THE IMPACT OF LEAN MANUFACTURING PRACTICES ON WASTE REDUCTION IN FOOD AND BEVERAGE MANUFACTURING FIRMS IN EDO STATE

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CERTIFICATON

This is to certify that this research work on the "The Impact of Lean Manufacturing Practices on Waste Reduction in Food and Beverage Manufacturing Firms in Edo State" was carried out with the Mat Number **ENG2002689.** Of the Department of Production Engineering, University of Benin, Benin City.

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DEDICATION

This work is dedicated to God for His Strength, Inspiration and guidance throughout this project and to my Parents, Mr. and Mrs. Jonathan Okhuelegbe in recognition of the countless sacrifices you made to ensure my education and well-being. I also want to thank my wonderful supervisor, Engr Dr N. H. Osadiaye, for his never-ending encouragements and continuous support towards my research study.

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ABSTRACT

The food and beverage manufacturing sector in Edo State is an important part of Nigeria's industrial economy but faces major inefficiencies, including spoilage, defects, and overproduction. Lean manufacturing, derived from the Toyota Production System, offers a structured approach to eliminating waste and improving performance. Tools such as 5S, Kaizen, Just-in-Time (JIT), and Total Productive Maintenance (TPM) have proven effective in boosting productivity, although lean adoption in developing countries remains limited by infrastructural weaknesses, supply chain issues, and resistance to change.

This study evaluates the contribution of lean practices to waste reduction and operational efficiency in selected food and beverage firms in Edo State. A mixed-methods design was adopted, using descriptive and analytical approaches. Data were obtained from 30 purposively selected firms through questionnaires, interviews, and direct observations. Descriptive statistics were used to categorize waste types, while regression and correlation analyses assessed the relationship between lean practices and waste reduction. Thematic analysis further examined barriers to implementation, and SPSS with Microsoft Excel ensured accurate data analysis.

Findings indicated that spoilage was the most widespread form of waste, followed by defects and overproduction. Lean practices, especially 5S and JIT, significantly improved waste reduction, accounting for 67% of the variation in performance. However, unstable electricity supply, insufficient employee training, and unreliable suppliers weakened overall lean adoption. The study recommends a gradual implementation of lean, starting with easier-to-apply tools such as 5S and Kaizen, along with capacity-building programs and strengthened supply chain collaboration. Policy support for infrastructure and industry-focused training is essential to improve lean outcomes and support long-term sustainability.

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NOMENCLATURE

ANOVA – Analysis of Variance

DMAIC – Define, Measure, Analyze, Improve, Control

FAO – Food and Agriculture Organization

JIT – Just-in-Time

OEE – Overall Equipment Effectiveness

SPSS – Statistical Package for the Social Sciences

5S – Sort, Set in Order, Shine, Standardize, Sustain

TPM – Total Productive Maintenance

TPS – Toyota Production System

VSM – Value Stream Mapping

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The food and beverage manufacturing sector occupies a vital position in Nigeria's industrial landscape, contributing significantly to employment generation, value addition, and food security. However, the sector continues to grapple with challenges of inefficiency and waste, which undermine productivity and competitiveness. Waste in this context extends beyond material loss to include spoilage, defects, overproduction, downtime, and energy inefficiencies, all of which increase production costs and reduce profit margins. The persistence of these waste streams makes it imperative for firms to adopt systematic approaches to process improvement and cost reduction in order to remain competitive both locally and internationally (Ohno, 1988; Taiichi, 2019). Lean manufacturing, which originated from the Toyota Production System, has gained global recognition as a strategic approach to minimizing waste and optimizing value creation in manufacturing environments. Its philosophy emphasizes the elimination of non-value-adding activities and continuous improvement through tools such as 5S, Kaizen, Just-in-Time (JIT), Total Productive Maintenance (TPM), and Six Sigma. Empirical evidence suggests that the implementation of lean practices leads to improved efficiency, higher product quality, and reduced operational costs in diverse industrial contexts (Womack & Jones, 2003; Liker, 2004). Within the food and beverage sector, lean techniques are particularly relevant because of the perishable nature of raw materials and finished products, which makes spoilage and defects costly forms of waste that directly affect consumer satisfaction and firm profitability (Abdulmalek & Rajgopal, 2007). In Edo State, Nigeria, food and beverage firms contend with unique contextual constraints such as unstable electricity supply, limited cold-storage facilities, and supply chain unreliability. These factors exacerbate spoilage and increase production losses, making waste reduction efforts both urgent and complex. Recent studies conducted among food and beverage firms in Edo State revealed that spoilage is the most significant waste type, followed by defects and overproduction, and that lean practices particularly 5S, Kaizen, and TPM are increasingly being adopted to address these inefficiencies (Ede & Oko, 2021). Statistical analysis from these studies indicated that lean practices accounted for about 67 percent of the variation in waste reduction, underscoring their effectiveness when properly implemented despite infrastructural and organizational challenges (Omoregie, 2022).

The emerging evidence demonstrates that lean manufacturing holds considerable promise for tackling systemic waste in the food and beverage sector of Edo State. Yet, barriers such as inadequate employee training, unreliable power supply, and weak supplier networks continue to hinder widespread adoption. This background creates a compelling case for investigating not only the extent of lean adoption but also its measurable impact on waste reduction, thereby generating insights that can guide firms, policymakers, and industry stakeholders in promoting operational excellence and sustainability.

1.2 Statement of the Problem

Despite the recognized importance of the food and beverage sector to Nigeria’s economic growth, firms in Edo State continue to grapple with significant levels of waste that erode profitability and weaken competitiveness. Spoilage, defects, and overproduction are recurring problems, often worsened by infrastructural deficiencies such as unstable electricity supply, inadequate storage facilities, and inefficient production systems. While lean manufacturing practices have been shown to reduce waste and improve efficiency in other industrial contexts, their adoption in Edo State remains inconsistent and limited in scope. Many firms apply basic tools such as 5S and Kaizen, but the deeper integration of lean techniques is hindered by organizational, technical, and environmental barriers. This gap between the potential benefits of lean practices and the actual outcomes experienced by firms presents a critical challenge. Without deliberate efforts to understand how lean can be more effectively applied, waste will continue to undermine operational performance, profitability, and sustainability in food and beverage manufacturing firms across the state.

1.3 Aim and Objectives of the Study

1.3.1 Aim of the Study

To evaluate the impact of lean manufacturing practices on waste reduction in food and beverage manufacturing firms in Edo State, with a focus on enhancing operational efficiency, reducing costs, and promoting sustainable production practices.

1.3.2 Objectives of the Study

To achieve the aim of this study, the following objectives would be pursued;

i. Identify and categorize the major types of waste in food and beverage manufacturing processes through the administration of structured questionnaires, direct observation, and descriptive statistical analysis.

ii. Examine the extent of lean manufacturing adoption in the study area by evaluating the application of tools such as 5S, Kaizen, Just-in-Time, and Total Productive Maintenance using survey data and frequency distributions.

iii. Assess the impact of lean practices on waste reduction and operational efficiency through correlation and multiple regression analysis of the data obtained from the sampled firms.

iv. Investigate the barriers to effective lean adoption by analyzing responses from semi-structured interviews, descriptive statistics, and thematic interpretation of open-ended data.

v. Provide context-specific recommendations for enhancing lean manufacturing practices based on the empirical findings, statistical outcomes, and thematic insights derived from the study.

1.4 Scope of the Study

This study is limited to food and beverage manufacturing firms operating within Edo State, with particular focus on Benin City as a major industrial hub in the region. The scope covers firms that are formally registered, employ at least twenty-five staff, and operate continuous production processes where waste management and lean practices are significant considerations. A total of thirty firms were purposively selected to reflect a balanced mix of small, medium, and large-scale enterprises, ensuring that the findings capture diverse operational realities. Within these firms, managerial staff, production supervisors, quality control officers, and operations or maintenance personnel were targeted as respondents since they are directly involved in implementing lean practices and addressing waste issues.

The study is further bounded by its focus on specific research variables, namely, the identification of major types of waste such as spoilage, defects, and overproduction, the extent of adoption of lean practices including 5S, Kaizen, Just-in-Time, and Total Productive Maintenance, and the measurement of their impact on waste reduction and operational efficiency. The research also addresses barriers that hinder the adoption of lean practices, including infrastructural, organizational, and human resource-related constraints. Although the findings provide meaningful insights into lean implementation in Edo State, the study does not extend to other states or sectors beyond food and beverage manufacturing, and its conclusions should be interpreted within these defined boundaries.

1.5 Significance of the Study

This study is significant because it provides both theoretical and practical insights into the role of lean manufacturing practices in reducing waste within the food and beverage sector of Edo State. From an academic perspective, it contributes to the growing body of literature on lean implementation in developing economies, where contextual challenges such as unreliable power supply, inadequate infrastructure, and skill gaps make the outcomes of lean adoption different from those reported in more industrialized settings. By examining how specific tools such as 5S, Kaizen, Just-in-Time, and Total Productive Maintenance influence waste reduction, the study deepens understanding of the applicability and effectiveness of lean in Nigeria's manufacturing environment.

that firms can adopt to minimize waste, lower costs, and improve operational efficiency. Its findings offer managers and decision-makers evidence-based insights into which lean practices are most effective within their operational context, while also exposing the barriers that must be addressed for successful implementation. Policymakers and regulators also benefit from the study, as the results underscore the need for infrastructural improvements and targeted training programs to support lean adoption. Ultimately, the study holds value for the broader economy by pointing to pathways through which local firms can strengthen competitiveness, enhance sustainability, and contribute more effectively to industrial development in Edo State and Nigeria as a whole.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In the food and beverage sector, the issue of waste is more critical due to the perishable nature of raw materials, the need for strict quality standards, and the high cost associated with production losses. Inefficient processes that result in spoilage, defects, downtime, or overproduction not only affect profitability but also have broader implications for food security and sustainability (Abdulmalek & Rajgopal, 2007). This has necessitated the adoption of structured process improvement methodologies that can effectively address these waste-related challenges. Lean manufacturing has emerged as one of the most widely accepted approaches to waste reduction and process optimization. Originating from the Toyota Production System, lean emphasizes the elimination of non-value-adding activities and the continuous improvement of processes to maximize customer value while minimizing waste (Ohno, 1988; Womack & Jones, 2003). The integration of lean practices such as 5S, Kaizen, Just-in-Time, Total Productive Maintenance, and Six Sigma has been shown to yield significant operational benefits across industries, including reduced cycle times, lower defect rates, and enhanced efficiency (Liker, 2004).

although contextual factors such as infrastructural challenges, limited technical expertise, and supply chain inefficiencies continue to limit their full potential (Akinwale & Adegbuyi, 2019). Within Nigeria, and specifically in Edo State, food and beverage firms operate in a challenging environment marked by unstable electricity supply, limited cold storage infrastructure, and resource constraints. These realities make waste reduction both a pressing concern and a difficult goal to achieve. At the same time, empirical evidence indicates that lean practices, when properly adapted, can make a substantial contribution to reducing waste and improving operational performance in the sector (Omoregie, 2022).

2.2 Concept and Evolution of Lean Manufacturing

Lean manufacturing is a systematic approach to production management that focuses on the elimination of waste, the optimization of resources, and the continuous creation of value for customers. The core concept of lean is rooted in the principle that every activity in a production system should either directly add value or support value-adding processes, and any activity that does not is considered waste. Waste, or *muda* as originally termed in Japanese, encompasses excess inventory, unnecessary movement, defects, overproduction, waiting times, and other inefficiencies that consume resources without enhancing customer value (Ohno, 1988). The lean concept therefore emphasizes efficiency not by working harder, but by working smarter streamlining processes, improving flow, and maximizing the utility of every input.

The evolution of lean manufacturing can be traced back to post-war Japan, when Toyota faced the challenge of producing vehicles with limited resources while competing against larger Western automakers. Taiichi Ohno, often regarded as the father of the Toyota Production System (TPS), developed a philosophy that combined just-in-time production, jidoka (automation with a human touch), and continuous improvement (Kaizen) to create a highly efficient and flexible production system (Ohno, 1988; Liker, 2004). This system enabled Toyota to achieve remarkable performance gains and ultimately set a new global standard for manufacturing efficiency.

