Table 4.3: Lab-Specific Products.

Laboratories	Products
Pastry laboratory	Bread, chocolate bread, croissant, birthday cake, macaroon, pies...
Kitchen laboratory	Mini pizzas, quiches, sandwiches, paninis...
Bakery laboratory	Different types of breads and baguettes, sandwich bread, pistol...

These products are divided into two categories:

a. OHC product

b. Paul's product

4.1.3.1 OHC products

The OHC products are the products delivered to all restaurants outside the home (not PAUL): restaurants such as "Pomme de pain", "McDonald's", hotels such as "Hayatt Regency", "Novotel", supermarkets are also targets that do not escape this invasion of DELI'S such as "Carrefour", "Acima"... are finished products (ready to be eaten) or semi cooked.

Figure 4.2: Some OHC Products.

4.1.3.2 Paul's products

PAUL products are delivered to PAUL stores as semi-finished products (raw or semi-cooked). All stages of finishing, cutting, decoration, cooking are completed in the stores just before being served to the customer. These products are more demanding in terms of quality and size. So, the means invested to ensure this quality are much more important. This justifies the large margin resulting from this quality in terms of consumer appreciation.

Figure 4.3: Paul's Pastries and Viennoiseries.

Note: The distinction between these two product divisions is primarily based on the product size and the quality of the raw material. However, the transformation methods employed remain the same for all products.

4.2 MANUFACTURING PROCESS

The factory is divided into four zones: laboratories, storage, packaging, and maintenance. There are four laboratories: viennoiserie laboratory, bakery laboratory, pastry laboratory, and kitchen laboratory. The pastry laboratory consists of five stations: assembly, macarons, cream, chocolate, and biscuit. The kitchen laboratory also consists of five stations: assembly, vegetable preparation, butchery, weighing, and packaging.

The following schema shows the manufacturing circuit at DELI'S:

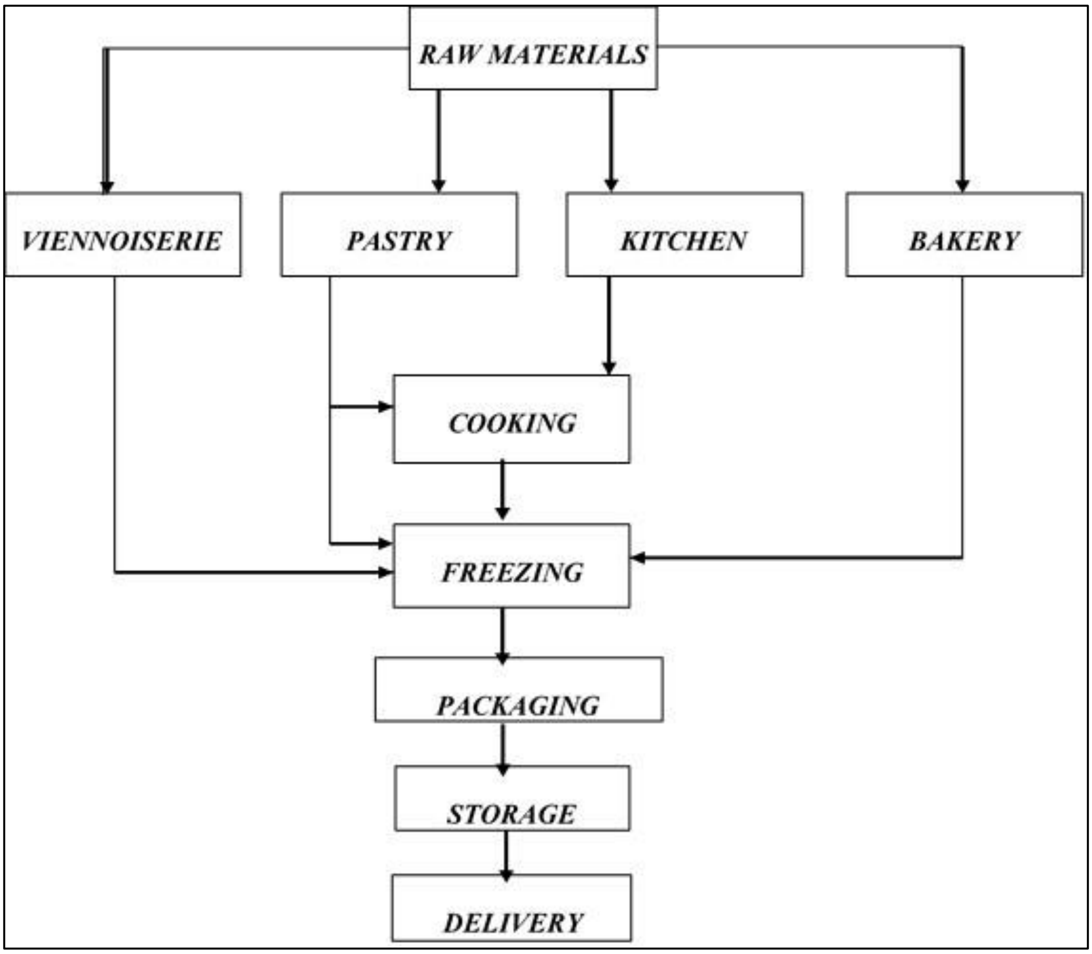

Figure 4.4: Manufacturing Circuit Diagram.

a. Raw material

The raw material is mostly the same for the four laboratories, with a few specific exceptions.

The specific raw materials for each laboratory are summarized in Table 2.

Table 4.4: The Specific Raw Materials for Each Laboratory**.**

LABORATORIES	RAW MATERIALS
Viennoiserie laboratory	Dark chocolate chips and sticks, dried raisins, fruits (apple, apricot), egg yolks, flour, butter...
Bakery laboratory	Chocolate discs (dark, white), milk, fruits, industrial caramel, cheese, biscuit, egg yolks, egg whites, gelatine, pectin.
Pastry laboratory	Chicken, fish, spices, vegetables (tomatoes, carrots...), salt, seafood, fruits...
Kitchen laboratory	Chocolate chips, olives, salt, cereals, and seeds.

i. Cooking

The products are baked in rotary trolley ovens that use a combination of oil and gas (Mazout-Gaz) as fuel. Versatile and very compact, they are well-suited for bakeries and pastries, with a temperature exceeding 120°C.

Figure 4.5: Rotary Oven for Cooking.

ii. Freezing

Freezing is a crucial step following the production of all products. They are frozen in "KOMA" blast freezers at temperatures between -20°C and -40°C.

Figure 4.6: "KOMA" Freezer.

iii. Packaging

After freezing the products manufactured by the four laboratories, the packaging stage begins. This operation is divided into two parts. First, it involves covering a defined quantity of the product with a plastic wrap, which is sealed by applying pressure. Then, secondly, these tightly sealed pouches are placed in cardboard boxes that pass through an automatic wrapping machine. This horizontal wrapper provides optimal film packaging of the products during storage and transportation, ensuring perfect protection against dust, moisture, and light. Finally, the role of handling pallets comes into play, which ensures the storage and transportation of the boxes, contributing to maintaining order and reducing clutter.

Figure 4.7: Conditioning.

Figure 4.8: Hermetic Press.

b. Storage

Storage of Raw Materials

Raw materials are stored in positive or dry areas. The positive areas are divided into two parts: Food and Non-Food. The Food part is reserved for food products, while the Non-Food part is dedicated to packaging and materials. The temperature ranges from 2°C to 16°C. The dry areas are used to store flour just after its reception to maintain temperature and humidity.

Storage of Finished and Semi-Finished Products:

The products packaged in cardboard boxes are subsequently stored in cold rooms, referred to as negative storage. The temperature ranges from -18°C to -30°C. These rooms are equipped with fans to ensure balanced air dispersion, maintaining the same temperature in all areas and corners of the room.

c. Delivery

Delivery is the final step. The stored products are delivered to customers by trucks that maintain suitable transport conditions: a temperature of -18°C to preserve their organoleptic and microbiological quality.

4.3 QUALITY CONTROL

Quality control is a process that aims to ensure the quality of a product or service meets specified standards, requirements, and customer expectations. It involves systematic and continuous activities and techniques to monitor, evaluate, and improve the various aspects of a process or product to prevent defects or non-conformities. Quality control activities may encompass inspections, testing, process management, statistical analysis, and other methodologies to verify that a product or service meets the desired level of quality and complies with established quality standards. The primary goal of quality control is to identify and rectify any issues or deviations from quality standards, ultimately delivering products or services that consistently meet or exceed customer expectations.

