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Unpacking the Lean Manufacturing Implementation in Small and Medium Food and Beverage Industries in Tanzania: A Factor Analysis Approach

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ABSTRACT

This paper examined the status of lean manufacturing implementation in food and beverage SMEs in the selected two regions through lean tools integrated and lean outputs achieved. The study employed a mixed method approach. Qualitative and quantitative designs were used to inform the analysis. The study used cluster random sampling with a sample of 120 industries consisting of different small and medium food and beverage processing industries. We used descriptive statistics and Index of Relative Importance to rank indicators for both lean tools implementation and lean output. Factor analysis was also used to identify the underlying relationships of the variables for lean implementation. Results show that majority of the food and beverage SMEs have adopted and implemented work standardization through presences of operation procedures to avoid variations; followed by Statistical Process Control. Also, out of the seventeen lean tools indicators, five are highly implemented in most of the selected industries for increasing process utilization, efficiency and quality improvement with the remaining twelve not highly implemented. Further, results revealed that, defective products are highly reduced in the SMEs after the implementation of lean tools, followed by reduction of inappropriate processing of products. It is recommended that, in order to identify areas for improvement, necessary for industry sustainability, the industries must do lean assessments, monitoring and evaluation mechanisms to ensure the continuous improvement of lean practices. Also, tailoring lean strategies to specific sectors within SMEs is very important.

Key words: Factor Analysis, Lean, Manufacturing Strategy, Small and Medium Sized Enterprises

I. INTRODUCTION

Lean production system is a new management approach and a business strategy that results in the elimination of waste (costs and time) and improvement of the performance and overall value of an organization (Molla et al., 2021). Scholars argue that lean practices have a direct correlation to the overall performance of the supply chain process with over a half of the performance of the supply chain process being directly determined by wastage and costs (Ongaro, 2019). The dilemma of waste management across man, material and money has remained a burden especially in the food and beverage industries. This constituted the academic enquiry into understanding the power of lean manufacturing to engender production efficiency (Amos et al., 2020). Due to high environmental degradation resulted by food consumption and food production, most of these industries have adopted new sustainable innovative techniques include lean adoption (Akanmu & Nordin, 2022).

The concept of lean manufacturing was developed for maximizing the resource utilization through minimization of waste, later on lean was formulated in response to the fluctuating and competitive business environment (Sundar et. al. 2014). According to Sundar et. al. (2014), any organization whether manufacturing or service oriented to survive may ultimately depend on its ability to systematically and continuously respond to these changes for enhancing the product value. In that regard, value adding process is necessary to achieve this perfection and hence implementing a lean manufacturing system is becoming a core competency for any type of organizations to sustain. Recent years have shown an increasing use of lean manufacturing (LM) principles and tools in several industrial sectors (Borges Lopes et.al. 2015). The literature trend lies in the barriers faced by lean manufacturing implementation, in framework development to support implementation, and in model building to evaluate what has been done (Molla et.al., 2021; Amos et. al, 2020; De Oliveira et.al., 2019) while give little discussions on the analysis and lean manufacturing implementation, the way this study is going to do by utilizing the strengths of descriptive statistics with factor analysis for the identification of key indicators through lean tools integrated and lean outputs achieved.

According to study by Pontevedra et al. (2019) on the factors for effective lean manufacturing implementation in Tanzania revealed that the adoption of lean manufacturing practices in Tanzania is positively influenced by real-time information, manufacturing planning and control, new product development, and, ultimately, significantly higher efficiency. According to Pontevedra et al. (2019), capacity optimization contributes positively to Tanzania's adoption of lean principles (Pontevedra et al., 2019). Additionally, Sinkamba et al. (2023) did thorough analysis of the literature revealed inadequacy in the field of lean manufacturing in developing nations, and generally direction towards lean manufacturing by recommending that lean manufacturing tools be established in a variety of manufacturing sectors in Tanzania (Sinkamba et al., 2023).

1.1 Statement of the Problem

Lean philosophies are adopted by industries to address environmental concerns, global competition and economic factors which influence these industries' existence and growth (Purushothaman et al., 2021). After lean adoption by the leaders United Parcel, Harley Davidson and Toyota, most of manufacturing industries globally have recently been driving out of all non-value adding activities in the eyes of customers in creative, cooperative and continuous learning mode. Over 70 percent of industries globally have used lean production methods to different extent which makes it popular and remains the best strategy as it includes a set of tools that are easier to utilize in a variety of business situations (Pontevedra et al., 2019). The transition process to lean manufacturing has been difficult process due to the resources, strategic factors and process for successful results (Dora et al., 2016).

Most of the studies on assessment methods developed for large industries include Belhadi et al. (2018) concluded that small and medium industries cannot adopt the developed assessment methods due to varying in needs and characteristics. Although there is sufficient growth of studies on lean implementation in manufacturing, they do not seem to assess lean implementation in small and medium food and beverage industries since most developed frameworks and methodologies are effective for large manufacturing industries (Belhadi et al., 2018). The current study is set to purposefully fill this knowledge gap.

1.2 Research Objective

The specific objective of this study is to determine the extent lean manufacturing is implemented in small and medium food and beverage industries in Tanzania.