The term “lean” was first popularized in Western literature by Womack, Jones, and Roos (1990) in The Machine That Changed the World. Their groundbreaking study of global automotive production revealed how Toyota’s methods produced higher quality vehicles at lower costs compared to mass production systems in the United States and Europe. This publication shifted lean from a company-specific system to a widely studied and transferable model for industrial improvement. Building on this work, Womack and Jones (2003) distilled lean into five guiding principles: defining value from the customer's perspective, mapping the value stream, creating flow, establishing pull, and striving for perfection. These principles transformed lean from a collection of tools into a coherent philosophy that could be applied across industries. As lean spread globally, its evolution extended beyond automotive manufacturing into other sectors such as electronics, aerospace, healthcare, construction, and food processing. In these industries, lean practices have been adapted to suit sector-specific challenges. For example, in healthcare, lean has been used to reduce patient waiting times and medical errors, while in construction it has been applied to minimize delays and material wastage. In the food and beverage sector, lean has become particularly significant due to the perishability of raw materials and the sensitivity of products to defects and delays. Lean principles such as Just-in-Time production, Total Productive Maintenance, and Poka-Yoke (error-proofing) have been found to directly reduce spoilage, downtime, and quality lapses in food production systems (Abdulmalek & Rajgopal, 2007).

tools. Six Sigma, for instance, was introduced to complement lean by providing a data-driven approach to reducing process variation and defects. The combination of lean and Six Sigma has produced a more robust framework that not only eliminates waste but also ensures process reliability and consistency (Shah & Ward, 2007). Similarly, Value Stream Mapping (VSM) has emerged as a critical visualization tool that helps firms identify bottlenecks and non-value-adding steps across entire supply chains. This integration of tools demonstrates how lean has evolved into a holistic management system that blends operational efficiency, quality assurance, and strategic decision-making.

In developing countries, the concept of lean has gained increasing traction as firms face the dual pressures of global competition and limited local infrastructure. Studies have shown that lean adoption in such contexts is often gradual and selective, with firms initially applying basic tools like 5S for workplace organization and Kaizen for small-scale improvements, before moving to more advanced systems such as Just-in-Time or Six Sigma that require greater technical and infrastructural support (Akinwale & Adegbuyi, 2019). In Nigeria, and specifically in food and beverage firms within Edo State, lean has been applied as a pragmatic response to challenges such as power instability, high spoilage rates, and unreliable supply chains. Evaluations indicate that while firms adopting lean experience measurable waste reduction and efficiency gains, systemic barriers such as inadequate employee training and infrastructural deficits hinder the full realization of lean's benefits (Ede & Oko, 2021; Omoregie, 2022).

2.3 Elements of Lean Manufacturing

The effectiveness of lean manufacturing lies in its structured set of elements that guide firms toward operational efficiency and waste minimization. These elements form the foundation of lean philosophy, translating its abstract principles into practical actions that can be applied across industries. At the core of lean are the five principles articulated by Womack and Jones (2003): defining value, mapping the value stream, creating flow, establishing pull, and pursuing perfection. These principles serve as a roadmap for organizations seeking to identify sources of waste, streamline processes, and build a culture of continuous improvement. The first element, value, emphasizes that production should be guided by what the customer perceives as useful and worth paying for. Any activity that does not add to this customer-defined value is regarded as waste. In food and beverage manufacturing, for instance, spoilage, defective packaging, or excess inventory does not contribute to consumer satisfaction and must therefore be reduced or eliminated. Closely related to this is the mapping of the value stream, which involves identifying all steps in the production process and distinguishing between those that add value and those that do not. By visualizing the entire production flow, managers are better able to pinpoint bottlenecks, redundancies, and inefficiencies that contribute to waste (Shah & Ward, 2007). Creating flow is another fundamental element of lean. It involves organizing the production process so that materials, products, and information move smoothly without unnecessary interruptions. In the food industry, where perishability is a major concern, maintaining flow is essential to minimizing spoilage and ensuring timely delivery to markets. The principle of pull complements this by ensuring that production is driven by actual customer demand rather than forecasts, thereby reducing overproduction and excess inventory. Pull systems, exemplified by Just-in-Time production, help food and beverage firms align their operations more closely with market demand, improving efficiency and reducing waste (Ohno, 1988; Abdulmalek & Rajgopal, 2007).

improvement. Lean views efficiency not as a one-time achievement but as an ongoing pursuit of excellence, where firms continually refine their processes, empower employees to solve problems, and aim for zero waste. This element is operationalized through practices such as Kaizen, Total Productive Maintenance, and error-proofing methods like Poka-Yoke, which together foster a culture where every worker contributes to organizational improvement. In food and beverage firms, the pursuit of perfection translates into reduced defect rates, better hygiene and safety standards, and consistently high product quality (Liker, 2004; Omoregie, 2022).

2.4 Tools and Techniques of Lean Manufacturing

2.4.1 Just-in-Time (JIT)

Just-in-Time (JIT) is one of the foundational techniques of lean manufacturing, developed within the Toyota Production System to address inefficiencies caused by excessive inventory and overproduction. The core philosophy of JIT is to produce and deliver goods in the exact quantity required, at the precise time they are needed, and in the right place. By doing so, JIT eliminates the need for large inventories, reduces storage costs, and minimizes the risk of waste from obsolescence or spoilage (Ohno, 1988). The technique is fundamentally demand-driven, meaning that production is pulled by actual customer orders rather than pushed by forecasts, thereby aligning production more closely with real market needs (Womack & Jones, 2003).

The implementation of JIT requires a reliable and synchronized flow of materials, where suppliers deliver inputs just as they are needed in the production process. This synchronization not only reduces inventory levels but also exposes inefficiencies and delays within the system, forcing firms to continuously improve their processes. In practice, JIT encompasses activities such as setup time reduction, small batch production, and close collaboration with suppliers to ensure timely deliveries (Shah & Ward, 2007).

In the food and beverage industry, JIT holds particular significance because of the perishable nature of raw materials and finished products. Excessive inventory in this sector often leads to spoilage, higher storage costs, and compromised product quality. By applying JIT, firms can reduce these risks by ensuring that production closely matches consumer demand and that inputs are consumed quickly after procurement. For instance, dairy or beverage producers that adopt JIT scheduling can minimize waste associated with expired products while also improving freshness for consumers.

However, the application of JIT in developing economies such as Nigeria presents notable challenges. Unstable infrastructure, unreliable transportation systems, and inconsistent supplier performance can make the precise timing required for JIT difficult to achieve. Power outages and poor logistics, common in the Nigerian context, may disrupt production schedules and reduce the effectiveness of JIT systems. Despite these constraints, studies in Nigerian food and beverage firms indicate that firms adopting elements of JIT, such as smaller batch sizes and closer supplier coordination, report reductions in overproduction and inventory-related losses (Ede & Oko, 2021; Omoregie, 2022).

2.4.2 Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) is a lean manufacturing technique that focuses on maximizing the effectiveness and lifespan of equipment through proactive and preventive maintenance. Unlike traditional maintenance strategies that often react to equipment breakdowns, TPM emphasizes the prevention of failures before they occur, thereby ensuring uninterrupted production flow. The core idea is that all employees, from machine operators to managers, share responsibility for maintaining equipment and ensuring optimal performance (Nakajima, 1988). The origins of TPM can be traced to Japan in the 1970s, when manufacturers sought to enhance productivity by reducing downtime and extending the life of machinery. TPM is built around eight pillars, which include autonomous maintenance, planned maintenance, focused improvement, early equipment management, training and education, quality maintenance, office TPM, and safety, health, and environment. Collectively, these pillars seek to create a holistic culture where maintenance is integrated into daily work rather than being treated as a separate or reactive function (Ahuja & Khamba, 2008).

In practice, TPM requires operators to carry out basic maintenance activities such as cleaning, lubrication, inspection, and minor adjustments. By involving operators in routine care, machines are less likely to suffer unexpected breakdowns, while maintenance teams can focus on more complex preventive and predictive tasks. The ultimate goal is to achieve "zero breakdowns, zero defects, and zero accidents," which aligns with lean's broader philosophy of continuous improvement and waste elimination (Sharma & Kodali, 2008).

Within the food and beverage industry, TPM plays a crucial role in ensuring consistent production and product quality. Food processing and packaging operations are highly dependent on specialized machinery, and unplanned equipment failures can lead to large-scale spoilage, contamination risks, and costly downtime. For example, a sudden failure in refrigeration or bottling equipment can result in significant product losses due to the perishable nature of goods. TPM helps mitigate these risks by ensuring that machines are reliable and available when needed, thus reducing spoilage and maintaining quality standards (Ahuja & Khamba, 2008). In developing economies like Nigeria, TPM is especially relevant given the high cost of equipment replacement and the difficulty of sourcing spare parts. Many firms face challenges such as poor infrastructure, irregular power supply, and limited technical expertise, which make equipment reliability a pressing concern. In this context, TPM provides a structured approach to extending the lifespan of machinery and reducing waste due to downtime. Studies conducted in Nigerian food and beverage firms have shown that firms applying TPM principles experience improved production efficiency, reduced breakdown frequency, and enhanced overall equipment effectiveness (Ede & Oko, 2021; Omoregie, 2022).

Despite its benefits, the implementation of TPM in Nigeria is often hindered by inadequate employee training, limited investment in maintenance programs, and resistance to cultural change.

Effective TPM requires not only technical interventions but also a shift in organizational mindset, where maintenance is seen as a shared responsibility rather than the sole duty of a specialized department. Nonetheless, TPM remains a powerful lean tool for ensuring smooth operations, reducing waste associated with downtime, and enhancing long-term productivity in food and beverage manufacturing.

2.4.3 5S (Lean tool)

The 5S methodology is one of the most fundamental and widely applied lean manufacturing tools, designed to improve workplace organization, efficiency, and safety. Derived from five Japanese terms Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), and Shitsuke (Sustain) the 5S approach provides a structured framework for eliminating clutter, streamlining workflow, and creating a disciplined production environment (Osada, 1991). Each of the five elements works together to promote efficiency, reduce waste, and enhance employee morale by ensuring that the workplace is orderly and conducive to high performance. The first step, Sort, involves identifying and removing unnecessary items from the workplace to create space and reduce confusion. Set in order ensures that tools, equipment, and materials are arranged logically and remain easily accessible. Shine emphasizes regular cleaning and inspection of the work environment, helping to identify abnormalities such as leaks or wear before they cause breakdowns. Standardize involves developing clear and consistent procedures to maintain workplace organization, while sustain ensures that 5S becomes ingrained as a cultural habit rather than a one-time activity (Hirano, 1995).

In the food and beverage industry, the application of 5S is particularly critical because of the sector's strict hygiene requirements and the high risk of contamination. A clean, organized environment ensures compliance with food safety standards while also reducing product defects and spoilage. For instance, sorting and proper arrangement of ingredients and packaging materials minimizes errors in production, while cleaning and standardization help maintain the hygiene necessary to meet regulatory requirements. Moreover, sustaining these practices promotes discipline among employees, which directly contributes to efficiency and consistency in production processes (Liker, 2004).

The benefits of 5S extend beyond hygiene and organization to include waste reduction and improved productivity. By minimizing time spent searching for tools or handling misplaced materials, 5S reduces motion waste and downtime, enabling employees to focus on value-adding tasks. Additionally, by embedding cleanliness and order into daily routines, firms can prevent minor inefficiencies from escalating into major disruptions. Research has shown that organizations implementing 5S experience enhanced operational efficiency, improved employee involvement, and better workplace safety (Ho, 1999).

In developing contexts such as Nigeria, 5S serves as an accessible entry point for firms seeking to adopt lean practices. Unlike more complex tools such as Just-in-Time or Six Sigma, 5S requires minimal capital investment and can be implemented incrementally. Studies in Nigerian food and beverage firms have shown that 5S adoption reduces production waste, improves workplace safety, and strengthens employee discipline, even in environments with infrastructural challenges (Ede & Oko, 2021; Omoregie, 2022). However, the long-term success of 5S depends on sustaining the cultural change it demands, which requires continuous training, leadership commitment, and regular audits to prevent backsliding.

2.4.4 Kaizen

Kaizen, a Japanese term meaning “continuous improvement,” is one of the core techniques of lean manufacturing and a cornerstone of the Toyota Production System. Unlike large-scale innovation that often requires substantial capital investment, Kaizen emphasizes incremental, ongoing improvements in processes, systems, and practices. The philosophy is grounded in the belief that small, consistent changes accumulated over time lead to significant long-term improvements in efficiency, quality, and productivity (Imai, 1997).

At the heart of Kaizen is the active involvement of employees at all levels of the organization. Workers on the shop floor, who interact most directly with machines and processes, are encouraged to identify inefficiencies, propose solutions, and take part in implementation. This bottom-up approach ensures that improvement initiatives are practical, context-specific, and sustainable. Managers and supervisors play a complementary role by providing guidance, resources, and support for employee-driven improvement initiatives (Liker, 2004). By integrating the knowledge of frontline workers with management oversight, Kaizen fosters a collaborative culture where everyone contributes to organizational excellence.

In the food and beverage sector, Kaizen plays a particularly important role in addressing inefficiencies linked to perishability, variability in demand, and quality control. For instance, employees may suggest modifications to packaging processes to reduce defects, adjustments to storage practices to minimize spoilage, or workflow changes to improve throughput. Because Kaizen is incremental, firms can implement these improvements without disrupting ongoing operations or incurring prohibitive costs. This makes Kaizen especially suitable for firms in developing economies, where resources for large-scale restructuring are often limited (Bhuiyan & Baghel, 2005).