Quality control measurement techniques in food establishments play a significant role in setting standards and criteria for production, guiding production activities, and developing suitable production planning. These techniques encompass a variety of approaches, including chemical, physical, and microbiological methods, as well as sensory assessment, all of which are crucial for ensuring and maintaining quality.

4.3.1 Certifications

4.3.1.1 Prerequisite Programs

DELI'S has implemented PRP (Prerequisite Programs) to control the probability of a hazard occurring related to food safety. The program encompasses all the means and general hygiene measures that the company has put in place to promote the effective implementation of specific measures aimed at ensuring product safety during the execution of process activities.

4.3.1.2 HACCP System

The company has succeeded in implementing the HACCP system to ensure food safety and provide high-quality products. This approach demands, before carrying out the HACCP analysis, the establishment and development of a plan for Good Hygiene Practices (GHP) related to the food sector. In the ISO 22000 standard, these GHPs are considered as PRPs (Prerequisite Programs).

4.3.1.3 Standard

The factory is now certified with ISO 22000 and FSSC 22000 for its manufacturing processes. FSSC 22000 is a new food safety standard approved by the GFSI. It represents one of the most comprehensive approaches to food safety management systems for those operating in the food product manufacturing sector. Derived from the ISO 22000 standard version of 2005, this new standard is progressively incorporating other quality management systems like ISO 9001, ISO 14001, and OHSAS 18001 to enhance quality and ensure safety.

4.3.2 Organoleptic Test

Organoleptic properties are the properties of food products that stimulate human sensory organs. In other words, the taste, smell, colour and appearance of foods are their organoleptic properties.

Microbiological tests are conducted in a microbial analysis laboratory named "Qualilab." Samples are collected from various sources including surfaces, materials, workers' hands, products, raw materials, and pesticides.

Due to its high standards in terms of PRP (Pre-Requisite Programs) and food safety, the factory is approved as an authorized supplier by McDonald's, Pizza Hut, and Costa Coffee based on their food safety and hygiene standards.

4.4 EXPERIMENTAL SECTION

In order to enhance the performance of the manufacturing area, we have chosen the 'DMAIC' approach of Lean Six Sigma. Indeed, it is a rigorous methodology that will allow us to identify the causes of losses, evaluate them, and implement the most appropriate actions to limit them. To achieve this, our project will be divided into several phases, namely: the 'Define' phase, the 'Measure' phase, the 'Analyze' phase, and the 'Innovate' phase.

4.4.1 The "Define" Phase

The first step of the DMAIC method involves defining the scope of the subject to be addressed and targeting the goal to be achieved, in line with the customer demand, as well as the necessary resources and timelines. It involves summarizing all known data to frame the project. An initial identification of the possible causes of customer dissatisfaction and/or variability occurrence can be sought using problem-solving methods such as the WWWWHW method.

i. Definition of the project

Scheduled working hours are becoming increasingly insufficient to produce the desired quantity of products while maintaining high quality. This has led the factory manager to consider a new methodology for analyzing and resolving the issue.

The goal of this work is to manage performance to assess the profitability and accomplishments of each employee, aiming to increase the yield rate in the most appropriate manner, based on the DMAIC approach of Lean Six Sigma.

ii. Project Scope

In the pastry assembly area, there are 10 operators divided into 2 shifts:

a. The first shift operates from 6 a.m. to 2 p.m. and consists of 4 workers and 1 shift leader.

b. The second shift operates from 2 p.m. to 10 p.m. and also consists of 4 workers and 1 shift leader.

These 2 teams are responsible for the assembly and finishing of pastry products, specifically cakes and desserts.

Figure 4.9: Working In the Pastry Lab.

iii. Formalization of the problem

The problem statement of this project was defined using the "WWWWHW" method, as shown in table 6:

Table 4.5: Problem Vision Using the WWWWHW Method.

Questions	**Answers**
What?	Production delay
Who?	Operators in the pastry assembly zone and the team leaders
Where?	In the pastry assembly area
When?	During the period of treatment
How?	By applying the DMAIC approach and calculating the OEE for each product.
Why?	Enhance profitability and efficiency.

iv. The project charters

With the aid of the project charter, we attempted to materialize all the elements of the "Define" phase to establish a solid foundation for the project's subsequent phases. This charter commits the workgroup to specific deadlines and anticipated results. The project will progress based on this foundation, subject to modifications if necessary due to its development.

Table 4.6: Project Charter.

Project charter	
Project name	Project name Implementation of lean-six sigma performance management in the pastry assembly area
Related products	Cakes and desserts
Team work	Production Manager
	Trainee
	Chefs and operators
Project presentation	This Industrial Project focuses on improving the profitability of operators in the pastry assembly area.
Project Objectives	Increase the performance and profitability
Constraints of the Project	The project's constraints are - The difficulty of witnessing the assembly of all products, given that production takes place according to customer demand. - Insufficient time to carry out an inspection stage. - Failure to meet deadlines for each stage.
Expected results	Increasing operator productivity

4.4.2 The "Measure" Phase

The objective of this phase is to gather field data that accurately represents the current situation, enabling a better understanding of the root causes of the problem (descriptive statistics - Pareto chart). It also involves assessing the current performance and its variation by ensuring that the measurement process is acceptable concerning the desired objectives. This is achieved by comparing the variance of the measurement process with the variance of the process to be measured.

At this stage, it is crucial to rely on reliable variables and data that will later provide relevant insights. It is also during this phase that potential causes of the problem are eliminated, aiming to narrow them down as much as possible.

i. Data collection

In our project, we will be working on the assembly of 33 cake and dessert pastry products. The assembly process for each product involves multiple steps (Annex 1).

We will group these 33 products into 10 families based on their shapes, which will simplify the timing of the steps. Table 7 represents these 10 families.

The steps for products belonging to the same family will have the same code to facilitate subsequent calculations of the pace (Annex 2)

Table 4.7: Product Families.

Family	Product
Frame	DUCHESSE -- GIANDUJA 40*60 -- JIVARA CADRE 40*60 -- OPERA 60*40 -- CARRE CARAMEL IND / 6 P – CARRE -- CHOCOLAT IND / 6 P -- DUO CHOCOLAT IND / 6 P -- FORET NOIRE IND / 6-8 PAX -- SUPREME CHOCOLAT IND
Square 10 p	JIVARA 10P
Square 8 p	JIVARA 8P

Table 4.7: Product Families "Table Continued".

Square 6 p	JIVARA 6P
Ind half-round	BALTHAZAR IND -- F AUTOMNE IND DOME
Half-round	B NEIGE IND -- FRAMBOISIER IND - ROYAL IND
Round 6	B NEIGE 6P -- F AUTOMNE 6P - ROYAL 6P
Round 8	B NEIGE 8P -- BALTHAZAR 6-8 PAX F AUTOMNE 8P -- FRAMBOISIER 6-8 PAX ROYAL 8P -- SUPREME CHOCOLAT 6-8 PAX
Round 10	B NEIGE 10P -- F AUTOMNE 10P -- ROYAL 10P
Band	CHARLOTTE

ii.Timing

Timing is carried out for each step of each product family. We will take the time four times for each operation to obtain the value of the "minimum repeatable time (MRT)" or the average time as shown in Table 8.

a. Minimum Repeatable Time (MRT):

Definition:

a. Minimum: This time represents when everything is going well, unaffected by any contingencies.

b. Repeatable: It is observed without timing errors or any exceptional phenomenon.

c. It should be conducted on a representative sample. Over multiple iterations, this time will often be the lowest time observed.

Purpose:

a. Minimum: Because we aim for excellence.

b. Repeatable: To ensure that its value is achievable

Table 8 presents the conducted timing with the precision of the start and stop points, and the MRT or the average.

Table 4.8: Timing of Each Product Assembly Step.