II. LITERATURE REVIEW

Small and medium industries role on national economies is critical and many have been adopting lean manufacturing after its success in large industries (Belhadi et al., 2016). Small and Medium Enterprises play a potential role in providing employment and vast contribution in Tanzania Gross Domestic Product. According to Economic and Social Research Foundation (ESRF), The Government of Tanzania's 2003 Small and Medium Enterprise Development Policy defines SMEs by considering the number of employees and the capital invested (ESRF, 2016), as shown in Table 1.

Table 1
Categorization of SMEs in Tanzania (ESRF, 2016)

Business Size	Number of Employees	Capital Investment (TZS)
Micro enterprise	1 to 4	Up to 5 million
Small enterprise	5 to 49	Above 5 million to 200 million
Medium enterprise	50 to 99	Above 200 to 800 million

2.1 Theoretical Review

Following World War II, the automotive industries in Japan and the United States developed performance standards and procedures that eventually led to the development of the Lean quality improvement methodology. Two past automotive sector cases (Toyota and Ford) illustrate its implications in other sectors (Lemahieu et al., 2017). The mass production model was the most well-known production model prior to the introduction of lean manufacturing. The established philosophy involved producing standardized goods in big quantities to satisfy a strong demand (Lopes et al., 2015; Oliveira et al., 2018). The Toyota Production System, developed by Toyota, is the foundation of lean manufacturing. Lean is the concept of addressing resource flow issues in production system to eliminate wastes (overproduction, defects, inventory, over-processing, waiting, transportation, non-utilized/wasted talents/knowledge and motion) (Lemahieu et al., 2017; Tanasic et al., 2022; Thoumy et al., 2022). Lean can also be defined as the industrial system constituting techniques and global management for creating value and reducing wastes. The most common definition of lean manufacturing is the elimination of eight significant wastes to reduce the consequences of variability and a manufacturing strategy that focuses on providing the highest-quality product on time and at the lowest cost, regardless of supply, processing time, or demand (Gaikwad & Sunnapwar, 2020; Nordin et al., 2010; Shrimali, 2017).

Initially, lean production is an ideological change of comparable significance rather than a technology advancement of the preceding and current industrial revolutions. Lean manufacturing philosophy has been in two implementing phases in which first wave of 1990's implemented lean methods separately whereas this was lesson learnt in the second wave (Hoellthaler et al., 2023). But with technology advancement digitalization has led to another wave of lean manufacturing implementation as shown in Figure 1.

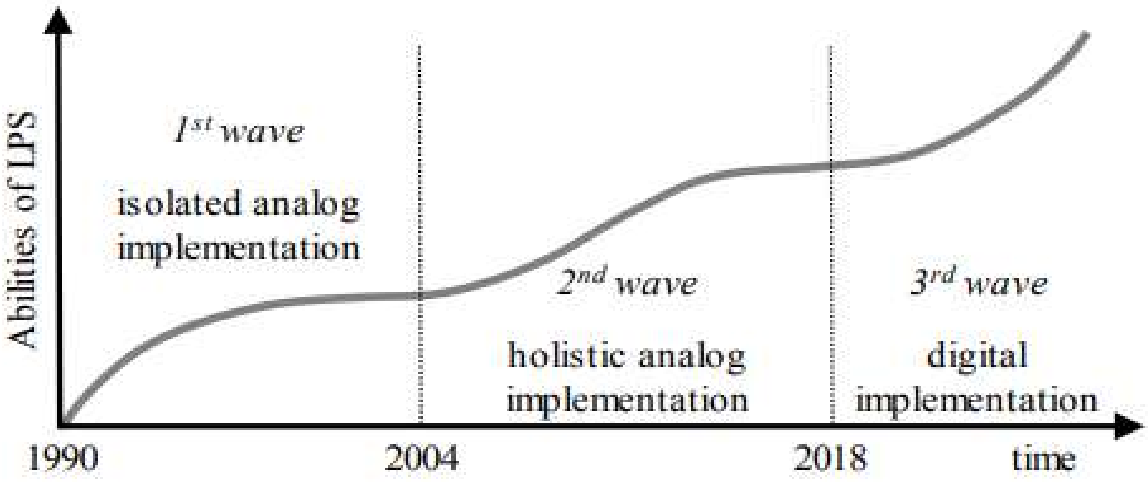

Figure 1
Preceding and Prospective Lean Production System Implementation (Hoellthaler et al., 2023)

Currently, industries that adhere to the lean production philosophy have averaged implementation rates in their manufacturing processes of over 90% (Hoellthaler et al., 2023). Lean manufacturing implementation enhances operational performance, particularly in terms of delivery and adaptability to customers (Herzog and Tonchia, 2014). A company's long-term strategy approach is reflected in its lean transformation. Lean is adopted gradually in levels using tools that are suitable for the organization's needs at the moment (Yadav, 2020). The foundation of lean manufacturing is comprised of lean ideas, techniques, and tools but using tools without first creating an integrative system (which serves as a prerequisite to the adoption of lean) is insufficient (Chaple, 2017; Shrimali, 2017).

2.1.1 The Theory

With its origins in the Toyota Production System (TPS), lean manufacturing is a structured approach for detecting and eliminating waste through continuous improvement. The underlying theories of lean manufacturing cover a range of concepts and methods designed to improve customer satisfaction and efficient operations (Oliveira *et al.*, 2018). Lean thinking is based on the idea of waste elimination, which is one of the fundamental theories underlying lean production. explain that the goal of lean manufacturing is to give customers more value by methodically eliminating activities that do not add value from production processes (Alkhoraif *et al.*, 2019a). Another essential component of lean manufacturing is continuous improvement (Kaizen) which promotes small adjustments that improve processes over time (Shafeek, 2019).