Beyond operational efficiency, Kaizen has also been linked to improvements in employee morale and organizational culture. By giving workers a sense of ownership and responsibility for process improvement, Kaizen promotes greater job satisfaction and reduces resistance to change. This cultural dimension is particularly valuable in food and beverage firms, where adherence to hygiene and quality standards requires collective commitment. Firms that institutionalize Kaizen often find that employees are more proactive in identifying risks, maintaining cleanliness, and ensuring compliance with safety standards (Singh & Singh, 2009).

In Nigeria, the application of Kaizen has shown promising results, though adoption is still at an early stage. Studies have reported that food and beverage firms in Edo State use Kaizen primarily in simple forms, such as daily meetings to discuss performance and small group problem-solving sessions. These practices have been effective in reducing production waste, improving packaging accuracy, and addressing minor quality defects (Ede & Oko, 2021; Omoregie, 2022). However, challenges such as limited training, hierarchical organizational structures, and resistance to employee-driven decision-making sometimes hinder the full integration of Kaizen into company culture.

2.4.5 Poka-Yoke

Poka-Yoke, a Japanese term meaning "mistake-proofing," is a lean manufacturing technique developed to prevent errors at their source and ensure that defects do not reach the customer. The concept was introduced by Shigeo Shingo in the 1960s as part of the Toyota Production System, and it remains one of the most practical approaches to quality assurance within lean frameworks (Shingo, 1986). The primary objective of Poka-Yoke is to design processes and systems in such a way that errors are either impossible to occur or immediately detectable before they cause defects. The technique operates on the principle that human error is inevitable but defects are preventable if processes are designed to anticipate and block mistakes. Poka-Yoke solutions often involve simple and low-cost devices, mechanisms, or procedural checks that automatically identify abnormalities and prevent incorrect actions. Examples include limit switches, sensors, alarms, visual indicators, or physical design features that only allow assembly in the correct orientation. By embedding such controls into production systems, organizations can significantly reduce quality failures and the costs associated with rework or product recalls (Chase *et al*., 2010). In the food and beverage industry, where consumer safety and product quality are paramount, Poka-Yoke plays a critical role in ensuring compliance with regulatory standards and customer expectations. Mistake-proofing devices can be used to detect mislabeling of packages, incorrect filling volumes in bottles, or contamination risks during processing. For example, sensors may stop production lines if packaging materials are misaligned, or if metal fragments are detected in food products. These safeguards not only prevent defective products from reaching consumers but also reduce wastage by addressing errors at the earliest possible stage (Saurin *et al*., 2010). The relevance of Poka-Yoke in Nigerian food and beverage firms is particularly high given the infrastructural and operational challenges they face. Frequent power fluctuations, outdated equipment, and limited technical expertise increase the likelihood of errors in production processes. In such environments, the introduction of automated checks and mistake-proofing devices provides a cost-effective way to maintain product quality and minimize defects. Case evidence from Edo State firms suggests that adopting Poka-Yoke techniques has helped reduce instances of defective packaging, inaccurate measurements, and contamination, thereby contributing to waste reduction and customer satisfaction (Ede & Oko, 2021; Omoregie, 2022). Despite its advantages, the implementation of Poka-Yoke is not without challenges. It requires upfront investment in devices or systems, and employees must be adequately trained to understand and maintain them. Furthermore, the cultural mindset within some organizations may underestimate the importance of proactive error prevention, focusing instead on reactive inspection. Overcoming these barriers requires management commitment, proper training, and integration of mistake-proofing into the overall quality culture of the organization.

2.4.6 Value Stream Mapping

Value Stream Mapping (VSM) is a lean manufacturing tool used to visualize and analyze the flow of materials and information through a production system. It provides a structured approach to identifying value-adding and non-value-adding activities within a process, thereby making waste more visible and easier to eliminate. By creating a graphical representation of the current state of operations and comparing it to an ideal future state, firms can develop a roadmap for process improvement and continuous waste reduction (Rother & Shook, 2003).

The core principle behind VSM is that inefficiencies often arise not from individual tasks but from the interactions between processes. Mapping the entire value stream allows organizations to see beyond localized improvements and focus on optimizing the system as a whole. A typical VSM exercise captures process steps, cycle times, inventory levels, waiting periods, and information flows, enabling managers to identify bottlenecks, redundancies, and sources of waste such as excess inventory, delays, or unnecessary movements (Hines & Rich, 1997).

In the food and beverage industry, VSM is particularly relevant because of the sector's reliance on complex supply chains and strict quality standards. Perishable inputs such as grains, dairy products, and fruits often move through multiple processing stages, each of which can contribute to waste if not carefully managed. By mapping the value stream, firms can pinpoint where spoilage occurs due to long waiting times, where defects are introduced during processing, or where overproduction leads to excess stock that risks expiring. For example, a beverage manufacturer may use VSM to identify inefficiencies in its bottling line, such as excessive downtime between filling and packaging, and redesign the process to achieve smoother flow and reduced waste (Abdulmalek & Rajgopal, 2007).

The application of VSM also extends to logistics and distribution in food and beverage firms. Inefficient scheduling, poor inventory control, or misaligned supply chains often contribute to delays and spoilage. By analyzing material and information flows from suppliers through to end customers, firms can develop leaner distribution networks that reduce transportation waste, shorten lead times, and improve responsiveness to demand. This is especially important in Nigeria, where infrastructural challenges such as poor road networks and unreliable electricity amplify supply chain inefficiencies (Ede & Oko, 2021).

One of the strengths of VSM is its ability to integrate both lean and Six Sigma approaches by highlighting not only waste but also sources of process variation. This dual focus allows firms to design improvements that address both efficiency and quality simultaneously. However, effective VSM requires accurate data collection and active involvement of employees across departments, which can be challenging in environments with limited technical expertise or weak organizational collaboration.

In Edo State, food and beverage firms that have adopted VSM report improved visibility of waste and greater coordination among production, quality control, and logistics functions. By applying VSM, these firms have been able to design future-state maps that guide the adoption of other lean tools such as Just-in-Time production and Kaizen, creating a more integrated approach to waste reduction (Omoregie, 2022). Despite infrastructural constraints, the adaptability of VSM makes it a valuable technique for systematically diagnosing inefficiencies and developing targeted improvement strategies.

2.4.7 Six Sigma

Six Sigma is a data-driven methodology aimed at reducing process variation, improving quality, and achieving near-perfect performance in production systems. Developed by Motorola in the 1980s and later popularized by General Electric, Six Sigma focuses on systematically identifying and eliminating the root causes of defects, with the ultimate goal of achieving a process capability that produces no more than 3.4 defects per million opportunities (Harry & Schroeder, 2000). Unlike traditional quality control methods that rely on inspection to detect errors after production, Six Sigma emphasizes prevention by embedding statistical and analytical tools into the entire production process.

At the heart of Six Sigma lies the DMAIC framework; Define, Measure, Analyze, Improve, and Control which provides a structured problem-solving methodology for process improvement. In the Define phase, project goals and customer requirements are clearly established. The Measure phase involves data collection to establish baseline performance. The Analyze phase identifies root causes of defects using statistical techniques, while the Improve phase implements solutions to address these causes. Finally, the Control phase establishes monitoring mechanisms to sustain improvements over time (Antony, 2006). This systematic cycle ensures that improvements are data-driven, measurable, and sustainable.

In the context of lean manufacturing, Six Sigma is often combined with lean principles to form Lean Six Sigma, a hybrid approach that balances efficiency with quality. While lean tools such as 5S, Kaizen, and Just-in-Time focus on eliminating waste and improving flow, Six Sigma addresses process variation and defect reduction. Together, they create a comprehensive framework for achieving operational excellence, where processes are both efficient and reliable (George, 2002). The application of Six Sigma in the food and beverage industry is particularly important due to the sector's strict regulatory requirements and the high cost of quality failures. Defects in this context may involve incorrect labeling, contamination, inconsistent filling volumes, or packaging errors, all of which compromise consumer safety and brand reputation. Six Sigma tools, such as statistical process control, cause-and-effect analysis, and design of experiments, help firms identify the sources of these problems and implement targeted solutions. For instance, beverage producers can use Six Sigma to analyze filling machine performance, identify causes of underfilling or overfilling, and implement process adjustments to ensure consistency (Corbett, 2011). The adoption of Six Sigma has been limited compared to developed nations, largely due to the technical expertise and data requirements needed for its successful implementation. However, firms that have integrated elements of Six Sigma into their operations have reported improvements in defect reduction and customer satisfaction (Ede & Oko, 2021). In Edo State, food and beverage firms that combine basic lean tools with Six Sigma methodologies achieve better control over product quality, reduce rework and wastage, and enhance competitiveness in increasingly demanding markets (Omoregie, 2022).

2.5 Waste Reduction in Food and Beverage Firms

Waste reduction is one of the most critical challenges in the food and beverage industry due to the perishable nature of raw materials, strict hygiene standards, and increasingly demanding consumer expectations. Unlike durable goods industries where excess inventory may be stored for extended periods, food and beverage firms face substantial risks of spoilage, contamination, and quality degradation. Waste in this sector is not limited to physical products alone but also includes time, energy, and resources lost through inefficient processes, poor planning, and inadequate infrastructure (Parfitt *et al.*, 2010). Effective waste reduction strategies are therefore essential not only for improving profitability but also for ensuring sustainability and compliance with regulatory requirements.

A major source of waste in food and beverage firms is overproduction, which occurs when firms produce more than market demand or produce too early. This often results in unsold goods reaching expiration, particularly in dairy, beverage, and confectionery industries. Closely related is inventory waste, where excessive raw materials or finished products are stored beyond their usable shelf-life. Defects, including damaged packaging, improper labeling, or contamination, also contribute significantly to waste, as such products must be discarded or reprocessed. Additionally, downtime from equipment failures or unreliable power supply leads to spoilage of in-process materials, while transportation delays can compromise product freshness during distribution (Garrone *et al*., 2014).

The application of lean manufacturing practices provides structured solutions to these challenges. For instance, Just-in-Time (JIT) reduces overproduction and inventory waste by aligning production with actual demand, while Total Productive Maintenance (TPM) minimizes downtime and spoilage by ensuring equipment reliability. 5S and Kaizen support waste reduction by improving workplace organization and fostering continuous improvement in processes, which in turn reduce motion waste and inefficiencies. Similarly, Poka-Yoke helps prevent errors such as mislabeling or underfilling, while Value Stream Mapping (VSM) identifies hidden bottlenecks and inefficiencies across the production chain (Shah & Ward, 2007; Abdulmalek & Rajgopal, 2007). In the Nigerian context, particularly within Edo State, waste reduction in food and beverage firms faces additional obstacles linked to infrastructural deficits. Poor road networks, inconsistent power supply, and inadequate storage facilities contribute to higher levels of spoilage and inefficiency compared to developed economies. Despite these challenges, firms that have adopted lean practices report measurable improvements.

For example, studies have shown that the mplementation of 5S and Kaizen initiatives reduced material waste and improved workplace safety in Nigerian beverage firms, while TPM adoption lowered machine breakdown rates and minimized production losses (Ede & Oko, 2021; Omoregie, 2022).

Beyond operational benefits, waste reduction in food and beverage firms has significant environmental and social implications. Reducing food waste helps conserve resources such as water, energy, and agricultural inputs, thereby contributing to sustainability goals. It also addresses ethical concerns, as food waste coexists with persistent food insecurity in many developing countries, including Nigeria (FAO, 2019). Firms that prioritize waste reduction not only enhance profitability but also build stronger reputations with regulators, consumers, and international partners concerned with sustainability standards.

2.6 Impact of Lean Manufacturing in Waste Reduction

Lean is designed to identify and eliminate non-value-adding activities, ensuring that resources are used efficiently to deliver products that meet customer requirements. In food and beverage firms, where waste manifests in the form of spoilage, defects, downtime, and inefficiencies in resource use, lean practices have shown considerable potential in minimizing losses and improving operational performance (Womack & Jones, 2003; Shah & Ward, 2007).

One of the most significant impacts of lean on waste reduction lies in its ability to address overproduction and inventory waste. By adopting Just-in-Time (JIT) systems, firms align production with actual customer demand, thereby reducing the accumulation of unsold goods and minimizing the risk of spoilage in perishable products. Studies in process industries have shown that JIT implementation leads to shorter lead times, lower storage costs, and fresher products reaching consumers (Abdulmalek & Rajgopal, 2007). Similarly, Value Stream Mapping (VSM) provides a visual framework for identifying bottlenecks and inefficiencies, enabling firms to redesign processes to achieve smoother flow and reduced waste.