	Operation	M1(en s)	M2(en s)	M3(s)	M4(en s)	Avg or TMR(s)
	Biscuit depot	21	24	21	26	21
	Soaked biscuit depot	42	42	39	44	42
	Foam deposit	36	33	43	41	38,25
	Tier deposit	50	40	40	46	46
	Fine deposit	22	23	21	23	23
Finishing	Frosting	40	43	40	45,38	*67,2
	Finishing	29,01	23,2	27,2	27,2	*67,2
	Cash deposit	3,4	3,7	3,2	3,3	3,4
	Biscuit depot	16,7	18,6	17	16,9	17,3
	Foam deposit	1,84	2	2	1,9	1,93
Tier deposit	Spread bearing	57	55	53	53	*78
	Cutting of the bearing and deposit on the product	25	27	25	27	*78
	Foam deposit	1,59	1,62	1,72	1,88	1,7
	Biscuit depot	14,84	13	14	13	13
Tier deposit	Spread bearing	51	49	50	50	*68
	Cutting of the bearing and deposit on the product	23	18	18	18	*68
	Biscuit depot	14,6	14,3	14,6	18,4	14,6
Tier deposit	Spread bearing	52	55	51	51	*71
	Cutting of the bearing and deposit on the product	24,5	20	20	19	*71
	Foam deposit	1,6	1,8	2	1,8	1,8
	Soaked biscuit depot	1	0,8	1	1,3	1

Table 4.8: Timing of Each Product Assembly Step "Table Continued".

	Operation	M1(en s)	M2(en s)	M3(s)	M4(en s)	TMR or AVG(s)
	Foam deposit	2,34	2,35	1,8	2,1	2,14
	Depot Level	2,5	2,5	3	2,5	2,5
	Cash deposit	5,6	5,7	3,8	3,5	4,65
	Finishing	22	19	22	22	22
	Biscuit depot	1,8	2,2	1,5	1,5	1,5
	Soaked biscuit depot	4	3	3	2,7	3
	Foam deposit	5	6	6	7	6
	Cash deposit	6	4	5	5	5
	Raspberry deposit	4,22	5	6	5	5
	Depot Level	3	2,7	2,8	2,8	2,8
	Finishing	7,9	10,73	10,51	9,42	9,64
	Biscuit depot	5	5	6	6	5
	Foam deposit	15	13	15	16	15
	Raspberry deposit	14,03	18	19,6	18	18
	Soaked biscuit depot	7,16	5,56	5,7	7,5	6,48
Tier deposit	**Praline depot**	5	6,16	4,37	4,5	*6,56
	Deposit on the product	1,34	1,76	1,42	1,75	*6,56
	Biscuit depot	1	1	2	1,5	1
	Raspberry deposit	12	14	14	16	14
	Foam deposit	7	6	6	5	6
	Soaked biscuit deposit	6,7	6,6	6,7	6,5	6,62

Table 4.8: Timing of Each Product Assembly Step “Table Continued”.

	Operation	M1(en s)	M2(en s)	M3(s)	M4(en s)	TMRou Avg(s)
Tier deposit	**Spread Bearing**	12	20	12	21	*15
	Depot Level	3	2	3	4	*15
	Biscuit depot	4	3,8	4	2,9	4
	Foam deposit	7,35	7,75	7,15	7,24	7,37
Wet bis deposit	**Biscuit soaking**	5,26	5	4,9	5	*7,76
	Soaked biscuit depot	2,7	3	2,3	3,04	*7,76
	Raspberry deposit	15	10	15	18,2	15
Tier deposit	**Spread bearing**	25	19	24	25	*28
	Depot Level	3	2,2	3,1	3	*28
Feuilletine deposit	**Spread sheet**	20	23	23	28	*30
	Feuilletine deposit	6	7	8	7	*30
	Cash deposit	10	10	10	11	11
	Finishing	106,1	95,87	91	91	91
	Biscuit depot	95	93	105	79	93
	Foam deposit	8,36	7	7	8	7
Soaked biscuit depot	**Biscuit cutting**	11	10	12	10	*29
	Biscuit soaking	6	6	7	7	*29
	Soaked biscuit depot	12	13	13	11	*29

b. The sum of the 2 steps:

Timing allows us to calculate the total time required to assemble each product to determine the rate of assembling cakes and desserts per hour.

The rate is calculated using the following relationship:

$$Cadence(\frac{production}{hour}) = \frac{3600\ (s)}{total\ time\ for\ product\ assembly\ (in\ s)} \quad (4.1)$$

Table 9 displays the total time for each product and their assembly rates.

$$\text{Total time} = \sum \text{MRT of each product assembly step} \quad (4.2)$$

Example: Total time for assembling Duchesse

Total time = 42+38.25+42+38.25+42+38.25+67.2

Total time = 307.95 s

Assembly rate = 3600/307.95

Assembly rate = 11.69

12 duchesse per hour

Table 4.9: Calculated Times for Each Product and Their Assembly Rate.

Description	Family	Time(s)	Rate (product/hour)
DUCHESS (EXECUTIVE)	**Frame**	307,95	11,690
GIANDUJA 40*60 PFU (FRAME)	**Frame**	120,5	29,876
JIVARA FRAME 40*60 PFU (FRAME)	**Frame**	164,5	21,884
OPERA 60*40 PFU (FRAME)	**Frame**	240,75	14,953
CARRE CARAMEL PFU (UNIT)	**Frame**	311,35	11,563
CARRE CHOCOLAT PFU (UNIT)	**Frame**	311,35	11,563
PFU CHOCOLATE DUO (UNIT)	**Frame**	231,1	15,578
IND PFU BLACK DRILL (UNIT)	**Frame**	231,1	15,578
SUPREME CHOCOLAT IND PFU (UNIT)	**Frame**	231,1	15,578
CARRE CARAMEL 6P PFU (UNIT)	**Frame**	311,35	13,202
CARRE CHOCOLAT 6P PFU (UNIT)	**Frame**	311,35	13,202
6P PFU CHOCOLATE DUO (UNIT)	**Frame**	231,1	18,708
DRILL BIT BLACK 6-8 PAX PFU (UNIT)	**Frame**	231,1	18,708
JIVARA 10P PFU (UNIT)	**10p square**	116,46	30,912
JIVARA 6P PFU (UNIT)	**Square 6p**	97,4	36,961
JIVARA 8P PFU (UNIT)	**Square 8p**	110,7	31,008
BALTHAZAR IND PFU (UNIT)	**half-round ind**	32,93	109,323
F AUTOMNE IND DOME PFU (UNIT)	**half-round ind**	8,78	410,023
B SNOW IND PFU (UNIT)	**ind ronde**	23	156,522
FRAMBOISIER IND PFU (UNIT)	**ind ronde**	41,64	86,455
ROYAL IND PFU (UNIT)	**ind ronde**	16,3	220,859

Table 4.9: Calculated Times for Each Product and Their Assembly Rate "Table Continued".

Description	Family	Time(s)	Rate (Product/hour)
B SNOW 10P PFU (UNIT)	**Round 10**	60,96	59,055
F FALL 10P PFU (UNIT)	**Round 10**	49,52	72,698
ROYAL 10P PFU (UNIT)	**Round 10**	46,56	77,320
B SNOW 6P PFU (UNIT)	**Round 6**	39,24	91,743
F FALL 6P PFU (UNIT)	**Round 6**	40,24	89,463
ROYAL 6P PFU (UNIT)	**Round 6**	38	94,737
B SNOW 8P PFU (UNIT)	**Round 8**	45,26	79,540
BALTHAZAR 6-8 PAX PFU (UNIT)	**Round 8**	147,26	24,447
F FALL 8P PFU (UNIT)	**Round 8**	58,26	61,792
RASPBERRY 6-8 PAX PFU (UNIT)	**Round 8**	151,39	23,780
ROYAL 8P PFU (UNIT)	**Round 8**	71,37	50,441
SUPREME CHOCOLAT 6-8 PAX PFU (UNIT)	**Round 8**	56,26	63,989
Charlotte (UNIT)	**Gang**	165	21,818

iii. Overall process efficiency:

Overall process efficiency (OPE) is calculated by the equation (iii.1)

$$OPE = \frac{Standard\ time\ for\ produced\ ranges\ x\ 100}{available\ time} \tag{4.3}$$

Or by the equation (iii-2)

$$OPE = \frac{Number\ of\ products\ produced\ per\ hour}{Cadence\ of\ the\ same\ product} \tag{4.4}$$

In the following project, we will calculate the OPE for each product following the second formula.

Table 10 displays the OPE calculations for each product.

Table 4.10: Calculation of OPE.