2.2 Empirical Reviews

A number of studies have been done by researchers on the road maps to lean manufacturing implementation include study done by Mostafa et al. (2013) who developed a project based framework of lean manufacturing implementation with four (4) phases (conceptualization phase, implementation design phase, implementation and monitoring phase and complete lean transformation phase) with 22 elements as activities to be done by the industry during the implementation process of lean manufacturing (Mostafa et al., 2013). Nordin et al. (2012) created framework that incorporates a concept that allows the deployment of the lean manufacturing system to happen in stages, based on the demands of the organization as well as the resources (financial, human, technical, and time) that are available, rather than all at once. A manufacturing company might utilize this framework as a road map to ensure successful implementation (Nordin et al., 2012); However, for the lean technique to be implemented effectively, management's willingness to raise working capital, providing personnel with lean philosophy training, and developing mechanisms for decreasing waste are essential (Pontevedra et al., 2019). The most important managerial factors for a successful lean implementation are leadership commitment and communication abilities (Bhadu et al., 2022; Tortorella et al., 2018).

2.2.1 Lean Manufacturing in SMEs

Large manufacturers are using new management systems, such as lean manufacturing, and it is crucial for small businesses (SMEs) to participate in this process (Shrimali, 2017). Studies discussed the strengths of SMEs in implementation of lean manufacturing such as Flexible systems which allows for quick development (Alkhoraif et al., 2019b; Sahoo & Yadav, 2018a; Shrimali, 2017), flat organizational structure with fewer levels of administration and departmental interactions, the top management provides leadership since they are highly visible, have a tendency for strong staff loyalty, direct interaction of managers and employees with consumers (Alkhoraif et al., 2019b; Shrimali, 2017), extremely quick action and decision implementation (Sahoo & Yadav, 2018a), give training programs priority, a culture that values learning new things and adapting instead of controlling (Lewis et al., 2006; Shrimali, 2017) and they are focused on people (Shrimali, 2017). Furthermore, different frameworks with roadmap of lean manufacturing implementation have been established by researchers for varying context such as Belhadi et al. (2016) developed framework for implementing lean manufacturing in SMEs with consideration of lean tools application and critical success factors in the three phases of lean manufacturing implementation (Belhadi, Touriki, El Fezazi, et al., 2016), Project based approach of four phases (conceptualization, implementation design, implementation and evaluation, and complete lean transformation phases) with 22 elements (Mostafa et al., 2013).

According to studies, industries have a lower chance of achieving their strategic goals if they don't measure the factors that are most important for success (Chaple, 2017). Numerous studies have indicated that implementing lean manufacturing processes is challenging and that firms face numerous obstacles during this protracted process of continuous improvement. SME environments cannot afford to lag behind in implementing lean manufacturing since it could jeopardize their continued existence (Bhadu et al., 2022; Dora et al., 2016). Based on case study survey done by Rymaszewska (2014), different internal and external factors facilitate and hinder lean manufacturing implementation in SMEs.

Moreover, through systematic literature review conducted by Abu (2019) highlighted some barriers which hinder lean manufacturing implementation include resistance from employees and middle management, lack of time, capital fund, know-how, lean expertise, understanding benefits and labor resources (Kotlyarova and Mekhantseva, 2016) and perceptions that lean is difficult to implement, gimmick and does not fit culture (Abu et al., 2019; Sahoo &Yadav, 2018a). After force field analysis done be Almanei et.al (2017) on the assessment of driving and hindering factors of planned change in SMEs identified internal and external organizational factors.

2.2.2 Lean Tools in Waste Reduction

To become highly responsive to customer demand while producing world-class quality products in the most efficient and economical manner, lean aims to eliminate waste of any kind. Waste is defined as anything that is done and adds no value to the product (Shrimali, 2017). Other scholars defined Waste as anything or distraction to the smooth flow of production process, making the system efficient and competitive (Chaple, 2017), minimizing non value adding activities and improving value adding activities (Karim and Arif-uz-zaman, 2013). There are eight types of waste: overproduction, waiting time, transportation, inventory, inappropriate processing, non-utilized talents, excess motion, and product defects (Gaikwad and Sunnapwar, 2020; Shrimali, 2017; Tanasic et al., 2022). Lean tools are those that are designed to decrease waste, boost customer satisfaction, increase process efficiency, and increase productivity (Naeemah and Wong, 2021). Lean tools are categorized based on value to customer, scheduling, maintenance, policy and organization focus (Purushothaman et al., 2021). These include all methods or strategies that help industries implement the five Lean Manufacturing principles (Khusaini et al., 2014). Implementing lean tools in small and medium industries can unlock significant improvements in efficiency, productivity, and customer satisfaction and eliminating non-value adding activities (Sinkamba et al., 2023). By embracing lean principles and adopting key tools such as Value Stream Mapping, 5S Workplace Organization, Kaizen Events, Kanban System, and Poka-Yoke, businesses can drive positive transformation and achieve sustainable growth (Pontevedra et al., 2019). This study used the following lean tools categorized and applied in varying organizations based on context and sector as Table 2 shown from different studies done.