Lean also has a strong impact on reducing defects and rework, which are particularly costly in the food and beverage sector due to strict quality and safety requirements. Techniques such as Poka-Yoke (error-proofing) and Six Sigma help prevent mistakes at the source and reduce process variation, ensuring that fewer defective products are produced. This reduces not only material waste but also the costs associated with recalls, reputational damage, and customer dissatisfaction (Shingo, 1986; George, 2002). Lean practices such as Total Productive Maintenance (TPM) significantly reduce downtime waste by ensuring that equipment is reliable and available when needed. By involving operators in preventive maintenance, TPM minimizes breakdowns and ensures continuity of production, which is especially critical in food processing operations where interruptions often lead to spoilage. 5S and Kaizen further contribute to waste reduction by fostering workplace organization, standardization, and continuous improvement, which together minimize motion waste, enhance efficiency, and sustain hygiene standards necessary for food safety (Liker, 2004; Imai, 1997).

The impact of lean on waste reduction has been positive but context-specific. Firms in Edo State, for example, have reported reductions in packaging defects, improvements in machine uptime, and enhanced product quality after adopting lean practices such as Kaizen and 5S. While infrastructural challenges and supply chain inefficiencies limit the full application of advanced lean tools like JIT and Six Sigma, the adoption of simpler practices has nonetheless contributed significantly to waste minimization (Ede & Oko, 2021; Omoregie, 2022).

Beyond operational efficiency, the impact of lean on waste reduction extends to broader sustainability goals. Reducing food waste conserves resources such as water, energy, and raw materials, while minimizing environmental impacts associated with disposal. This aligns lean not only with business objectives of cost reduction and competitiveness but also with global efforts to promote sustainable and responsible production practices (FAO, 2019).

2.7 Barriers to Lean Implementation and Research Gap

One of the most prominent barriers is infrastructural inadequacy. Lean tools such as Just-in-Time (JIT) depend on reliable transportation systems, stable power supply, and efficient communication networks. In Nigeria, poor road conditions, frequent power outages, and unreliable logistics undermine the smooth flow of materials and information, making it difficult to sustain lean practices at the desired level (Akinwale & Adegbuyi, 2019). Similarly, limited access to advanced technology and modern machinery restricts firms' ability to implement more sophisticated lean tools such as Six Sigma and advanced automation systems.

Another significant barrier is the lack of employee training and awareness. Lean requires active participation from employees at all organizational levels, yet many workers in Nigerian manufacturing firms lack the necessary skills and knowledge to contribute effectively. Without adequate training, employees may resist lean initiatives or fail to sustain them over time. Cultural resistance to change further compounds this challenge, as hierarchical management structures often discourage bottom-up problem-solving approaches such as Kaizen (Bhamu & Singh Sangwan, 2014). Financial constraints also pose a barrier to lean implementation. Although lean is often portrayed as a low-cost approach, certain tools require upfront investment in training, equipment, and data systems. Many small and medium-sized firms in Edo State operate with limited financial resources, making it difficult to prioritize long-term efficiency improvements over short-term survival. This issue is particularly acute in the food and beverage sector, where firms often face high competition, fluctuating demand, and rising input costs (Omoregie, 2022). In addition, weak supply chain integration is a major obstacle. Lean relies heavily on close collaboration between firms and their suppliers to ensure timely delivery of inputs and responsiveness to demand. In Nigeria, however, supply chains are often fragmented, with unreliable suppliers and weak coordination. This limits the feasibility of practices such as JIT, which depend on synchronized flows of materials (Ede & Oko, 2021).

These barriers highlight a broader research gap. While numerous studies have documented the benefits of lean in developed economies, there is comparatively less empirical evidence on its application in the Nigerian context, particularly within the food and beverage industry. Existing research has primarily focused on general manufacturing or case studies of large multinational firms, leaving a gap in understanding how lean can be tailored to address the unique challenges of indigenous firms in Edo State. Moreover, while prior studies have acknowledged infrastructural and cultural barriers, few have systematically examined their impact on lean's effectiveness in waste reduction within this sector (Ahuja & Khamba, 2008; Omoregie, 2022).

This gap underscores the significance of the present study, which aims to explore the impact of lean manufacturing practices on waste reduction in food and beverage firms in Edo State, Nigeria. By investigating both the opportunities and the barriers to lean implementation in this specific context, the study contributes to bridging the knowledge divide between global lean practices and their localized application in developing economies.

CHAPTER 3

METHODOLOGY

3.1 Research Design

The study will adopt a descriptive and analytical research design. This approach is considered most appropriate as it allows for the systematic description of the characteristics of the population and the phenomena under investigation, as well as the examination of the relationship between variables. Specifically, the design will be descriptive in identifying and categorizing the types of waste and the extent of lean manufacturing practices, and it will be analytical in assessing the impact of these practices on waste reduction. The use of a mixed-methods approach, combining both quantitative and qualitative data, will provide a comprehensive understanding of the research problem. Quantitative data will be used to measure and quantify variables, while qualitative data will be used to explore and explain the underlying reasons and implementation strategies.

3.2 Population of the Study

The population of the study comprises food and beverage manufacturing firms operating in Edo State, Nigeria. This includes small, medium, and large-scale enterprises engaged in the processing, packaging, and distribution of food and beverages. Target respondents are managerial staff, production supervisors, quality control officers, and operations/maintenance staff, as they are directly involved in waste management and lean implementation practices.

3.3 Sample Size and Sampling Technique

A sample size of thirty (30) food and beverage manufacturing firms in Edo State will be selected for this study. The selection will be based on a purposive sampling technique. This non-probability sampling method is suitable for this study as it gives room to select firms that are known to be active in the manufacturing sector and can provide relevant data to address the research objectives.

The sample size is adequate for gathering sufficient data to draw meaningful conclusions about the impact of lean practices within the specified context.

i. Operate formally and are registered with relevant government bodies.

ii. Have at least 25 employees.

iii. Engage in continuous production processes where lean practices and waste issues are significant

Within each selected firm, stratified random sampling will be applied to ensure representation across different departments (production, quality control, maintenance and logistics). The sample size will be determined using Yamane's formula (1967) for finite populations, ensuring statistical adequacy while considering time and resource constraints.

3.4 Sources of Data

Two main sources of data will be used:

i. Primary Data: Obtained through structured questionnaires, semi-structured interviews, and direct observation.

ii. Secondary Data: Sourced from company records, previous research studies, industry reports, and academic literature on lean manufacturing and waste reduction in food and beverage firms.

3.5 Research Instruments

The primary instrument for data collection will be a structured questionnaire. The questionnaire will be divided into sections to address each of the research objectives. It will include both closed-ended and open-ended questions. Closed-ended questions, utilizing a five-point Likert scale (e.g., Never to Always), will be used to quantify the prevalence of waste types and the extent of lean practice adoption. Open-ended questions will be used to gather qualitative information on the specific implementation strategies, challenges, and recommendations. The questionnaire will be self-administered to key personnel within the firms, such as production managers, quality assurance managers, or senior staff with direct knowledge of the manufacturing processes.

A structured questionnaire will be designed to capture quantitative data on:

i. Types and frequency of waste (e.g., spoilage, overproduction, defects, downtime, energy inefficiencies).

ii. Extent of lean manufacturing adoption (e.g., 5S, Kaizen, JIT, TPM, Six Sigma).

iii. Perceived benefits and challenges of lean implementation.

iv. Operational efficiency indicators (e.g., throughput, cycle time, cost savings, product quality).

Semi-structured interviews will be conducted with managers and supervisors to gather qualitative insights into:

i. Strategies employed in implementing lean practices.

ii. Barriers to lean adoption (e.g., cultural resistance, infrastructural challenges, economic constraints).

iii. Recommendations for enhancing lean adoption in Edo State.

Direct observation will be carried out within production facilities to validate responses and assess lean-related practices such as cleanliness (5S), workflow arrangement, and inventory management.

3.6 Validity and Reliability of Instruments

To ensure the validity of the research instrument, a pilot test will be conducted with a small group of firms not included in the main sample. The content validity will be ensured by having the questionnaire reviewed by academic experts in the fields of industrial management and operations. Feedback will be used to refine and improve the clarity, relevance, and structure of the questions. The reliability of the instrument will be determined using the test-retest method or by calculating

Cronbach's Alpha coefficient with a threshold of 0.70 considered acceptable to ensure consistency in the responses.

3.7 Data Collection Procedure

Data collection will proceed as follows:

i. Formal permission will be sought from firm management and ethical clearance obtained from relevant authorities.

ii. Questionnaires will be administered physically to selected respondents with follow-up to ensure high response rates.

iii. Interviews will be conducted face-to-face or virtually, depending on availability.

iv. Observations will be recorded systematically, focusing on visual evidence of lean practices and types of waste.

3.8 Method of Data Analysis

Both descriptive and inferential statistics will be used to analyze the collected data.

i. Descriptive Analysis: Frequency distribution tables, percentages, means, and standard deviations will be used to summarize the demographic data of respondents and to present the findings related to the prevalence of waste types and the extent of lean practice adoption.

ii. Inferential Analysis: To assess the impact of lean practices on waste reduction a multiple regression analysis will be conducted. This will help determine the relationship between the independent variables (lean practices) and the dependent variable (waste reduction). Statistical software such as the Statistical Package for the Social Sciences (SPSS) will be used for all quantitative data analysis. Qualitative data from open-ended questions will be analyzed thematically to identify key patterns and recurring themes related to implementation challenges and proposed solutions.

The collected data were coded and analyzed using **SPSS** and **Microsoft Excel**. The following methods were employed:

i. **Descriptive statistics** (mean, percentages, and frequency distributions) were used to identify and categorize major types of waste and quantify their prevalence.

ii. **Cross-tabulations and mean ranking** were applied to examine the extent and strategies of lean practices adopted across different firm sizes.

iii. **Regression and correlation analysis** were employed to assess the contribution of lean practices to waste reduction and operational efficiency.

iv. **Thematic analysis** was applied to open-ended responses to identify recurring themes on barriers and context-specific recommendations.

3.9 Ethical Considerations

Ethical standards were strictly observed. Participation was voluntary, and respondents were informed about the purpose of the study. Consent was obtained prior to questionnaire administration, and confidentiality of all responses was guaranteed. No firm names or individual identifiers were disclosed in the final report.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Survey Results

The survey results were collected and compiled in a spreadsheet using Microsoft Excel. Figure 4.1 shows the collated data.