Description	Time (s)	Cadence	Start time	End time	Duration	Number of products made during the period	Number of operators	Number of realized products/Hour	OPE
DUCHESS	307,95	11,690	06:40	13:28	358 min	74 frames	3 operators	4.13 frames	**35**%
GIANDUJA 40*60	120,5	29,876	12:26	13:15	49 min	15 executives	2 operators	9.18 frames	**31 %**
JIVARA FRAME 40*60	164,5	21,884	14:40	17:00	140 min	50 executives	3 operators	7.14 executives	**33 %**
OPERA 60*40	240,75	14,953	07:30	10:08	160 min	60 executives	4 operators	5.5 executives	**37 %**
CARAMEL EDGE	311,35	11,563	07:35	10:35	120 min	41.5 executives	3 operators	6.91 executives	**60 %**
CHOCOLATE SQUARE	311,35	11,563	10:33	11:57	90 min	24 frames	3 operators	4 frames	**35 %**
CHOCOLATE DUO	231,1	15,578	11:55	13:20	85 min	26 executives	3 operators	6.11 executives	**39 %**
BLACK IND DRILL	231,1	15,578	10:50	12:55	125 min	40 executives	3 operators	6.4 executives	**41 %**
SUPREME CHOCOLAT IND	231,1	15,578	08:40	11:00	140 min	50 executives	3 operators	7.14 executives	**46 %**
SQUARE CARAMEL 6P	311,35	11,563	07:35	10:35	120 min	41.5 executives	3 operators	6.91 executives	**60 %**

Table 4.10: Calculation of OPE "Table Continued".

CARRE CHOCOLAT 6P	311,35	11,563	10:33	11:57	90 min	24 frames	3 operators	4 frames	**35 %**
CHOCOLATE DUO 6P	231,1	15,578	11:55	13:20	85 min	26 executives	3 operators	6.11 executives	**39 %**
DRILL BIT BLACK 6-8 PAX	231,1	15,578	09:07	10:45	98 min	30 units	3 operators	6.12 units	**39 %**
JIVARA 10P	116,46	30,912	11:20	12:15	55 min	64 units	3 operators	23.26 units	**72 %**
JIVARA 6P	97,4	36,961	10:55	11:20	25 min	36 units	3 operators	28.8 units	**78 %**
JIVARA 8P	110,7	31,008	08:15	10:15	120 min	180 units	3 operators	30 units	**97 %**
BALTHAZAR IND	32,93	109,323	06:50	08:10	80 min	300 units	3 operators	75 units	**69 %**
F AUTUMN IND DOME	8,78	410,023	09:55	11:03	68 min	624 units	4 operators	164.11 units	**40 %**
B SNOW IND	23	156,522	10:50	12:00	70 min	600 units	4 operators	128.57 units	**82 %**
RASPBERRY IND	32	112,500	14:55	16:33	98 min	300 units	2 operators	91.83 units	**82 %**
ROYAL IND	16,3	220,859	11:30	12:13	43 min	280 units	3 operators	130.23 units	**59 %**
B SNOW 10P	60,96	59,055	11:45	12:33	48 min	40 units	3 operators	20 units	**26 %**

4.4.3 The "Analyse" Phase

This phase involves 42nalysing the gap between the current situation and the set objectives to identify the root cause of the problem. This helps in formulating potential solutions to bridge the gap between the present situation and customer objectives.

4.4.3.1 Analysis and Interpretation of Results:

To facilitate the interpretation and analysis of the results, a graphical representation of the Overall Performance Efficiency (OPE) of each product and the ideal OPE is created as follows:

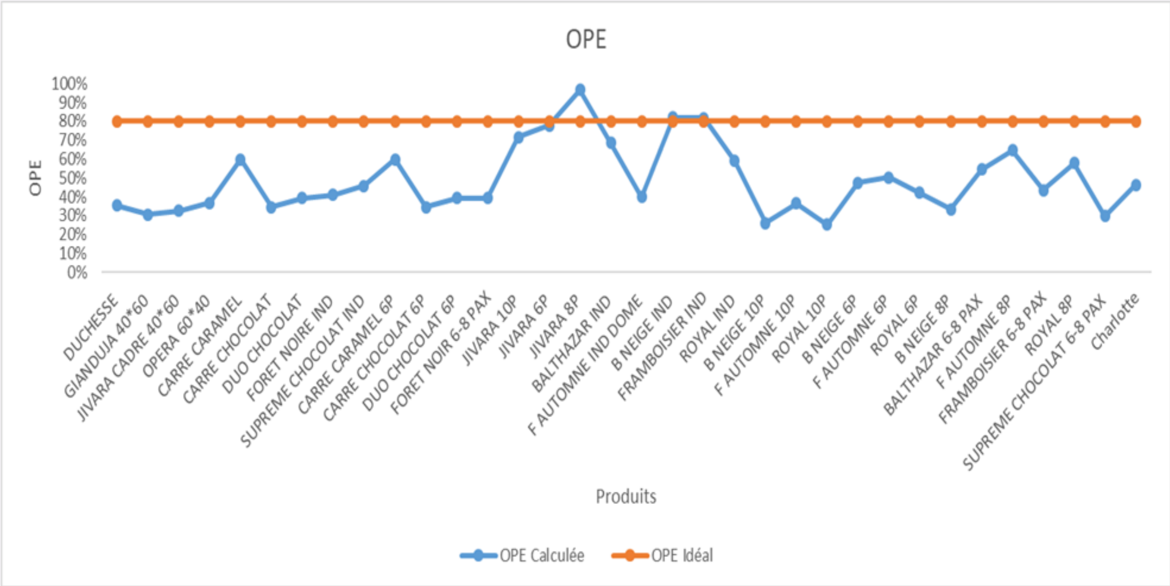

Figure 4.10: Graphic Representation of the OPE.

Results from the figure show a considerably low Overall Performance Efficiency (OPE) for most products, none of which reach or exceed the ideal OPE value of 80%, except for four products: JIVARA 6P, JIVARA 10P, B. NEIGE IND, FROMBOISIER IND. Consequently, the pastry assembly zone is a critical area.

These low OPE values are attributed to the poor productivity rate of the product assembly operators in the assembly zone. Several causes contribute to this issue:

a. Human factors (illness, emotional state, poor morale).

b. Lack of small equipment (spatula, ladle, scissors, and knife).

c. Non-conformities in essential components (biscuit, mousse, glaze).

d. Delay in preparing mousses and biscuits.

e. Extended time dedicated to setting up frames and molds for work.

f. Varied work speed among operators.

4.4.3.2 Monetary Cost of Losses in the Pastry Assembly Zone:

The significant impact of a low OPE on cost savings is highly noticeable. The calculation of these losses was determined using the following relation:

$$loss = (selling\ price\ x\ cadence) - (selling\ price\ x\ number\ of produced\ product) \quad (4.5)$$

i. Loss calculation for each product:

Table 4.11: Loss Calculation for Each Product.

Description	Product family	Selling Price (Per DHS)	Quantity price that needs to be done (by DHS)	Price of the quantity achieved (Per DHS)	Loss (Per DHS)	Cadence (Product/h)	Quantity Completed (Product/h)
DUCHESS	Executive family	623,93	7293,87	2576,83	4717,04	11,690	4,13
GIANDUJA 40*60		593,8	17740,08	5451,08	12289,00	29,876	9,18
JIVARA FRAME 40*60		611,65	13385,65	4367,18	9018,47	21,884	7,14
OPERA 60*40		428,84	6412,56	2412,23	4000,34	14,953	5,625
CARAMEL EDGE		305,1	3527,73	2108,24	1419,49	11,563	6,91
CHOCOLATE SQUARE		305,1	3527,73	1220,40	2307,33	11,563	4
CHOCOLATE DUO		305,1	4752,75	1865,99	2886,76	15,578	6,116
BLACK IND DRILL		340,2	5299,52	2177,28	3122,24	15,578	6,4
SUPREME CHOCOLAT IND		426,6	6645,43	3045,92	3599,51	15,578	7,14
SQUARE CARAMEL 6P		318	3677,03	2197,38	1479,65	11,563	6,91
CARRE CHOCOLAT 6P		318	3677,03	1272,00	2405,03	11,563	4
CHOCOLATE DUO 6P		318	4953,80	1944,89	3008,92	15,578	6,116
DRILL BIT BLACK 6-8 PAX		354	5514,61	2166,48	3348,13	15,578	6,12
JIVARA 10P	Square family 10P	131,38	4061,21	3055,90	1005,31	30,912	23,26
JIVARA 6P	Square family 6P	103,33	3819,18	2975,90	843,27	36,961	28,8
JIVARA 8P	Square family 8P	113,53	3520,31	3405,90	114,41	31,008	30
BALTHAZAR IND	Ind family half round	8,6	940,18	645,00	295,18	109,323	75
F AUTUMN IND DOME		10,02	4108,43	1644,38	2464,05	410,023	164,11
B SNOW IND	Ind round family	10,77	1685,74	1384,70	301,04	156,522	128,57
RASPBERRY IND		7,9	888,75	725,46	163,29	112,500	91,83
ROYAL IND		9,71	2144,54	1264,53	880,01	220,859	130,23

ii. Total losses for each family:

Table 12 shows the sum of losses for each family.