Table 2
Summary of Lean Tools Categorizations and Application

Lean tools applied	Lean tool category	Lean wastes minimized	Studied industry
5S	Industry focus- working-environment organization (Monsalvo-buelvas, 2020; Purushothaman *et al.*, 2021)	Waiting time, inventory, non-utilized talents (Tanasic *et al.*, 2022), Unnecessary movement (Naeemah and Wong, 2021; Sahoo and Yadav, 2018a)	SMEs (Alkhoraif *et al.*, 2019b; Dresch *et al.*, 2019; Sahoo and Yadav, 2018a), Food and Beverage (Farissi *et al.*, 2021; Khusaini *et al.*, 2014; Lopes *et al.*, 2015; Monsalvo-buelvas, 2020)
Value Stream Mapping	Value to customer- cost reduction, waste elimination (Purushothaman *et al.*, 2021)	Defective products, waiting time (Sahoo, 2020), identifying all waste (Tanasic *et al.*, 2022)	SMEs (Alkhoraif *et al.*, 2019b; Antosz and Stadnicka, 2017; Belhadi, Touriki, El Fezazi, *et al.*, 2016; Sahoo and Yadav, 2018a)
Kaizen	Value to customer- continuous improvement (Purushothaman *et al.*, 2021)	Defects, non-utilized talents (Naeemah and Wong, 2021), identifying all waste (Tanasic *et al.*, 2022)	SMEs (Alkhoraif *et al.*, 2019b; Antosz and Stadnicka, 2017; Belhadi, Touriki, El Fezazi, *et al.*, 2016; Zhou, 2016)
Single Minute Exchange of Dies (SMED)	Setup time reduction (Stapelbroek *et al.*, 2022)	Waiting time (Dresch *et al.*, 2019)	Food and Beverage (Khusaini *et al.*, 2014; Lopes *et al.*, 2015; Stapelbroek *et al.*, 2022) and SMEs (Alkhoraif *et al.*, 2019b; Dresch *et al.*, 2019; Farissi *et al.*, 2021; Sahoo, 2017)
Kanban/Pull system	Scheduling (Purushothaman *et al.*, 2021)	Waiting time, unnecessary movements (Dresch *et al.*, 2019; Naeemah and Wong, 2021), identifying all wastes (Tanasic *et al.*, 2022)	SMEs (Belhadi *et al.*, 2016; Dresch *et al.*, 2019; Sahoo and Yadav, 2018b; Zhou, 2016; Alkhoraif *et al.*, 2019)), Food and Beverage (Khusaini *et al.*, 2014)
Just in time (JIT) delivery	Scheduling (Purushothaman *et al.*, 2021)	Inventory, waiting time, overproduction (Naeemah and Wong, 2021; Sahoo, 2017)	Food and Beverage (Dora *et al.*, 2016; Farissi *et al.*, 2021; Khusaini *et al.*, 2014)
Visual aids and Visual Information System	Industry focus- visualization (Purushothaman *et al.*, 2021)	Inappropriate processing, defects (Dresch *et al.*, 2019; Sahoo, 2017)	SMEs (Dresch *et al.*, 2019; Sahoo, 2017; Zhou, 2016)
Statistical Process Control (SPC)	Value to customer- cause to quality problem	Defects, inappropriate processing (Akanmu and Nordin, 2022)	SMEs (Belhadi, Touriki, El Fezazi, *et al.*, 2016; Sahoo, 2017)
Total Productive Maintenance (TPM)	Maintenance (Purushothaman *et al.*, 2021)	Waiting time, defects (Akanmu and Nordin, 2022; Dresch *et al.*, 2019; Seow and Jiying, 2006)	SMEs(Belhadi, Touriki, El Fezazi, *et al.*, 2016; Dresch *et al.*, 2019; Sahoo and Yadav, 2018a; Zhou, 2016), Food and Beverage (Akanmu and Nordin, 2022)
Poka yoke/ Error Proofing system	Value to customers- quality improvement (Purushothaman *et al.*, 2021)	Defects (Dresch *et al.*, 2019), overproduction, non-utilized talents, defects, waiting (Tanasic *et al.*, 2022)	SMEs (Dresch *et al.*, 2019; Sahoo and Yadav, 2018a; Zhou, 2016), Food and beverage (Khusaini *et al.*, 2014)
Group Technology	Value to customer and industry focus	Defects, unnecessary motion and movement (Shrimali, 2017)	SMEs (Shrimali, 2017), food and beverage (Khusaini *et al.*, 2014)
Cellular layout	Industry focus- visualization	Unnecessary movement, transportation, waiting time (Sahoo, 2017)	SMEs (Psomas *et al.*, 2018; Sahoo, 2020; Sahoo and Yadav, 2018a; Zhou, 2016), food and beverage (Khusaini *et al.*, 2014)
Work Standardization	Scheduling (Purushothaman *et al.*, 2021)	Defective products, inappropriate process, waiting time (Sahoo, 2017), identifying all wastes (Tanasic *et al.*, 2022)	SMEs (Alkhoraif *et al.*, 2019b; Belhadi, Touriki, El Fezazi, *et al.*, 2016; Psomas *et al.*, 2018; Sahoo and Yadav, 2018a; Zhou, 2016)
Jidoka/Autonomation	Value to customer- waste elimination (Purushothaman *et al.*,	Defective products (Tanasic *et al.*, 2022)	SMEs (Sahoo, 2017; Sahoo and Yadav, 2018a), Food and Beverage (Khusaini *et al.*, 2014)