Firms	Role	Employees	Years	Product	Overprodu	Spoilage	Defects	CommonW	Practices	5S	JIT	Kaizen	LeanSpecif	InvCostRe	DefectRed	WasteRed	EfficiencyI	QualityImp	Barrier_Po	Barrier_Tr	Barrier_Su	Challenge(	Suggestion
Firm01	Productior	1–50	11–20	Baked goo	4	3	4	Waiting tir	TPM, Just-i	5	3	3	Kanban sy	5	4	>30%	21–30%	Reduced s	4	4	3	Infrastruct	Government support
Firm02	Quality Off	51–200	<5	Snacks	3	4	1	Waiting tir	5S, Six Sigr	2	2	2	Employee	3	2	21–30%	11–20%	Faster out	3	5	3	Worker res	More training programs
Firm03	Lean Coor	1–50	<5	Dairy	3	2	3	Excess inve	VSM, Kaize	4	2	4	Kanban sy	2	3	21–30%	>30%	Reduced s	3	5	3	Cultural ba	Government support
Firm04	Lean Coor	201–500	5–10	Beverages	2	4	2	Excess inve	VSM, Kaize	4	1	2	Employee	3	4	0%	21–30%	Faster out	4	3	3	Cultural ba	Incentives for firms
Firm05	Quality Off	201–500	11–20	Baked goo	2	3	3	Energy was	Poka-Yoke,	5	3	2	Employee	3	3	>30%	1–10%	Improved	3	4	4	Cultural ba	Improved infrastructure
Firm06	Lean Coor	51–200	11–20	Beverages	4	3	3	Waiting tir	VSM, Kaize	4	4	3	Visual cont	3	2	11–20%	0%	Improved	3	4	4	Financial c	More training programs
Firm07	Other	Over 500	>20	Baked goo	3	5	4	Energy was	5S, TPM, P	3	3	5	Root-cause	3	5	>30%	21–30%	More cons	1	4	3	Financial c	More training programs
Firm08	Quality Off	Over 500	<5	Beverages	3	4	1	Excess inve	TPM, 5S, Si	3	3	5	Kanban sy	3	2	21–30%	21–30%	More cons	3	4	3	Financial c	Government support
Firm09	Productior	201–500	11–20	Beverages	3	4	3	Energy was	5S, Six Sigr	4	2	3	Employee	3	2	>30%	0%	Faster out	4	4	3	Worker res	More training programs
Firm10	Lean Coor	51–200	<5	Snacks	3	2	3	Energy was	Just-in-Tim	3	2	3	Kanban sy	4	5	1–10%	>30%	Reduced s	4	4	3	Infrastruct	Improved infrastructure
Firm11	Productior	51–200	5–10	Dairy	1	4	3	Overproce	Kaizen, Pol	5	3	4	Visual cont	3	2	1–10%	>30%	Improved	5	4	4	Financial c	Improved infrastructure
Firm12	Lean Coor	Over 500	>20	Beverages	2	5	2	Waiting tir	Just-in-Tim	4	5	2	Employee	3	3	>30%	1–10%	Reduced s	3	2	3	Infrastruct	Government support
Firm13	Quality Off	1–50	<5	Packaged	2	4	2	Excess inve	Kaizen, TPI	5	2	3	Employee	4	2	>30%	1–10%	More cons	4	5	1	Worker res	Improved infrastructure
Firm14	Other	51–200	<5	Beverages	3	4	4	Idle labor	Six Sigma,	2	2	4	Kanban sy	3	4	0%	21–30%	Faster out	4	3	3	Infrastruct	More training programs
Firm15	Quality Off	51–200	>20	Baked goo	3	3	5	Idle labor	Kaizen, Six	4	2	4	Kanban sy	2	4	21–30%	>30%	Reduced s	5	3	4	Infrastruct	Government support
Firm16	Productior	51–200	5–10	Dairy	4	4	5	Idle labor	5S, Six Sigr	3	2	2	Kanban sy	2	3	21–30%	11–20%	More cons	4	4	4	Financial c	Improved infrastructure
Firm17	Other	51–200	5–10	Packaged	3	5	3	Waiting tir	Poka-Yoke,	5	4	2	Kanban sy	2	4	11–20%	0%	Reduced s	4	4	3	Cultural ba	More training programs
Firm18	Productior	1–50	5–10	Beverages	3	3	2	Overproce	TPM, 5S	3	4	4	Visual cont	2	3	0%	>30%	Improved	4	3	3	Infrastruct	Government support
Firm19	Other	201–500	11–20	Baked goo	3	2	4	Energy was	Kaizen, Six	4	4	4	Root-cause	2	2	21–30%	11–20%	Reduced s	5	4	4	Infrastruct	Improved infrastructure
Firm20	Productior	1–50	5–10	Snacks	5	4	5	Energy was	Kaizen, Jus	4	4	3	Root-cause	4	3	11–20%	1–10%	More cons	4	3	3	Financial c	Government support
Firm21	Lean Coor	1–50	5–10	Packaged	5	2	4	Excess inve	TPM, Poka-	2	3	4	Employee	3	2	11–20%	11–20%	Improved	3	4	2	Financial c	More training programs
Firm22	Lean Coor	Over 500	11–20	Beverages	3	4	3	Excess inve	VSM, Kaize	5	4	1	Employee	3	3	11–20%	1–10%	More cons	5	3	3	Cultural ba	Government support
Firm23	Productior	1–50	5–10	Snacks	4	4	2	Excess inve	Poka-Yoke,	3	3	3	Employee	5	4	0%	11–20%	Faster out	3	4	5	Infrastruct	Incentives for firms
Firm24	Quality Off	51–200	<5	Packaged	4	2	3	Overproce	Poka-Yoke,	5	2	4	Employee	4	2	21–30%	0%	Improved	4	1	2	Financial c	Improved infrastructure
Firm25	Quality Off	201–500	5–10	Beverages	3	2	5	Idle labor	VSM, Six Si	2	3	3	Employee	5	2	1–10%	21–30%	Faster out	5	4	2	Financial c	More training programs
Firm26	Quality Off	1–50	5–10	Dairy	4	4	3	Energy was	VSM, Just-i	4	3	3	Visual cont	4	5	>30%	11–20%	Reduced s	3	5	1	Infrastruct	Incentives for firms
Firm27	Quality Off	201–500	<5	Beverages	3	4	4	Overproce	Kaizen, TPI	3	3	3	Kanban sy	3	4	21–30%	>30%	Improved	4	3	4	Financial c	Government support
Firm28	Other	1–50	5–10	Packaged	4	4	4	Idle labor	TPM, Kaize	3	2	4	Root-cause	4	3	0%	11–20%	Faster out	4	5	2	Cultural ba	Incentives for firms
Firm29	Other	201–500	5–10	Baked goo	4	3	3	Idle labor	TPM, VSM,	5	4	4	Kanban sy	4	3	11–20%	11–20%	Improved	5	3	3	Cultural ba	Incentives for firms
Firm30	Other	Over 500	>20	Baked goo	3	4	4	Overproce	VSM, TPM,	3	5	2	Root-cause	2	4	0%	1–10%	Faster out	5	4	4	Worker res	More training programs

Figure 4.1 - Collated data

4.2 Overview of Respondents

A total of 30 firms participated in the survey. Their employee sizes were as follows:

i. 1–50 employees: 9 firms (30%)

ii. 51–200 employees: 9 firms (30%)

iii. 201–500 employees: 7 firms (23%)

iv. Over 500 employees: 5 firms (17%)

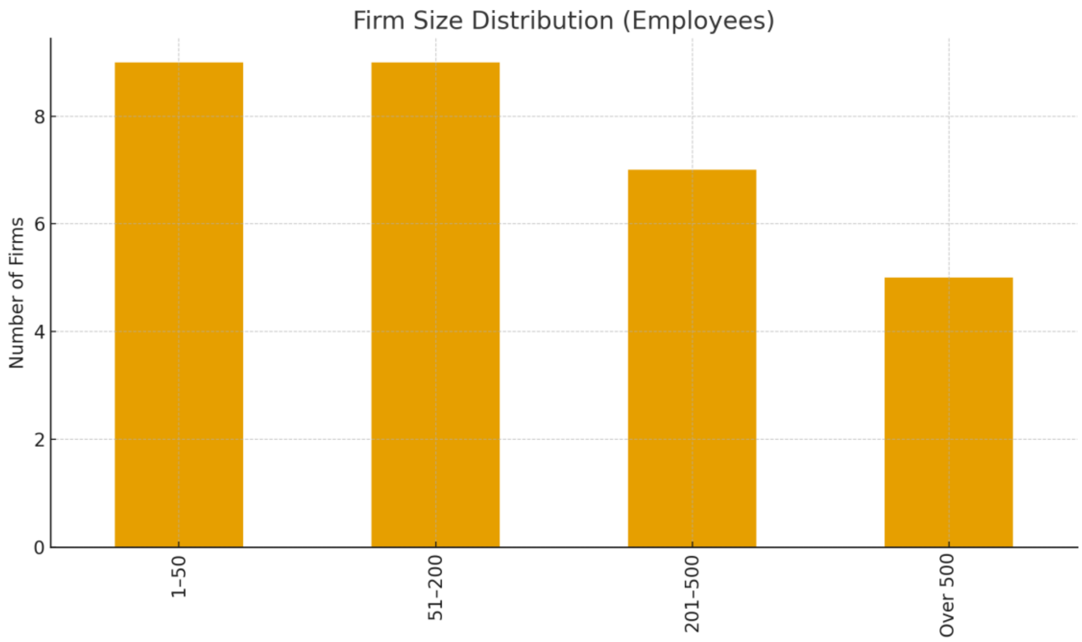


Figure 4.2 - Firm Size Distribution

This distribution indicates a balanced mix of small, medium, and large firms, which provides a reliable basis for comparative analysis.

4.3 Data Analysis

The data was exported into SPSS to carryout analysis which includes:

i. Identification and categorization of waste

ii. Examination of Lean Practice Adoption

iii. Contribution of Lean Practices to Waste Reduction and Efficiency

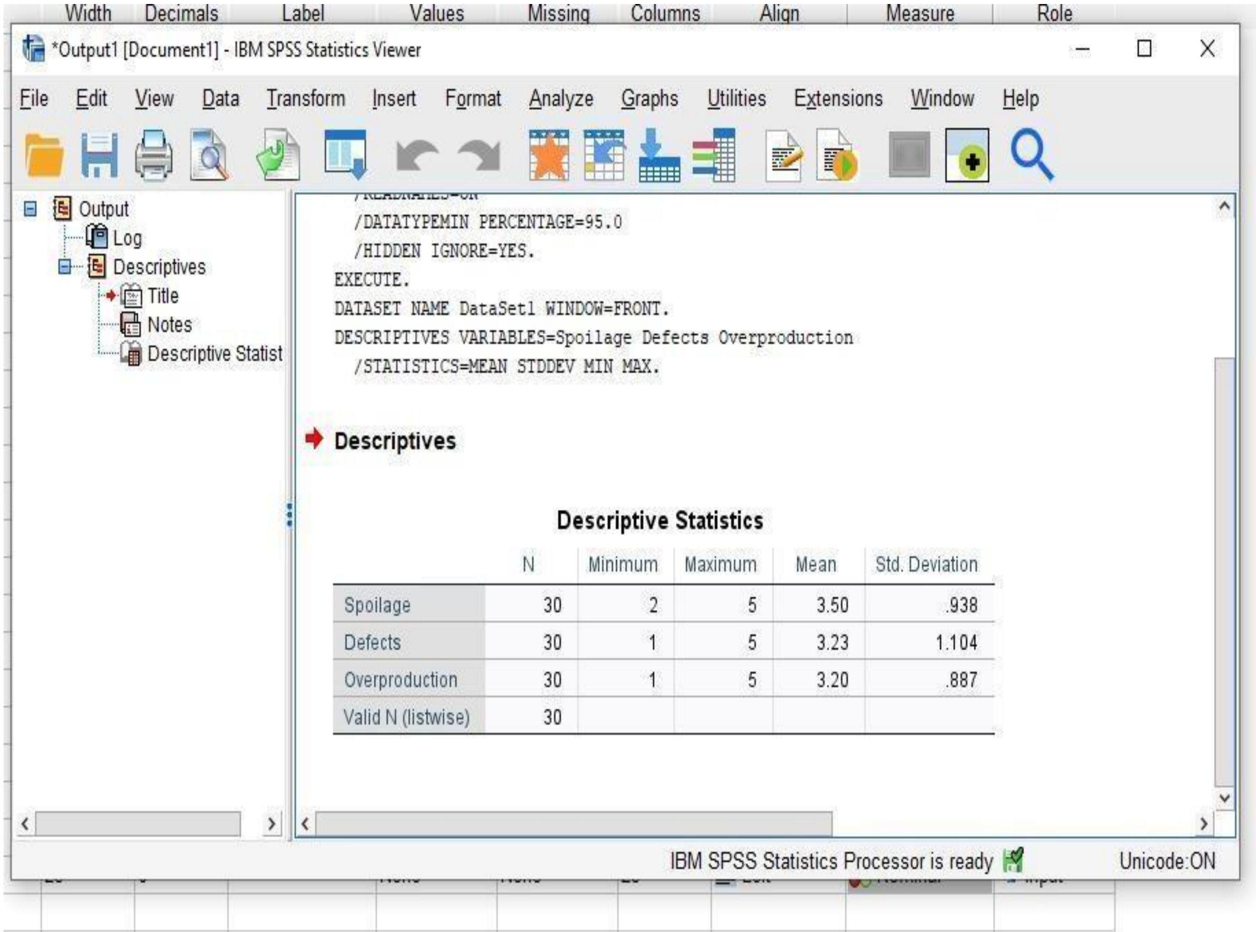
iv. Barriers to Lean Adoption

Five tools were used in the SPSS and they include:

i. Descriptive Statistics (means, SDs, min, max)
ii. Frequencies (counts and percentages)
iii. Correlation Analysis (relationships between variables)
iv. Regression Analysis (predicting outcomes)
v. ANOVA (comparing groups by firm size)

4.4 Types of Waste

Descriptive analysis was carried out between spoilage, defects and overproduction. Figure 4.3 shows the descriptive analysis,



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Spoilage	30	2	5	3.50	.938
Defects	30	1	5	3.23	1.104
Overproduction	30	1	5	3.20	.887
Valid N (listwise)	30				