Table 4.12: Losses per Family.

Product family	Sum (per DHS)
Executive family	53601,91
Square family 10P	1005,31
Square family 6P	843,27
Square family 8P	114,41
Ind family half round	2759,22
Ind round family	1344,34
Round 10 Family	17644,85
Round Family 6	11745,42
Round Family 8	14314,76
Gang family	1490,49

The percentages are shown in Figure 11:

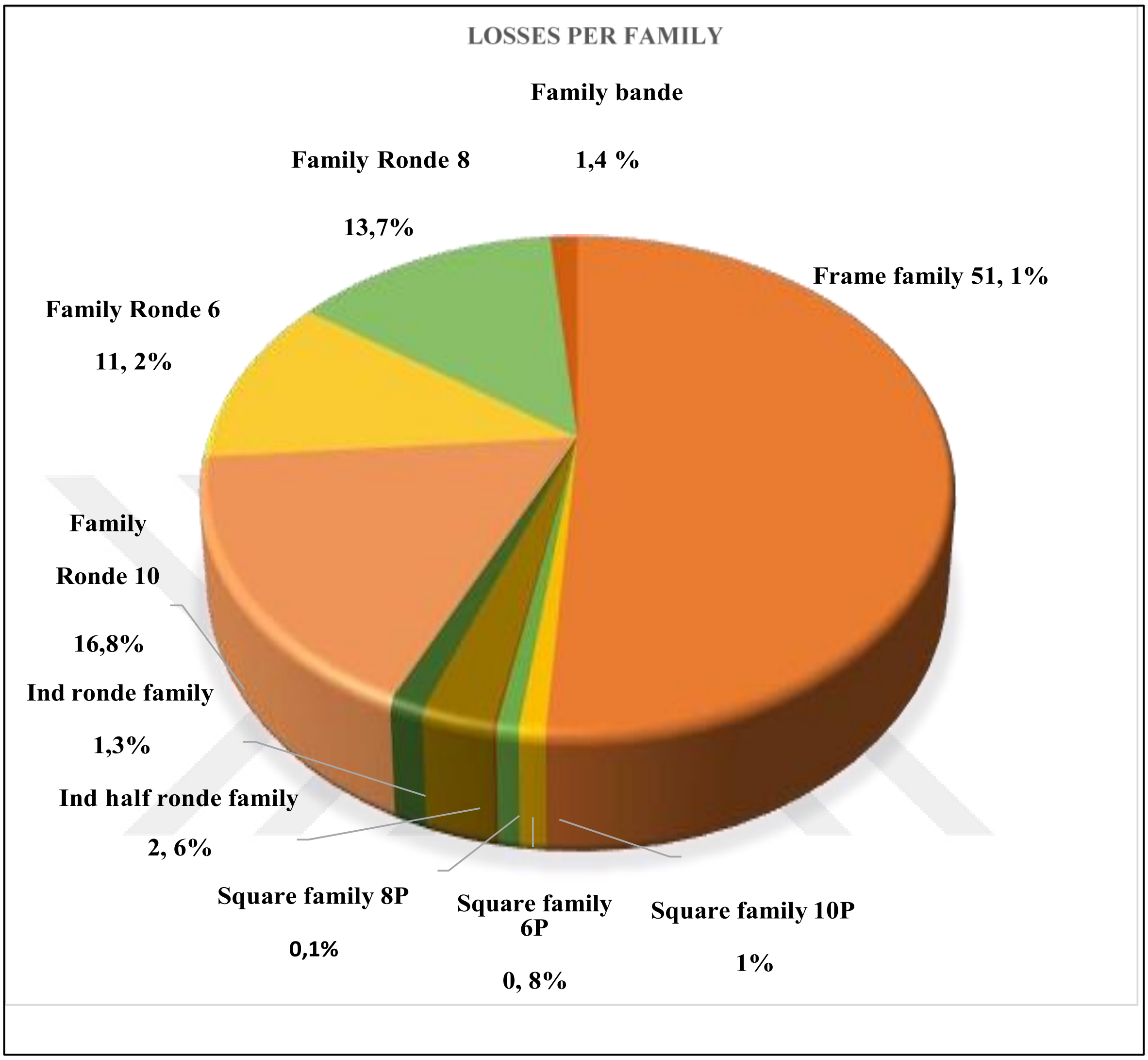

Figure 4.11: Percentage of Losses for Each Family.

Losses are very high for the executive family, with a percentage that exceeds half (51.1%), due to the low OPE of the family's products.

iii. Ishikawa diagram:

The Ishikawa diagram is a graphical representation of the link between causes and effects, classifying the various causes according to their categories (the 5 M's):

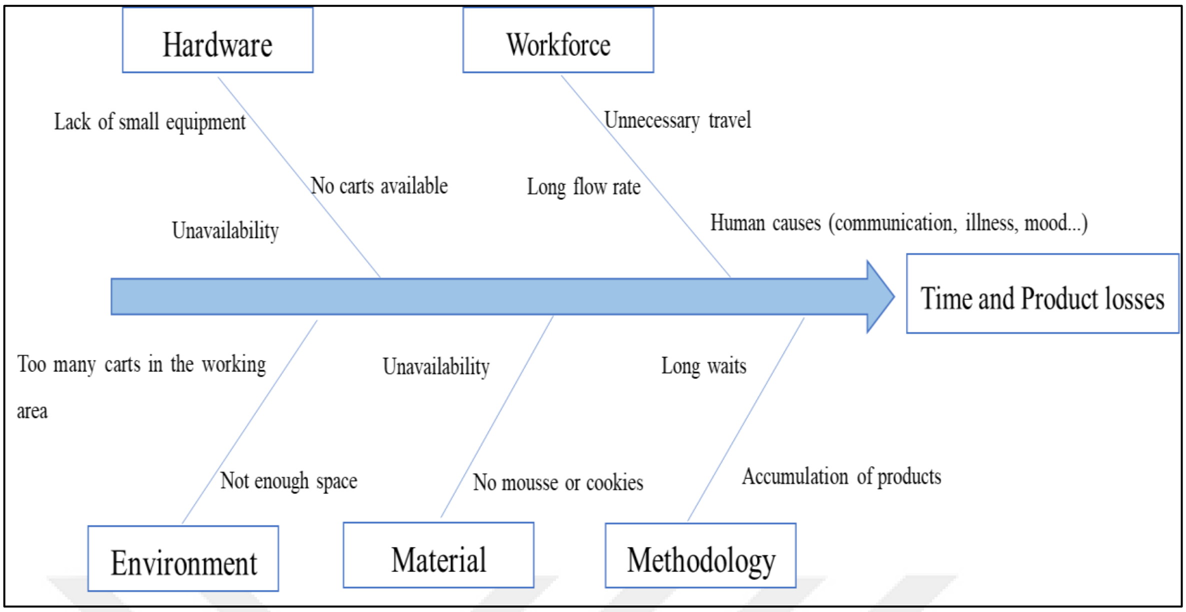

Figure 4.12: Ishikawa Diagram.

iv. Pareto chart:

The Table 13 shows the major causes of downtime.

Table 4.13: Major Causes of Stoppages.