Lean tools applied	Lean tool category	Lean wastes minimized	Studied industry
	2021), workplace safety (Monsalvo-buelvas, 2020)		
Heinjuka/Level Scheduling	Scheduling (Purushothaman *et al.*, 2021)	Overproduction, inappropriate processing, non-utilized talent (Sahoo, 2017)	SMEs (Alkhoraif *et al.*, 2019b; Sahoo, 2017; Sahoo and Yadav, 2018a) Food and Beverage (Khusaini *et al.*, 2014)
One piece flow/ Continuous flow	Scheduling (Purushothaman *et al.*, 2021)	Inappropriate process, inventory, defective products, non-utilized talents, overproduction (Akanmu and Nordin, 2022)	SMEs (Antosz and Stadnicka, 2017; Sahoo and Yadav, 2018a; Zhou, 2016), Food SMEs (Psomas *et al.*, 2018), Food and Beverage (Akanmu and Nordin, 2022; Khusaini *et al.*, 2014)
Andon/Lighting signal	Industry focus-visualization (Purushothaman *et al.*, 2021)	Inappropriate processing, defects	SMEs (Antosz and Stadnicka, 2017; Rymaszewska, 2014), Food and beverage (Khusaini *et al.*, 2014)

2.2.3 Extent of Lean Manufacturing Implementation

In order to evaluate and measure the extent of lean implementation within current manufacturing systems, Herzog and Tonchia (2014) conducted a survey study in 72 medium- and large-sized Slovenian manufacturing companies. Based on a synthesis of the "lean" literature, eight key areas were identified: value concept and customers; value stream mapping (VSM); pull/kanban and flow; waste elimination; just-in-time (JIT); employee involvement; and the establishment of excellent suppliers (lean suppliers). Likert scales (with level of agreement) were used to construct the variables in these key areas that can be used to determine extent of lean manufacturing implementation (Herzog and Tonchia, 2014). Cluster analysis was one of the method used to classify the firms on status of lean manufacturing implementation in three groups : non-lean, in-transition, and lean (Nordin et. al., 2010; Sahoo and Yadav, 2018a). According to the survey on Malaysian automotive manufacturing industry by Nordin et.al. (2010) on exploring the degree of lean manufacturing implementation, the respondent industries' status was determined from the Likert scale (with level of implementation) of five lean categories with lean practices/tools (Process and equipment, manufacturing planning and control, human resources, supplier relationships and customer relationships). The results of this survey indicated the majority of the Malaysia automotive industries have implemented lean manufacturing to some extent (in-transition) (Nordin et al., 2010).

Various researchers explored into the extent that SMEs in industrialized nations such as United States, Japan etc. are adopting and implementing lean manufacturing principles. Based on the study's findings, the majority of SMEs comprehend the lean idea and philosophy rather well (Psomas et al., 2018; Sahoo, 2020; Zhou, 2016). Hence survey in 14 Indian automotive component manufacturing SMEs was done to assess lean implementation by considering different lean tools and programs adopted by these industries. The results of the survey showed that Cellular manufacturing was the top-ranked lean tool adopted in these industries (Sahoo, 2020).

III. METHODOLOGY

This study targeted small and medium food and beverage processing industries in Dar es Salaam and Coast regions in Tanzania where on the computation of recorded data, approximately 180 establishments of this subsector were achieved because of the specific characteristics of these industries and their large contribution to the economy. Due to the large population and dispersed SMEs for food and beverage, cluster random sampling was an appropriate strategy. The sample size of this study was drawn randomly from different small and medium food and beverage processing industries found in Dar es Salaam and Coast region. The study employed a variety of distribution channels for the questionnaire, including face-to-face interactions and the internet (e-mail and web questionnaire). The questionnaire was initially presented to the expert for checking the content validity and construct validity of the questionnaire was done through Exploratory Factor Analysis (EFA) which checks the structure of data and consistency to theoretical constructs. After data collection Descriptive analysis of lean tools and lean outputs was conducted as foundation for Principal Component Analysis which was done for factor reduction. There were 113 questionnaires given to the respondents in the chosen sample. The first section of the questionnaire was made up of questions about demographics, such as organizational size, educational attainment, and managerial status. The second section of the questionnaire which captured 17 lean tools (as stated in Table 2) in which the company representatives were required to rate their level of agreement on implementation of proposed lean manufacturing tools. The last section constituted lean outputs as the respondents had to rate their level lean wastes were minimized after application of lean manufacturing tools. On a five-point Likert scale, respondents were asked to show how much they agreed or disagreed (1 highly disagree, 2 disagree, 3 neutral, 5 strongly agree, and 4 agree).

IV. FINDINGS & DISCUSSION

4.1 Descriptive Statistics for the Lean Tools Indicators

Table 3 provides the descriptive statistics for the lean tools indicators that were calculated based on the likert scale ranging of 1-5 space.