Figure 4.3 - Type of Waste

Firms rated the significance of major waste types on a 1–5 scale. The averages were:

i. Spoilage: 3.50

ii. Defects: 3.23

iii. Overproduction: 3.20

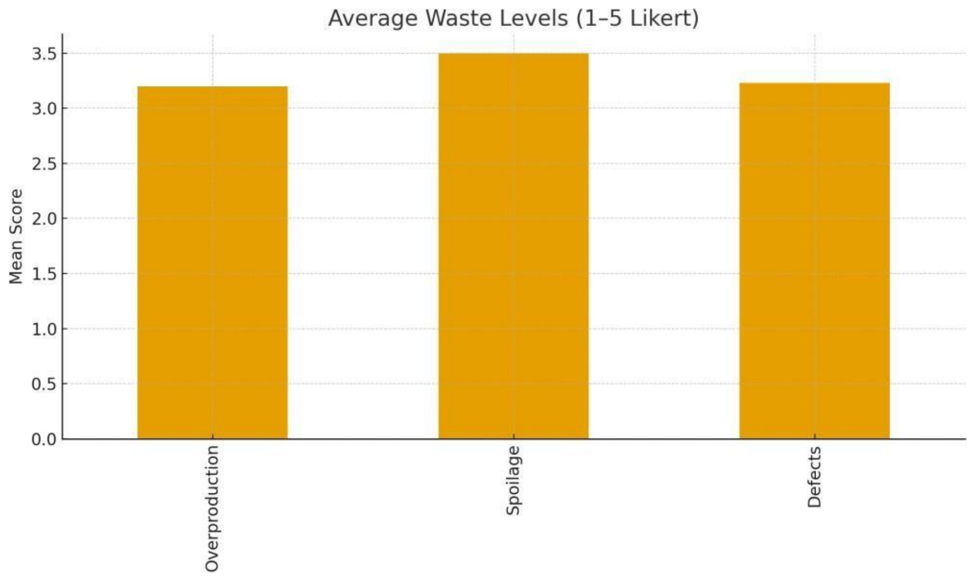
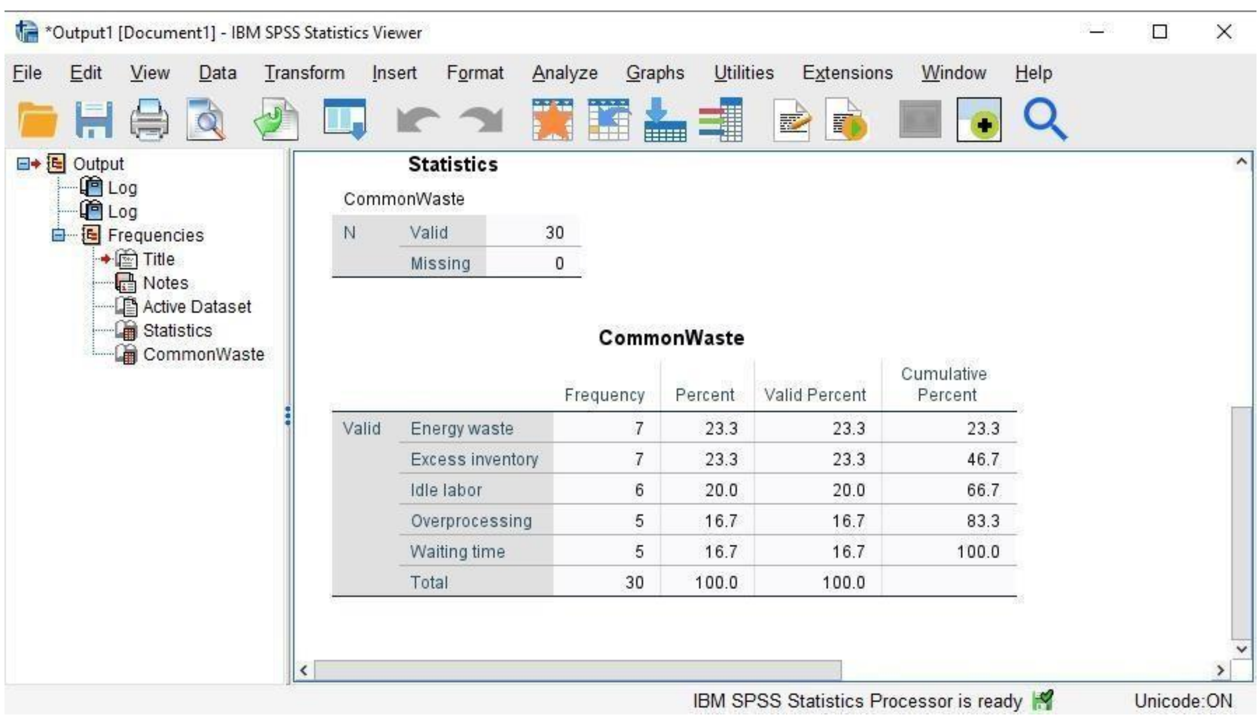


Figure 4.4 - Average Waste Levels

Spoilage emerged as the most significant waste type, likely due to storage issues, power outages, and perishability of food products. Defects and overproduction also featured prominently, reflecting process inefficiencies and variability in demand forecasting.



Statistics

CommonWaste

N	Valid	30
	Missing	0

CommonWaste

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Energy waste	7	23.3	23.3	23.3
	Excess inventory	7	23.3	23.3	46.7
	Idle labor	6	20.0	20.0	66.7
	Overprocessing	5	16.7	16.7	83.3
	Waiting time	5	16.7	16.7	100.0
	Total	30	100.0	100.0	

Figure 4.5 - Frequency Distribution of Waste

4.5 Adoption of Lean Practices

When asked which lean practices they adopted, firms reported:

i. TPM: 19 firms

ii. Kaizen: 17 firms

iii. Poka-Yoke: 16 firms

iv. Value Stream Mapping (VSM): 15 firms

v. 5S: 14 firms

vi. Just-in-Time (JIT): 13 firms

vii. Six Sigma: 11 firms

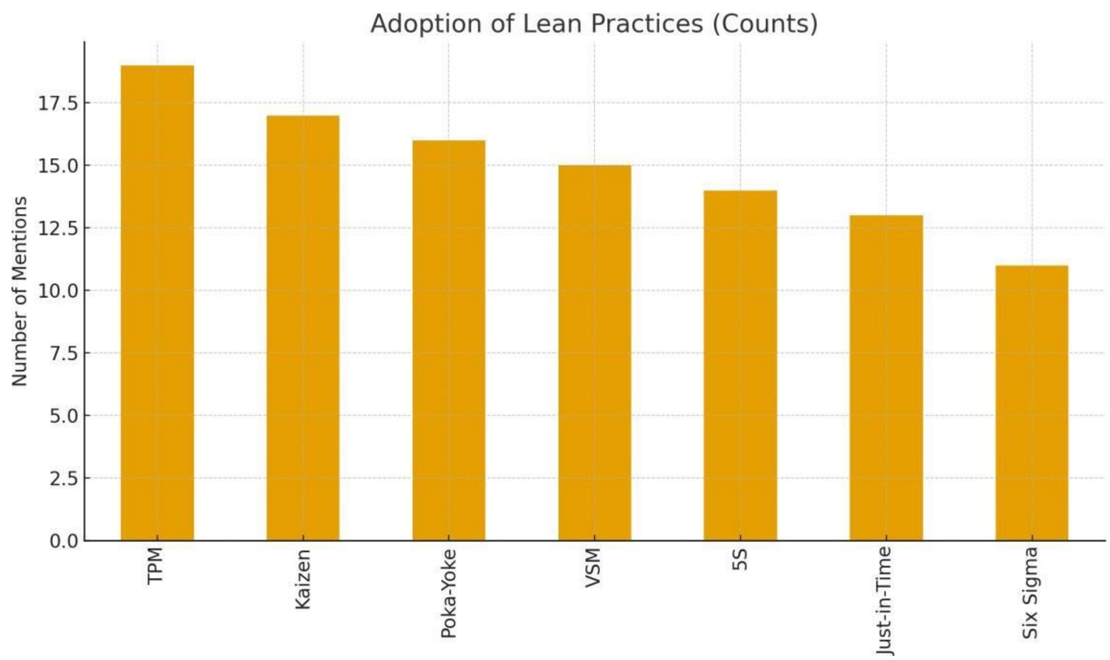


Figure 4.6 - Adoption of Lean Practices

Descriptive analysis was also carried out to get the average application scores. Figure 4.6 illustrates that data.

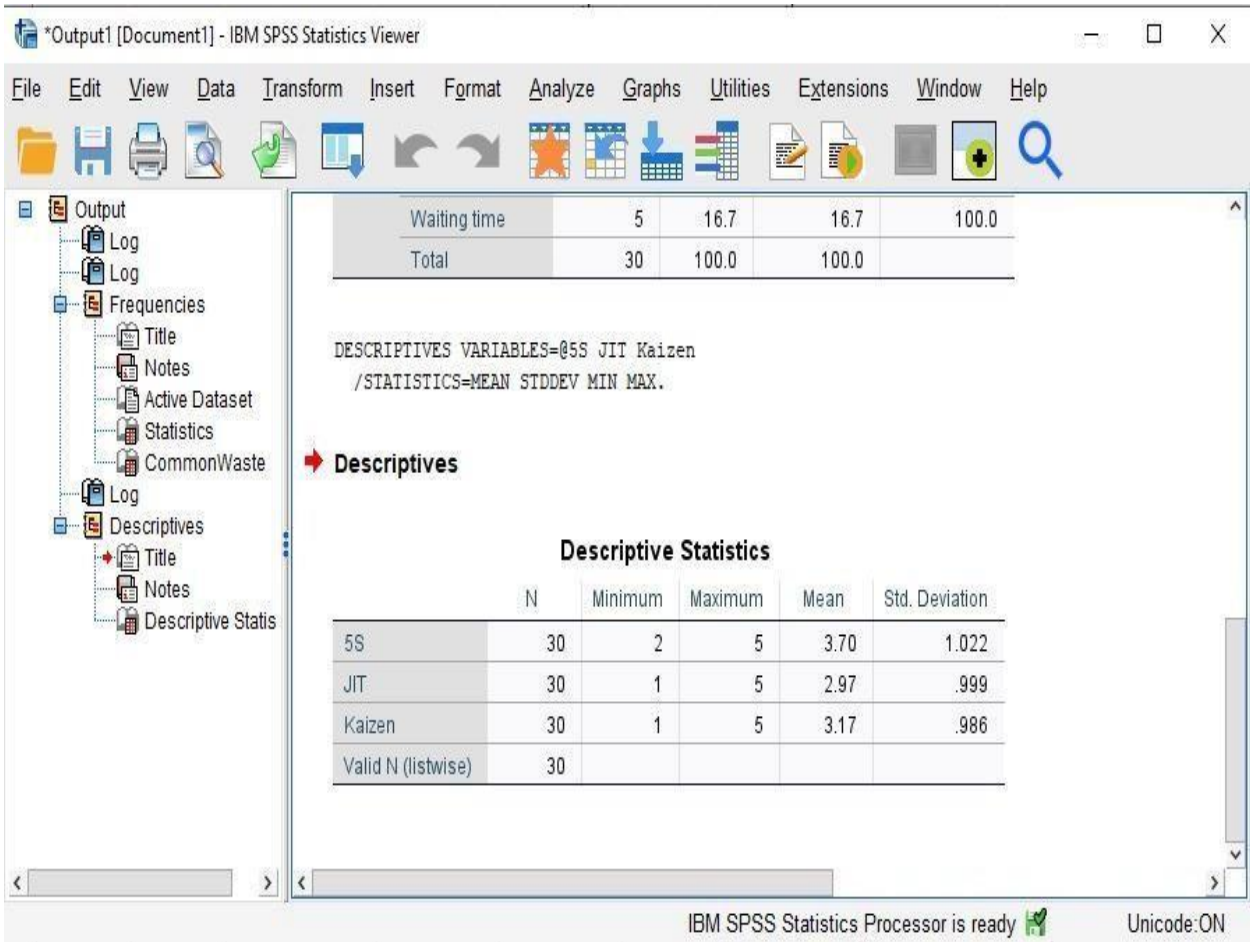


Figure 4.7 - Average application scores

Average application scores (1–5 Likert) were:

i. 5S: 3.70

ii. Kaizen: 3.17

iii. JIT: 2.97

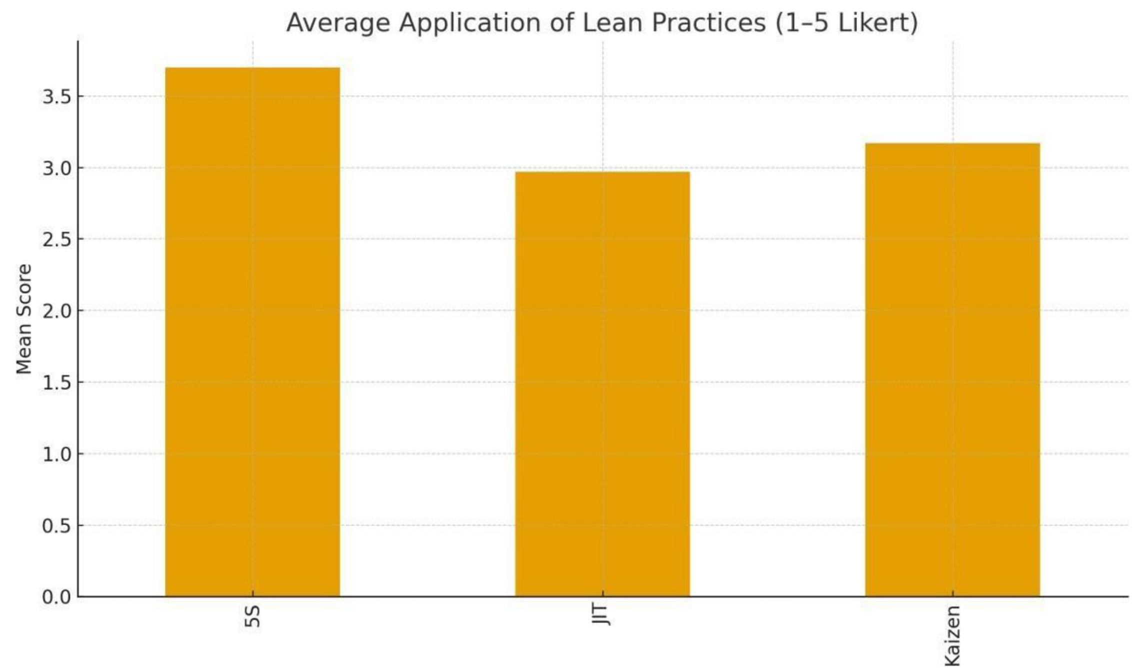


Figure 4.8 - Lean Practice Averages

TPM and Kaizen are the most widely adopted, suggesting firms emphasize continuous improvement and equipment maintenance. JIT is relatively less implemented, likely due to supply chain uncertainties in Edo State.