Cause of judgments	Downtime	%	%
Non-compliance of foams and biscuits	20	33,33	33,33
Delay of mousses and biscuits	15	25,00	58,33
Space management	10	16,67	75,00
Equipment not available	5	8,33	83,33
Lack of small equipment	3	5,00	88,33
Human causes	3	5,00	93,33
Unnecessary displacement	2	3,33	96,66
Lack of trolleys	2	3,33	100,00
Total	60	100,00	

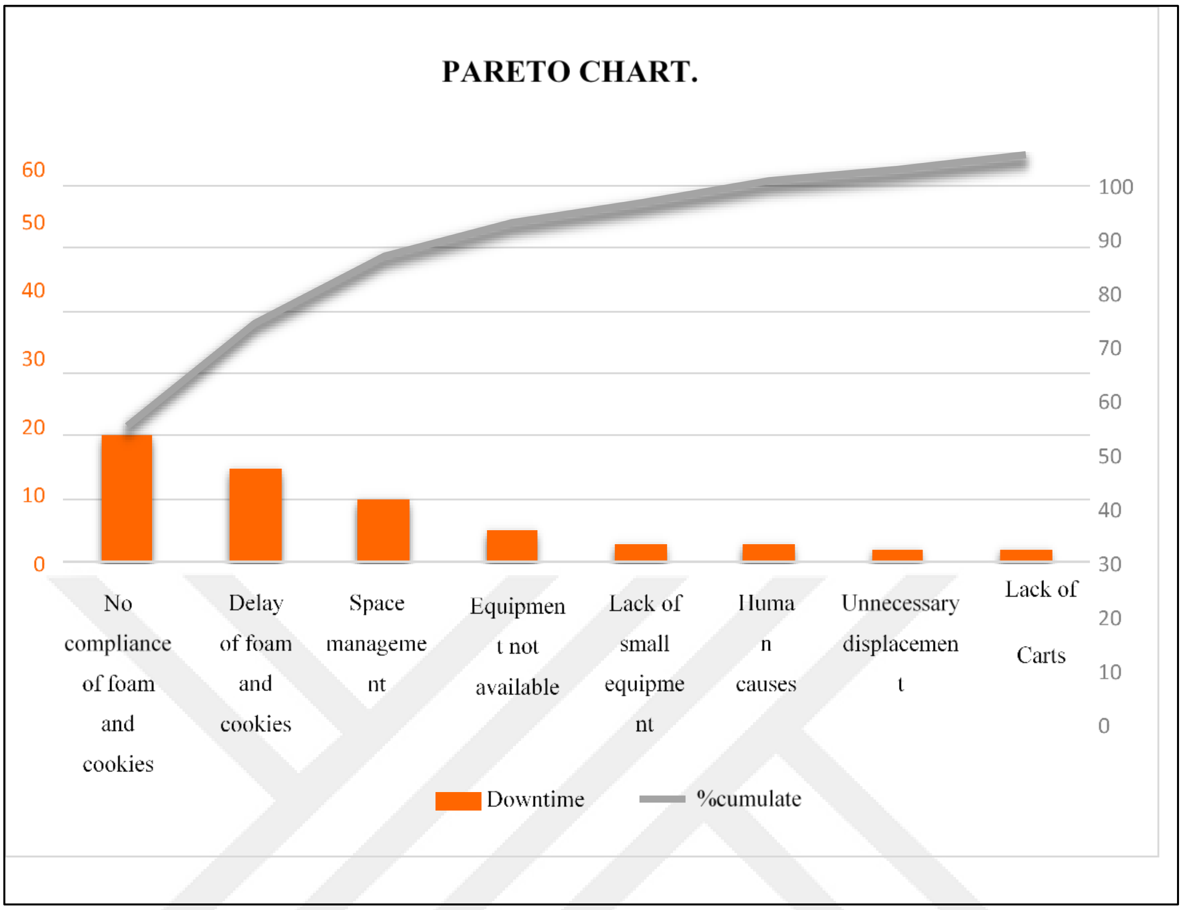

Figure 4.13: Pareto Chart.

The Pareto chart shows that the main cause of shutdowns is: non-conformity of foams and cookies with a percentage of 33.3% followed by delay of foams and cookies (25%) and space management with a percentage of 16.67%. To reduce the percentage of all causes, we need to propose an effective and workable action plan.

4.4.4 The “Innovate/Improve” Phase

Once the causes of the problem have been identified, the next step is to launch the crucial and particularly complex problem-solving phase.

On the basis of the results of the analysis carried out above, the aim is to establish the solutions that will enable the process to be brought under control in order to reduce variability. The solutions selected must be economically and technically viable, and fit into the current process. Improvements are then implemented to eliminate the original causes of the problem.

This stage can be divided into 3 points:

a. Skills and resources.

b. The awareness meeting.

c. The 5 S's.

The major causes of losses that we have found from the Pareto chart are the non-conformity and the delay of foams and cookies. To solve these problems, we need to interact with operators' skills.

4.4.4.1 Skills and Resources

By 48nalysing resources and skills, we can identify the strategic capabilities on which to build a sustainable competitive advantage.

a. Skill:

Skills are the activities and processes through which a company deploys its resources. It is the ability to deploy resources.

They reflect an ability to carry out an activity (innovation, renewal, etc.). In other words, a skill is the ability of a group of resources to carry out a task or activity.

In the pastry laboratory especially, and in DELI'S generally, all operators have a diploma in pastry or in their areas of work, which gives them the basics for successful assembly of cakes and deserts and all DELI'S products. What's more, each worker has passed a trial training course to assess his or her knowledge and skills in the field.

The problem resolution is to be carried out in all the other areas of the pastry lab: the cream area, the cookie area and the oven area. This will be done by training on:

i. Correct selection of the different types of cookies used in assembling cakes and entremets.

ii. Respect for the exact dosage of ingredients in the preparation of a ready-to-use mousse and cookie.

iii. Raising awareness of the importance of time in the preparation and mixing of mousses and cookies.

iv. Respect the correct baking temperature.

b. Resources:

It’s all the resources (tangible and intangible) a company has at its disposal to create and add value through its activities.

The availability of all the necessary resources within the company helps to improve performance and create a suitable working atmosphere.

In our project, we found that among the causes of losses were material ones, based on the absence or unavailability of materials, thus the need to draw up a list of requirements for the materials needed to assemble cakes and entremets.

Table 14 shows the list of requirements with the exact number of items required.

Table 4.14: List of Materials Required.

Needs	**Numbers**
Scissors	4 (one chisel for each operator)
Knives	8: 4 small and 4 large (2 knives for each each operator)
Carts	5 extra carts just for the assembly area
Spatulas	4 (one spatula for each operator)
Ladles	3(one small, the second medium and the third large for the operator who foam on the product)

Table 4.14: List of Materials Required "Table Continued".

Measuring device	A special large dosing machine for the assembly area
Ruler	4 (one ruler for each operator)

4.4.4.2 Awareness meeting

The human factor is the main concern in our project, which motivated us to hold an awareness-raising meeting with the operators and chefs in the assembly area of the pastry lab. This meeting was based on 3 points:

a. Why this is important: Performance management based on an OPE calculation has major benefits for the company on the one side, and for employees on the other side.

b. The OPE calculation.

c. Best practices for reducing assembly time.

4.4.4.3 The 5 S approach

To manage the working environment and eliminate the percentage of waste due to space management by operators, we opted for a 5 S approach.

The 5S methodology is a systematic approach used to organize the workplace for efficiency and effectiveness. It is a foundational part of Lean Manufacturing principles, originating in Japan.

This approach helps to improve working conditions and morale for everyone in the company, since it's better to work in a clean and tidy environment, and to achieve greater efficiency for the project team, while wasting less time and energy, and therefore improving the final quality of production. The term "5S" stands for five Japanese words, each of which describes a step in the process

Table 4.15: The 5s.

Each S	Goals
Seiri (Sort)	The first step involves sorting and removing unnecessary items from the workplace. This step focuses on identifying and eliminating unneeded tools, materials, and supplies. It is about distinguishing between what is necessary and what is not and getting rid of the non-essential items.
Seiton (Set in Order)	Once unnecessary items are removed, the next step is organizing and arranging the essential items in a systematic and easily accessible way. This step is about optimizing the placement of tools, materials, and equipment, ensuring they are easily available when needed.
Seiso (Shine)	This step emphasizes cleanliness. It involves maintaining a clean and organized workplace by regular cleaning. The goal is to keep everything in its designated place and maintain cleanliness to avoid any safety or health hazards.
Seiketsu (Standardize)	Standardization involves creating consistent practices and processes for maintaining the first three S's. It means creating and adhering to standards, schedules, and procedures for keeping the workplace organized, clean, and efficient.
Shitsuke (Sustain)	The final step is about making the 5S principles a habit. It requires maintaining the discipline and persistence to continuously follow the established standards and systems. This step is about creating a culture of continuous improvement and accountability in maintaining the workplace organization.