Table 3

Summary Statistics for the Lean Tools Indicators

Variable	Count	Mean	Std.Dev.	Min	Max
Leantools15S	110	3.354545	1.161985	1	5
Leantools2~i	110	3.909091	.9630366	1	5
Leantools3~i	110	3.454545	1.028372	1	5
Leantools4~h	110	2.381818	.8671563	1	5
Leantools5~s	110	4.018182	.8457321	1	5
Leantools6~M	110	3.309091	1.002249	2	5
Leantools7~s	110	2.700000	1.054044	1	5
Leantools8~e	110	3.790909	.9295896	1	5
Leantools9~r	110	2.463636	.8639282	1	5
Leantools1~y	110	2.627273	.9173065	1	5
Leantools~ut	110	3.027273	1.061927	1	5
Leantools~at	110	4.036364	.8342142	1	5
Leantools1~a	110	3.154545	1.059569	1	5
Leantoo~ling	110	2.827273	1.021414	1	5
Leantools1~w	110	3.772727	.9351357	1	5
Leantoo~ting	110	2.936364	.9793957	1	5
Leantools1~n	110	3.454545	1.046062	1	5

Overall, there is no variation on the responses as can be seen from the individual standard deviation implying that the responses of the industries' representatives were related and reliable. The highest mean is 4.036 and represent the work standardization followed closely by the Statistical Process Control (SPC) tools with an average of 4.018. This implies that majority of the food and beverage SMEs have adopted and mostly implement Work standardization through presences of operation procedures to avoid variations; this is followed by SPC which is widely used by these industries in controlling the process by identifying the deviations.

4.1.1 Index of Relative Importance for the Lean Tools Indicators

The Index of relative importance is a statistical measure that is used to assess the relative importance of variables or indicators that are used for a particular context. In this case, assessing indicators used to measure lean tools was sought important as it provides the knowledge of the extent to which the lean tools are being implemented by the industries. The mean was used to provide the insight with the associated standard deviation. The higher the mean meant the higher the ranking as shown the 5th column in Table 4. A total of seventeen (17) attributes were used for the calculation of the indices as shown in Table 4.

Table 4

Index of Relative Importance for the Lean Tools Indicators

Code	Indicator	Mean	Std. Dev	Rank
Leantools~at	Work standardization	4.036	0.834	1
Leantools5~s	Statistical Process Control (SPC) tools	4.018	0.846	2
Leantools2~i	Value Stream Mapping	3.909	0.963	3
Leantools8~e	Just in Time	3.791	0.930	4
Leantools1~w	One piece flow	3.773	0.935	5
Leantools3~i	Visual aids and Visual Information System	3.455	1.028	6
Leantools1~n	Kaizen	3.455	1.046	7
Leantools15S	5S	3.354	1.162	8

Code	Indicator	Mean	Std. Dev	Rank
Leantools6~M	Total Productive Maintenance	3.309	1.002	9
Leantools1~a	Jidoka / Autonomation	3.155	1.059	10
Leantools~ut	Cellular layout	3.027	1.062	11
Leantoo~ting	Andon / Lighting Signal	2.936	0.979	12
Leantoo~ling	Level scheduling / Heinjuka	2.827	1.021	13
Leantools7~s	Kanban cards	2.700	1.054	14
Leantools1~y	Group technology	2.627	0.917	15
Leantools9~r	Poka yoke / Error proofing system	2.463	0.864	16
Leantools4~h	Single Minute Exchange of Dies (SMED)	2.382	0.867	17
Grand Mean		**3.248059**		

Results from Table 4 shows that of the seventeen (17) lean tools indicators, the first five indicators ranked higher by average are work standardization (mean = 4.036), statistical process control tools (mean = 4.018), Value stream mapping (mean = 3.909), Just –in- time (mean = 3.791) and one-piece flow (3.791). This implies that these lean tools are highly implemented in most of the selected industries for increasing process utilization, efficiency and quality improvement as supported in the case study done by Belhadi et.al (2016) to the five cases (from varying manufacturing sector category) on the development of road map for implementing lean tools in SMEs (Belhadi et. al., 2016). On the other hand, the last five lean tools indicators are predominantly level scheduling (mean = 2.827), Kanban cards (mean = 2.700), group technology (mean = 2.627), Poka yoke/error proofing system (mean = 2.463) and the least is single minute exchange of dies (mean = 2.382). This means that these tools are not highly implemented in most of the SMEs in Tanzania which could be due to resources constraints, lack of expertise and awareness and their complexity in implementation. The survey done Khusaini et.al (2014) identified some similar lean tools least favorable while others not know in Food and Beverage industries (Khusaini et al., 2014).

4.1.2 Descriptive Statistics for the Lean Output Indicators

The lean output indicators were performed the descriptive statistics, and the measures were mean, standard deviation, maximum and minimum valued response. A total of eight (8) indicators were used and the values of the descriptive statistics are as shown in Table 5 as well as Table 6.