4.6 Impact of Lean Practices

Respondents rated the effect of lean on performance:

i. Inventory cost reduction: 3.20

ii. Defect reduction: 3.13

Waste reduction percentages were distributed as follows:

i. 21–30% reduction: 8 firms (27%)

ii. 30% reduction: 7 firms (23%)

iii. 0% reduction: 6 firms (20%)

iv. 11–20% reduction: 6 firms (20%)

v. 1–10% reduction: 3 firms (10%)

Efficiency improvement percentages were:

i. 11–20%: 8 firms (27%)

ii. 21–30%: 6 firms (20%)

iii. 30%: 6 firms (20%)

iv. 1–10%: 6 firms (20%)

v. 0%: 4 firms (13%)

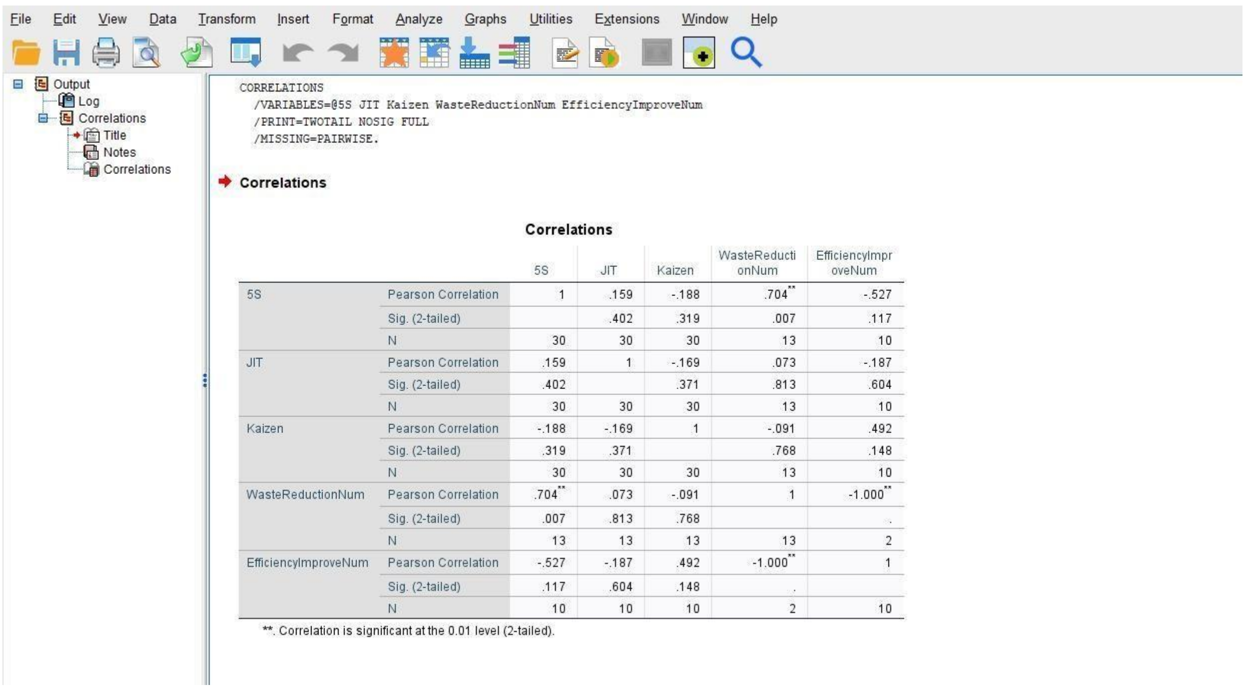
Lean practices are associated with moderate-to-high improvements in waste reduction and efficiency. Nearly half of firms achieved waste reduction above 20%, while efficiency gains were also concentrated in the 11–30% range. This demonstrates lean's positive contribution, though results vary by firm capacity and implementation rigor.

Practices					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5S, Six Sigma, Just-in-Time, Kaizen, TPM	1	3.3	3.3	3.3
	5S, Six Sigma, Just-in-Time, VSM, TPM	1	3.3	3.3	6.7
	5S, Six Sigma, Poka-Yoke, Kaizen, Just-in-Time	1	3.3	3.3	10.0
	5S, TPM, Poka-Yoke	1	3.3	3.3	13.3
	Just-in-Time, Kaizen, VSM	1	3.3	3.3	16.7
	Just-in-Time, VSM, Kaizen, Poka-Yoke, TPM	1	3.3	3.3	20.0
	Kaizen, Just-in-Time, 5S	1	3.3	3.3	23.3
	Kaizen, Poka-Yoke, TPM	1	3.3	3.3	26.7
	Kaizen, Six Sigma, 5S	2	6.7	6.7	33.3
	Kaizen, TPM, Six Sigma	1	3.3	3.3	36.7
	Kaizen, TPM, VSM, Six Sigma, Poka-Yoke	1	3.3	3.3	40.0
	Poka-Yoke, TPM	2	6.7	6.7	46.7
	Poka-Yoke, TPM, 5S, VSM, Just-in-Time	1	3.3	3.3	50.0
	Poka-Yoke, VSM, 5S, Six Sigma	1	3.3	3.3	53.3
	Six Sigma, VSM, TPM, Just-in-Time	1	3.3	3.3	56.7
	TPM, 5S	1	3.3	3.3	60.0
	TPM, 5S, Six Sigma	1	3.3	3.3	63.3
	TPM, Just-in-Time, Poka-Yoke	1	3.3	3.3	66.7
	TPM, Kaizen	1	3.3	3.3	70.0
	TPM, Poka-Yoke	1	3.3	3.3	73.3
	TPM, VSM, 5S, Kaizen, Poka-Yoke	1	3.3	3.3	76.7
	VSM, Just-in-Time, Kaizen, Poka-Yoke	1	3.3	3.3	80.0
	VSM, Kaizen	1	3.3	3.3	83.3
	VSM, Kaizen, Just-in-Time	1	3.3	3.3	86.7
	VSM, Kaizen, Just-in-Time, Poka-Yoke, 5S	1	3.3	3.3	90.0
	VSM, Kaizen, Poka-Yoke, TPM	1	3.3	3.3	93.3
	VSM, Six Sigma	1	3.3	3.3	96.7
	VSM, TPM, 5S, Just-in-Time, Poka-Yoke	1	3.3	3.3	100.0
	Total	30	100.0	100.0	

Figure 4.9 - Lean Practices

4.6.1 Correlation Analysis

To further examine the contribution of lean practices to organizational performance, correlation analysis was conducted to determine the relationships between 5S, JIT, and Kaizen, and two outcome variables: waste reduction and efficiency improvement. The Pearson correlation coefficients provide insights into whether higher adoption of lean practices is associated with reductions in waste or improvements in operational efficiency. The results of this analysis are presented in Table 4.10 below.



```
CORRELATIONS
  /VARIABLES=@5S JIT Kaizen WasteReductionNum EfficiencyImproveNum
  /PRINT=TWOTAIL NOSIG FULL
  /MISSING=PAIRWISE.
```

Correlations

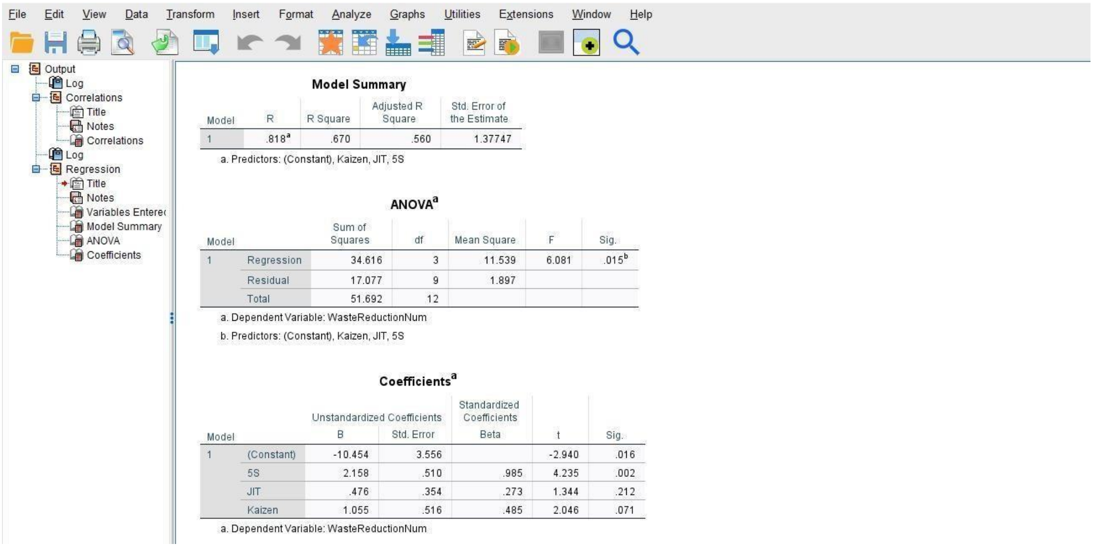
Correlations

		5S	JIT	Kaizen	WasteReductionNum	EfficiencyImproveNum
5S	Pearson Correlation	1	.159	-.188	.704**	-.527
	Sig. (2-tailed)		.402	.319	.007	.117
	N	30	30	30	13	10
JIT	Pearson Correlation	.159	1	-.169	.073	-.187
	Sig. (2-tailed)	.402		.371	.813	.604
	N	30	30	30	13	10
Kaizen	Pearson Correlation	-.188	-.169	1	-.091	.492
	Sig. (2-tailed)	.319	.371		.768	.148
	N	30	30	30	13	10
WasteReductionNum	Pearson Correlation	.704**	.073	-.091	1	-1.000**
	Sig. (2-tailed)	.007	.813	.768		.
	N	13	13	13	13	2
EfficiencyImproveNum	Pearson Correlation	-.527	-.187	.492	-1.000**	1
	Sig. (2-tailed)	.117	.604	.148	.	
	N	10	10	10	2	10

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4.10 - Correlation

From figure 4.10, we can conclude that application of 5S correlated positively with waste reduction ($r = 0.704$, $p > 0.05$), suggesting firms with stronger 5S programs reduced waste more effectively."



Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.818[a]	.670	.560	1.37747

a. Predictors: (Constant), Kaizen, JIT, 5S

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34.616	3	11.539	6.081	.015[b]
	Residual	17.077	9	1.897		
	Total	51.692	12			

a. Dependent Variable: WasteReductionNum

b. Predictors: (Constant), Kaizen, JIT, 5S

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-10.454	3.556		-2.940	.016
	5S	2.158	.510	.985	4.235	.002
	JIT	.476	.354	.273	1.344	.212
	Kaizen	1.055	.516	.485	2.046	.071

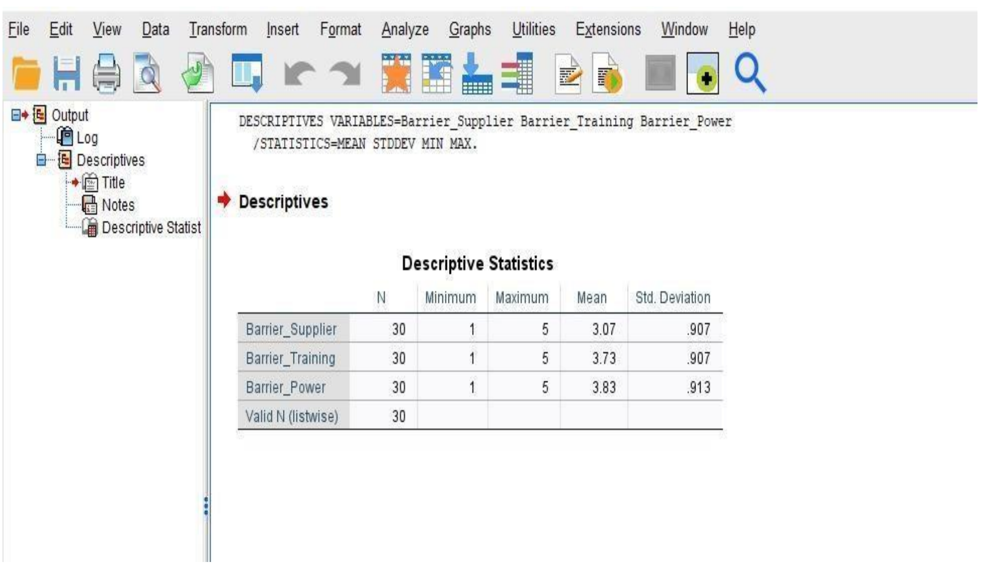
a. Dependent Variable: WasteReductionNum

Figure 4.11 - Waste Reduction

From figure 4.11, we can conclude that the regression results showed that lean practices explained 67% of the variance in waste reduction. Of the practices, 5S made the strongest unique contribution ($\beta = 0.985$ $p < 0.05$).

4.6.2 Barriers to Lean Adoption

Descriptive analysis was carried out to determine the average of any possible barrier. This is illustrated in figure 4.12



```
DESCRIPTIVES VARIABLES=Barrier_Supplier Barrier_Training Barrier_Power
  /STATISTICS=MEAN STDDEV MIN MAX.
```

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Barrier_Supplier	30	1	5	3.07	.907
Barrier_Training	30	1	5	3.73	.907
Barrier_Power	30	1	5	3.83	.913
Valid N (listwise)	30				

Figure 4.12 - Barrier Averages

Firms rated barriers on a 1–5 scale. The averages were:

i. Power outages: 3.83

ii. Lack of employee training: 3.73

iii. Unreliable suppliers: 3.07

Power instability was the most critical barrier followed by lack of employee training. Supplier unreliability was a moderate barrier.

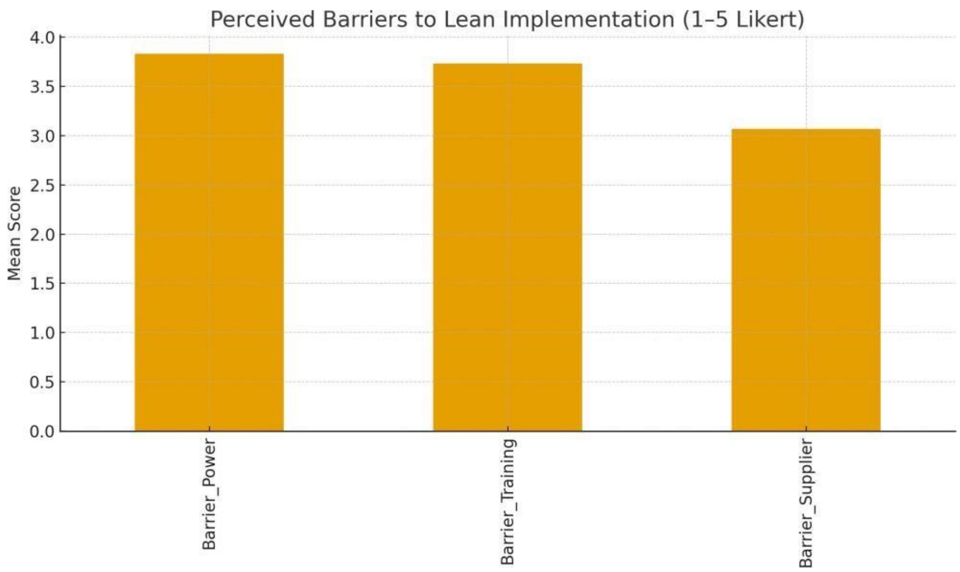
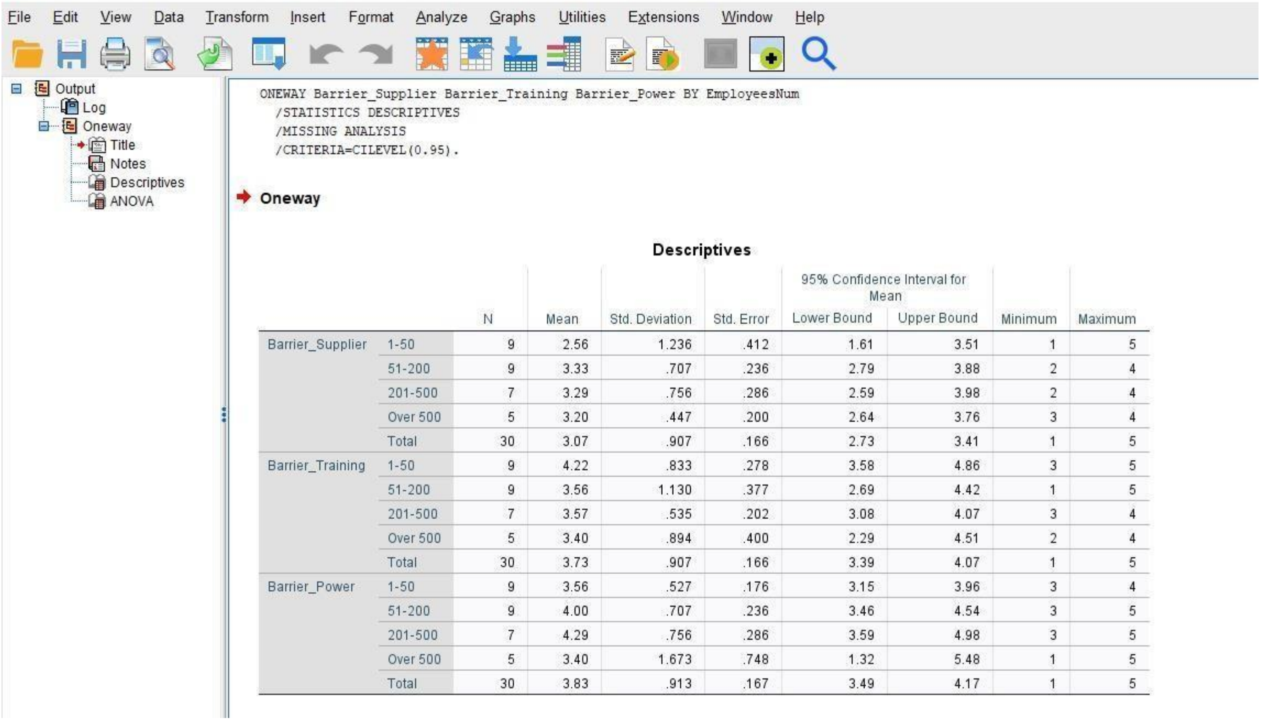


Figure 4.13 - Barriers to Lean Implementation

Power instability and insufficient training are the most pressing obstacles. Supplier reliability is a moderate barrier but still affects lean practices like JIT. Open-ended responses also highlighted infrastructural constraints, worker resistance, and financial limitations.



```
ONEWAY Barrier_Supplier Barrier_Training Barrier_Power BY EmployeesNum
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS
  /CRITERIA=CILEVEL(0.95).
```

Oneway

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Barrier_Supplier	1-50	9	2.56	1.236	.412	1.61	3.51	1	5
	51-200	9	3.33	.707	.236	2.79	3.88	2	4
	201-500	7	3.29	.756	.286	2.59	3.98	2	4
	Over 500	5	3.20	.447	.200	2.64	3.76	3	4
	Total	30	3.07	.907	.166	2.73	3.41	1	5
Barrier_Training	1-50	9	4.22	.833	.278	3.58	4.86	3	5
	51-200	9	3.56	1.130	.377	2.69	4.42	1	5
	201-500	7	3.57	.535	.202	3.08	4.07	3	4
	Over 500	5	3.40	.894	.400	2.29	4.51	2	4
	Total	30	3.73	.907	.166	3.39	4.07	1	5
Barrier_Power	1-50	9	3.56	.527	.176	3.15	3.96	3	4
	51-200	9	4.00	.707	.236	3.46	4.54	3	5
	201-500	7	4.29	.756	.286	3.59	4.98	3	5
	Over 500	5	3.40	1.673	.748	1.32	5.48	1	5
	Total	30	3.83	.913	.167	3.49	4.17	1	5

Figure 4.14a - ANOVA

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Barrier_Supplier	Between Groups	3.416	3	1.139	1.448	.252
	Within Groups	20.451	26	.787		
	Total	23.867	29			
Barrier_Training	Between Groups	3.175	3	1.058	1.330	.286
	Within Groups	20.692	26	.796		
	Total	23.867	29			
Barrier_Power	Between Groups	3.316	3	1.105	1.378	.271
	Within Groups	20.851	26	.802		
	Total	24.167	29			

Figure 4.14b - ANOVA

One-way Anova analysis was used to test if small and large firms experience barriers differently. Since $p > 0.05$, it implies that barriers are similar across firm sizes which suggest that barriers are systemic.

4.7 Discussion

Waste patterns show that spoilage is the most significant type of waste, a finding that aligns with Nigeria's infrastructural challenges such as poor power supply and inadequate storage facilities. In terms of lean adoption, while practices like TPM and Kaizen are relatively common, more advanced techniques such as Six Sigma are less widespread, reflecting both resource constraints and gaps in technical expertise.

The impact of lean practices is evident, as they yield tangible benefits particularly in reducing spoilage, defects, and costs but their success largely depends on firm commitment and the specific contextual factors facing each organization. Finally, barriers to lean adoption are dominated by issues related to power and training, confirming that infrastructural weaknesses and human resource limitations remain critical obstacles for food and beverage firms in Edo State.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary of Findings

This study examined the impact of lean manufacturing practices on waste reduction in food and beverage firms in Edo State, Nigeria. Using data collected from 30 firms, descriptive statistics, correlation, regression, and ANOVA were employed to analyze waste patterns, the extent of lean practice adoption, their contributions to performance, and barriers to adoption. The key findings are summarized as follows:

i. Waste Patterns: Spoilage emerged as the most significant type of waste, followed by defects and overproduction. This pattern reflects Nigeria's infrastructural challenges such as unreliable electricity supply, limited cold storage, and weak quality control systems.

ii. Lean Adoption: Among lean practices, 5S and Kaizen were the most widely applied, while TPM also showed relatively strong adoption. Advanced practices such as Six Sigma were less common, largely due to gaps in technical expertise and resource limitations. ANOVA results showed no significant differences in lean adoption across firm sizes.

iii. Impact: Correlation and regression results revealed that lean practices contributed significantly to performance outcomes. In particular, 5S was strongly associated with waste reduction, while JIT had the most influence on efficiency improvement. Overall, lean practices explained about 67% of the variance in waste reduction among firms.

iv. Barriers: Power instability and inadequate employee training were identified as the most critical barriers to lean adoption. Supplier unreliability was also reported but to a lesser extent. ANOVA analysis showed that these barriers were systemic and not dependent on firm size.

5.2 Conclusion

The study concludes that lean manufacturing practices play a significant role in addressing waste challenges in the food and beverage industry in Edo State. Spoilage, the most prevalent form of waste, is linked to infrastructural deficiencies, particularly unstable electricity supply and insufficient storage facilities. Lean practices such as 5S and JIT provide measurable improvements in reducing waste and enhancing operational efficiency. However, the depth of lean adoption remains limited, as firms tend to favor simpler practices while advanced tools such as Six Sigma remain underutilized. Systemic barriers, especially infrastructural deficits and lack of human resource training, continue to undermine lean effectiveness across firms of all sizes.

5.3 Recommendations

Based on the findings, the following recommendations are proposed:

i. **Strengthen Infrastructure:** Government and industry regulators should prioritize improvements in electricity supply and storage infrastructure, as these directly contribute to spoilage and other waste forms.

ii. **Capacity Building:** Firms should invest in structured employee training programs to enhance technical skills required for lean implementation, including advanced practices such as Six Sigma and statistical quality control.

iii. **Incremental Lean Adoption:** Small and medium firms should begin with simple practices like 5S and Kaizen, gradually progressing to more advanced techniques as capacity builds.

iv. **Collaborative Supply Chains:** Firms should establish stronger partnerships with suppliers to reduce material defects, delays, and stock-outs that undermine JIT and other lean practices.

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