The 5S methodology aims to improve productivity, safety, and quality by streamlining the work environment and ensuring that everything has its place, is easily accessible, and is properly maintained.

To implement this method in the pastry laboratory, we need to follow the steps below:

a. Preparing the work area: Familiarize operators and their supervisors with the approach, using a guide to prepare all the necessary materials. Set up an activity chart and prepare training materials for staff, and organize the 5 S Day.

b. Sorting and junk removal: In this step, you remove anything that doesn't belong to the workspace, following these instructions:

i. Anything that hasn't been used for a year must be thrown away, or recycled if it can be.

ii. Of what's left over, anything used less than once a month is kept out of the way (for example, in the factory's storage area).

iii. Of what's left over, anything used less than once a week is placed in the material reserve area.

iv. Of the remainder, anything used less than once a day is placed at the workstation.

v. Of the remainder, anything used less than once an hour is at the workstation, within easy reach.

vi. And anything used at least once an hour is directly with the operator (small equipment, etc.).

c. Put in order: Layout the workspace in such a way as to avoid wasting time and energy. Frequently-used objects (such as spatulas, rulers, pockets, etc.) should be located close to the operator. All items used by staff should be arranged in order of use.

d. Assignment: Define the ideal layout for the workstation and create temporary floor markings with coloured tape.

e. Cleaning: Use cleaning products to help remove sources of soiling. Write cleaning routines and draw up daily, weekly and monthly schedules.

f. Visual control: Finalize painted floor markings. View setting and storage parameters.

g. Maintenance: Raise awareness of 5S among the company's employees and implement an internal policy supporting the method. Provide a reminder of the method by means of a diagram on posters to be displayed on the walls of the pastry station.

5. CONCLUSIONS

Embarking on the final leg of our academic journey, our project bore the mantle of a transformative mission to elevate the productivity and performance benchmarks within the hallowed precincts of the pastry laboratory's assembly area. A beacon lighting our path, the operational objective loomed large: to attain an OEE (Overall Equipment Effectiveness) of 80%, an ambitious target meticulously etched by the discerning minds of the production department. Our compass for this ambitious journey?

The proven tools of Lean Six Sigma, harnessed within the structured contours of the DMAIC (Define, Measure, Analyze, Improve, Control) methodology.

Inaugurating our odyssey was the indispensable "Define" phase, a diagnostic exploration that peeled back the layers of the assembly area's current state. This foundational step was pivotal, rendering a panoramic comprehension of the existing intricacies and nuances that defined our battlefield.

As we unfurled the canvas of the assembly area's present, our gaze was steadfastly fixed on the ultimate tapestry of achievement the attainment of an OEE standing tall at 80%. The baton then passed seamlessly into the hands of the "Measure" phase, marked by the precision of timing. With meticulous rigor, we sought to delineate the temporal intricacies governing each product's production cycle. The actual time invested was juxtaposed against the calculated cycle time, birthing the quantitative cornerstone of our OEE evaluation. The crux lay in unravelling the narrative that lay hidden within these temporal metrics a tale of efficiency, or the lack thereof.

Our analytical arsenal found further augmentation in the "Analyze" phase. Here, the venerable Ishikawa diagram and the discerning Pareto chart became our accomplices, guiding our expedition through the labyrinth of causality. Every minute detail was scrutinized, every causal relationship dissected an in-depth exploration to unearth the roots of our productivity puzzle. As architects of transformation, we emerged from the chrysalis of analysis, poised for action. Proposing solutions became our clarion call, a harmonious symphony of strategic interventions:

a. Empowering the workforce through skill augmentation, breathing vitality into their professional prowess.

b. Combatting the resource deficit by raising awareness about the project's paramount significance.

c. Orchestrating a transformative dance of order through the implementation of the revered 5S methodology, meticulously conducted by the project team.

In the crucible of our final academic crucible, we not only applied the tools of our trade but also unearthed novel methodologies. Our foray into the industrial ecosystem served as a crucible for experiential learning a rich tapestry woven with threads of technical acumen and interpersonal finesse. As we stand at the denouement of our academic saga, our project is not merely an epitaph etched in ink; it's a narrative resonating with the ethos of transformative change. It's a testament to our journey a symphony composed not in isolation but in the harmonious interplay of tools, methodologies, and human ingenuity.

REFERENCES

[1] M. Haddad et R. Otayek, « Addressing the challenge of lean manufacturing sustainment with system dynamics modeling: a case study on apparel manufacturing in a developing country », 2018.

[2] A. C. Sommer et E. Z. Blumenthal, « Implementation of Lean and Six Sigma principles in ophthalmology for improving quality of care and patient flow », *Surv. Ophthalmol.*, vol. 64, nº 5, p. 720-728, sept. 2019, doi: 10.1016/j.survophthal.2019.03.007.

[3] M. D. R. Q. Castro et J. G. A. Posada, « Implementation of lean manufacturing techniques in the bakery industry in Medellin », *Gest. Produção*, vol. 26, nº 2, p. e2505, 2019, doi: 10.1590/0104-530x-2505-19.

[4] B. Gładysz, A. Buczacki, et C. Haskins, « Lean Management Approach to Reduce Waste in HoReCa Food Services », *Resources*, vol. 9, nº 12, p. 144, déc. 2020, doi: 10.3390/resources9120144.

[5] D.-L. Gómez-Molina et J. Moyano-Fuentes, « Lean management in universities: a systematic literature review », *Int. J. Lean Six Sigma*, vol. 13, nº 1, p. 156-177, janv. 2022, doi: 10.1108/IJLSS-12-2020-0224.

[6] C. Maware, M. O. Okwu, et O. Adetunji, « A systematic literature review of lean manufacturing implementation in manufacturing-based sectors of the developing and developed countries », *Int. J. Lean Six Sigma*, vol. 13, nº 3, p. 521-556, mai 2022, doi: 10.1108/IJLSS-12-2020-0223.

[7] I. Leksic, N. Stefanic, et I. Veza, « The impact of using different lean manufacturing tools on waste reduction », *Adv. Prod. Eng. Manag.*, vol. 15, nº 1, p. 81-92, mars 2020, doi: 10.14743/apem2020.1.351.

[8] S. Singh et K. Kumar, « A study of lean construction and visual management tools through cluster analysis », *Ain Shams Eng. J.*, vol. 12, nº 1, p. 1153-1162, mars 2021, doi: 10.1016/j.asej.2020.04.019.

[9] S. Nallusamy, R. Nivedha, E. Subash, V. Venkadesh, et S. Vignesh, « MINIMIZATION OF REJECTION RATE USING LEAN SIX SIGMA TOOL IN MEDIUM SCALE MANUFACTURING INDUSTRY ».

[10] M. Singh et R. Rathi, « A structured review of Lean Six Sigma in various industrial sectors », *Int. J. Lean Six Sigma*, vol. 10, nº 2, p. 622-664, mai 2019, doi: 10.1108/IJLSS-03-2018-0018.

[11] Universitas Mercu Buana Jakarta, S. Widjajanto, et H. Hardi Purba, « SIX SIGMA IMPLEMENTATION IN INDONESIA INDUSTRIES AND BUSINESSES: A SYSTEMATIC LITERATURE REVIEW », *J. Eng. Manag. Ind. Syst.*, vol. 9, nº 1, p. 23-34, mai 2021, doi: 10.21776/ub.jemis.2021.009.01.3.

[12] R. Gilligan, R. Moran, et O. McDermott, « Six Sigma application in an Irish meat processing plant to improve process yields », *TQM J.*, vol. 35, nº 9, p. 210-230, mai 2023, doi: 10.1108/TQM-02-2023-0040.

[13] A. D. Makwana et G. S. Patange, « A methodical literature review on application of Lean & Six Sigma in various industries », *Aust. J. Mech. Eng.*, vol. 19, nº 1, p. 107-121, janv. 2021, doi: 10.1080/14484846.2019.1585225.