Table 5

Summary Statistics for the Lean Tools Indicators

Variable	Count	Mean	Std.Dev.	Min	Max
Leanoutput~f	110	4.009	.7839614	1	5
Leanoutput~d	110	3.645	.9915826	1	5
Leanoutput~y	110	3.464	1.001625	1	5
Leanoutput~r	110	3.973	.7717381	1	5
Leanoutput~e	110	3.218	.9896883	1	5
Leanoutput~a	110	3.227	.9922552	1	5
Leanoutput~u	110	3.845	.8586993	1	5
Leanoutput~i	110	3.245	.9402943	2	5

Table 5 provides descriptive statistics for the lean output indicators that were calculated based on the likert scale as well ranging of 1-5 space. Overall, there is no variation on the responses as can be seen from the individual standard deviation displaying that the responses provided by the respondents were related. The highest mean is 4.009 numbers of defective products followed closely by the inappropriate processing of products with an average of 3.973. This implies that defective products are highly reduced in most of the studied SMEs after the implementation of lean tools which is followed by reduction of inappropriate processing of products.

4.1.3 Index of Relative Importance for the Lean Output

Calculations for the Index of relative importance helped in identifying which factor contributes most significantly to the outcome variable and that which among the attributes aid mostly in making decisions. The ranking would always be an attempt to provide systematic ranking by looking at the large mean value. As stated earlier, the lean output was measured using eight (8) attributes as shown in Table 6 with their relative importance from the largest to the smallest. Table 6 gives the ranking in column 5.

Table 6
Index of Relative Importance for the Lean Output Indicators

Code	Indicator	Mean	Std.dev	Rank
Leanoutput~f	Number of defective products	4.009	0.7839614	1
Leanoutput~r	Inappropriate processing of products	3.973	0.7717381	2
Leanoutput~u	Overproduction	3.845	0.8586993	3
Leanoutput~d	Waiting and queuing	3.645	0.9915826	4
Leanoutput~y	Unnecessary stocked inventory	3.464	1.001625	5
Leanoutput~i	Excessive transportations	3.245	0.9402943	6
Leanoutput~a	Unnecessary movements	3.227	0.9922552	7
Leanoutput~e	Non-utilized talents	3.218	0.9896883	8
Grand Mean		**3.578**		

Results from Table 6 shows that of the eight (8) lean output indicators, the first three indicators ranked higher by average are number of defective products (mean = 4.009), inappropriate processing of products (mean = 3.973), overproduction (mean = 3.845). This implies that implementation of lean tools have impacted in reducing number of defective products, inappropriate processing and overproduction at large extent to most of the studied SMEs which is supported by study done by Arevalo-Barrera et al.(2019) on the wastes reduction in bricks production through implementation of lean manufacturing tools. On the other hand, the last three lean output indicators are excessive transportations (mean = 3.245), unnecessary movements (mean = 3.227), and the least is non- utilized talents (mean = 3.218). This means that lean manufacturing tools reduce these kinds of wastes at low extent for most of the studied SMEs. In general, the lean output indicators provide an insight on their dependence to lean inputs where as lean output is achieved through wastes minimization and the lean inputs are considered by the lean tools implemented. Therefore, the extent different kinds of lean wastes are minimized depend with the application of identified lean tools.

4.2 Factor Analysis: Lean Tools Indicators

The proportion of variance of which variables were accounted for were measured and the extraction values of all 17components (lean tools) were high (above 0.5) close to initial solution implying that they are fit for factor solution. To ascertain the number of components to be extracted, the minimum variance collected by the factors (at least 60%) when combined with the latent root criterion (eigenvalue more than 1.00) was applied (Mano et al., 2022). From Table 7, three (3) were extracted whose eigenvalue is greater than 1 and the total variance explained from the extraction for 3 components extracted was 68.245% which is above acceptable variance (60%) effective for factor analysis.

Table 7
Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.843	46.133	46.133	7.843	46.133	46.133	4.085	24.030	24.030
2	2.729	16.051	62.184	2.729	16.051	62.184	3.999	23.525	47.555
3	1.030	6.061	68.245	1.030	6.061	68.245	3.517	20.690	68.245
4	.822	4.835	73.080						
5	.666	3.919	76.999						
6	.613	3.609	80.608						
7	.499	2.937	83.545						
8	.474	2.787	86.332						
9	.418	2.459	88.791						
10	.392	2.304	91.095						
11	.287	1.686	92.780						
12	.272	1.600	94.381						
13	.260	1.531	95.911						
14	.220	1.292	97.203						
15	.179	1.052	98.255						
16	.168	.989	99.244						
17	.129	.756	100.000						

Extraction Method: Principal Component Analysis.

With the Scree plot in Figure 3, the three principal components whose Eigenvalue were above 1 while the remaining 14 components were below Eigenvalue 1, implying that only three principal components will be retained.