[14] L. B. M. Costa, M. Godinho Filho, L. D. Fredendall, et G. M. D. Ganga, « The effect of Lean Six Sigma practices on food industry performance: Implications of the Sector's experience and typical characteristics », *Food Control*, vol. 112, p. 107110, juin 2020, doi: 10.1016/j.foodcont.2020.107110.

[15] N. N. Azalanzazllay, S. Abdul Halim-Lim, U. F. Ungku Zainal Abidin, et A. Priyono, « Gearing Food Manufacturing Industry Towards Lean Six Sigma Implementation: An Exploratory Study on Readiness Factors », in *2020 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, Singapore, Singapore: IEEE, déc. 2020, p. 375-379. doi: 10.1109/IEEM45057.2020.9309886.

[16] S. Tampubolon et H. H. Purba, « Lean six sigma implementation, a systematic literature review », *Int. J. Prod. Manag. Eng.*, vol. 9, nº 2, p. 125, juill. 2021, doi: 10.4995/ijpme.2021.14561.

[17] N. N. Azalanzazllay, S. A. H. Lim, U. F. U. Z. Abidin, et C. Anass, « Uncovering Readiness Factors Influencing the Lean Six Sigma Pre-Implementation Phase in the Food Industry », *Sustainability*, vol. 14, nº 14, p. 8941, juill. 2022, doi: 10.3390/su14148941.

[18] « Chapter11PerformanceManagement-preeditedversion2009.pdf ».

[19] « Performance Management: A roadmap for developing, implementing, and evaluating performance management systems ».

[20] Q. Zhang, X. Zhu, et M. Hassan, « Lean Six Sigma: A Literature Review », vol. 3, nº 10, 2012.

[21] « document (1).pdf ».

[22] B. R. Krishnan et K. A. Prasath, « SIX SIGMA CONCEPT AND DMAIC IMPLEMENTATION ».

APPENDIX A

ASSEMBLY STEPS FOR EACH PRODUCT

Description	Family	*Transaction Detail 1*	*Transaction Detail 2*	*Transaction Detail 3*	*Transaction Detail 4*	*Transaction Detail 5*	*Transaction Detail 6*	*Transaction Detail 7*	*Transaction Detail 8*
JIVARA 8P	square 8p	foam	biscuit	Foam	bearing	biscuit			
BALTHAZAR IND	half-round ind	foam	Soaked biscuit	Foam	Soaked biscuit	finishing	Cash deposit		
F AUTUMN IND DOME	ind half ronde	foam	Bearing	biscuit Soaked	Foam	biscuit soaked			
B SNOW IND	ind ronde	moistened biscuit	Foam	Raspberry	Soaked biscuit	foam			
RASPBERRY IND	ind ronde	biscuit soaked	Foam	biscuit Soaked	foam	Raspberry	biscuit soaked	Foam	Finishing raspberry
ROYAL IND	ind ronde	biscuit	Foam	Bearing	Foam				
B SNOW 10P	Round 10	foam	soaked biscuit	Raspberry	Foam	moistened biscuit			
F FALL 10P	Round 10	foam	Bearing	soaked biscuit	foam	moistened biscuit			
ROYAL 10P	Round 10	foam	biscuit	Bearing	Foam	biscuit			
B SNOW 6P	Round 6	foam	soaked biscuit	Raspberry	Foam	moistened biscuit			
F FALL 6P	Round 6	foam	Bearing	biscuit Soaked	Foam	biscuit soaked			
ROYAL 6P	Round 6	foam	biscuit	Bearing	Foam	biscuit			
B SNOW 8P	Round 8	foam	soaked biscuit	Raspberry	foam	moistened biscuit			
BALTHAZAR 6-8 PAX	Round 8	moistened biscuit	feuilletine	Foam	Soaked biscuit	foam	Finishing	Cash deposit	
F FALL 8P	Round 8	foam	Bearing	soaked biscuit	foam	moistened biscuit			
RASPBERRY TREE 6-8 PAX	Round 8	biscuit soaked	foam	biscuit Soaked	Foam	Raspberry	biscuit soaked	Foam	Finishing
ROYAL 8P	Round 8	foam	biscuit	Bearing	Foam	biscuit			
SUPREME CHOCOLATE 6-8 PAX	Round 8	biscuit soaked	foam	biscuit Soaked	foam	finishing	Depot cashier		
Charlotte	Gang	Biscuit	Foam	soaked biscuit	Foam	moistened biscuit			

Description	Family	Transaction Detail 1	Transaction Detail 2	Transaction Detail 3	Transaction Detail 4	Transaction Detail 5	Transaction Detail 6	Transaction Detail 7	Transaction Detail 8
DUCHESS	Frame	moistened biscuit	Foam	soaked biscuit	Foam	moistened biscuit	Foam	finishing	
GIANDUJA 40*60	Frame	biscuit	Foam	Fine deposit	Foam				
JIVARA FRAME 40*60	Frame	biscuit	Bearing	Foam	biscuit	Foam			
OPERA 60*40	Frame	moistened biscuit	Foam	soaked biscuit	Foam	moistened biscuit	Foam		
CARAMEL EDGE	Frame	moistened biscuit	Foam	soaked biscuit	Foam	moistened biscuit	Foam	finishing	Cash deposit
CHOCOLATE SQUARE	Frame	moistened biscuit	Foam	soaked biscuit	Foam	moistened biscuit	Foam	finishing	Cash deposit
CHOCOLATE DUO	Frame	moistened biscuit	Foam	soaked biscuit	Foam	finishing	Cash deposit		
BLACK IND DRILL	Frame	biscuit soaked	Foam	biscuit Soaked	Foam	finishing	Depot cashier		
SUPREME CHOCOLAT IND	Frame	biscuit soaked	Foam	biscuit Soaked	Foam	finishing	Depot cashier		
SQUARE CARAMEL 6P	Frame	biscuit soaked	Foam	biscuit Soaked	Foam	biscuit soaked	Foam	Finishing	Depot cashier
CARRE CHOCOLAT 6P	Frame	moistened biscuit	Foam	soaked biscuit	Foam	moistened biscuit	Foam	Finishing	Cash deposit
CHOCOLATE DUO 6P	Frame	moistened biscuit	Foam	soaked biscuit	Foam	finishing	Cash deposit		
DRILL BIT BLACK 6-8 PAX	Frame	moistened biscuit	Foam	soaked biscuit	Foam	finishing	Cash deposit		
JIVARA 10P	10p square	foam	biscuit	Foam	bearing	biscuit			
JIVARA 6P	square 6p	foam	biscuit	Foam	bearing	biscuit			

APPENDIX B

AWARENESS MEATING SHEET

B.1 PERFORMANCE MANAGEMENT

B.1.1 Performance Management:

The management of employees who are present within a company. Its objective is to:

a. Have a clear view and control of the individual contribution of the employee to the achievement of the organization's objectives.
b. Optimal use of talents by placing the right one Person in the right place.
c. To provide as much uniformity and objectivity as possible in evaluations and to motivate and lay solid foundations for a system of remuneration and development.

The company:

a. An increase in the organization's income,
b. Improved people-to-people links between members and simplification of management tasks by introducing a system of control.

Employees can also benefit from:

a. A wage increase
b. Recognition within the organization they work for.
c. Incentives to contribute more to the success of the company, which leads the organization to benefit from this performance.

B.1.2 CFS Calculation Method

The help of operators and managers is very important to establish correct and real calculations of the OPE index

What ?	The overall efficiency of an equipment is a hierarchy of measures that assesses and indicates how effectively manufacturing operation is used
For whom ?	The products of the assembly area of the pastry lab: Cakes and Entremets.
How ?  	The steps of the measurements: a. Know the assembly steps of each product b. Time each operation of the assembly c. The calculation of the cadence d. The time of editing on the spot e. Comparison between field mount time and Cadence

B.1.3 Best practices for increasing CFS

In our project, we are not looking for a 100% CFS but only the increase of the CFS to reach a percentage of 80%.

To succeed in this project, operators should follow his instructions:

i. Tidy and clean your worktop

ii. Prepare at the beginning the implementation

iii. Bring next to you all the necessary material for assembly

iv. Avoid wasting time in communication between operators

v. Divide the work between the 4 present operators

vi. Enjoy the time of expectations in another job

vii. Claim in the event of a problem Chiefs

viii. Supervise the work of operators

ix. Assist in case of shortage or workload.

x. Ensure the quality of the mousses and biscuits to avoid stops.