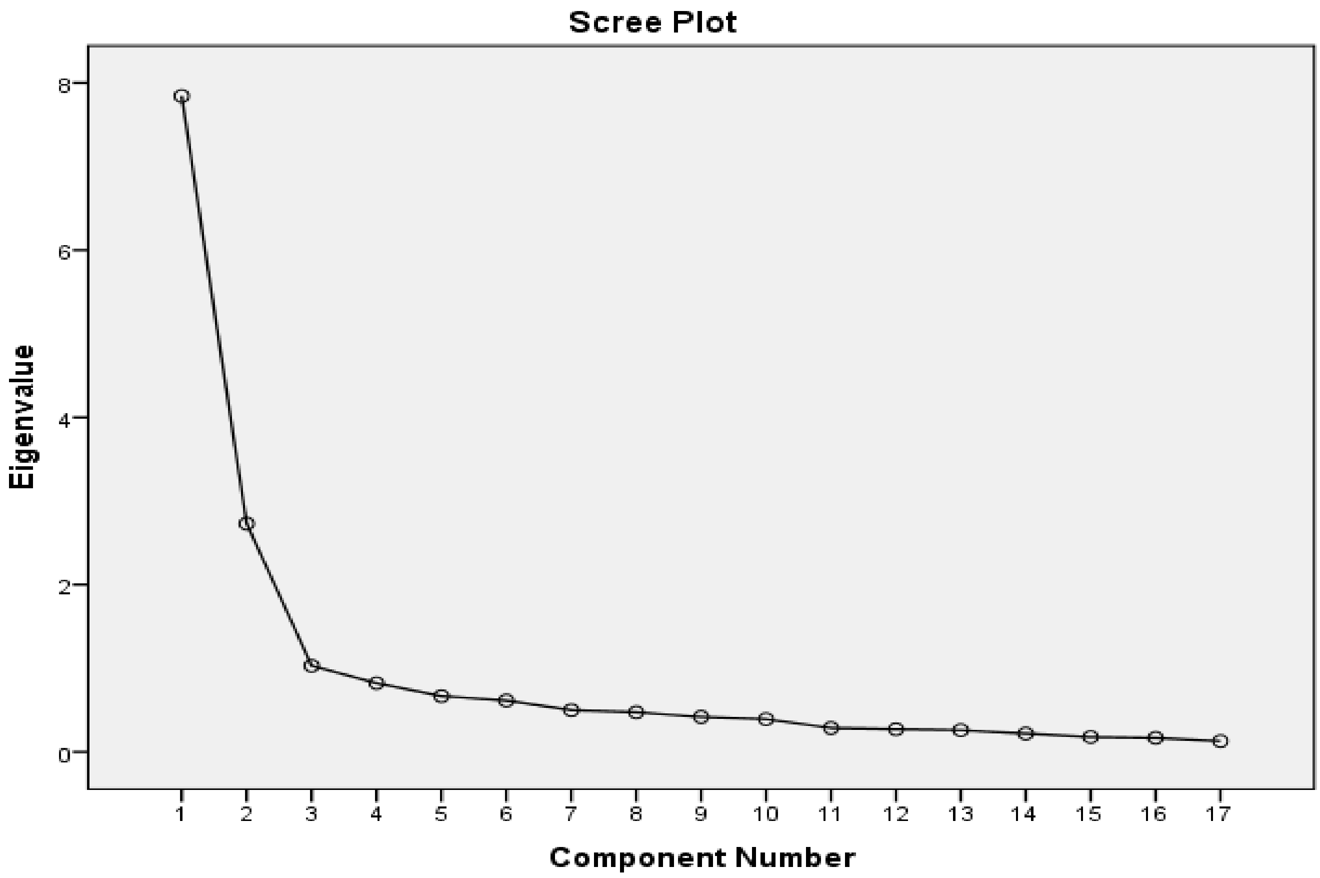

Figure 3
The Scree Plot

4.2.1 Components/ Variables from Factor Analysis

Varimax rotation with Kaiser Normalization rule was done. Factor loading/Rotated component matrix shows Pearson correlation between variables and the principal components from which trait can be identified. Table 8 show the lean tools grouping into the principal components which were further interpreted.

Table 8
Rotated Component Matrix

	Component		
	1	2	3
Lean tools 6: Total Productive Maintenance	.788		
Lean tools 13: Jidoka / Autonomation	.687		
Lean tools 3: Visual aids and Visual Information System	.685		
Lean tools 1: 5S	.680		
Lean tools 10: Group technology	.618		
Lean tools 16: Andon / Lighting Signal	.613		
Lean tools 11: Cellular layout	.579		
Lean tools 17: Kaizen	.531		
Lean tools 2: Value Stream Mapping		.896	
Lean tools 8: Just in Time		.887	
Lean tools 15: One piece flow		.873	
Lean tools 5: Statistical Process Control (SPC)		.764	
Lean tools 12: Work standardization		.695	
Lean tools 9: Poka yoke / Error proofing system			.874

	Component		
	1	2	3
Lean tools 4: Single Minute Exchange of Dies (SMED)			.825
Lean tools 14: Level scheduling / Heinjuka			.712
Lean tools 7: Kanban cards			.550

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

The first principal component was named based on the function of the grouped lean tools in Table 9, which all of them focus on facilitating in easy identification of waste for proper response and standardization through workplace organization with 5S, Visual Management, Group technology and Cellular layout; Real time problem identification through Andon, Kaizen; and equipment and Process reliability with TPM, Jidoka. The first principal component was named as "Lean Process Optimization and Control Systems Tools"

Table 9
Principal Component 1 - Lean Process Optimization and Control Systems Tools

Lean tools 6: Total Productive Maintenance
Lean tools 13: Jidoka / Automation
Lean tools 3: Visual aids and Visual Information System
Lean tools 1: 5S
Lean tools 10: Group technology
Lean tools 16: Andon / Lighting Signal
Lean tools 11: Cellular layout
Lean tools 17: Kaizen

The principal component 2 was named based on the function of the grouped lean tools which all of them focus on Process optimization through One-piece flow, VSM; inventory management with application of JIT; and quality control and standardization through SPC and work standardization. This group presented in Table 8 was named as "Lean Process Efficiency Tools".

Table 10
Principal Component 2 - Lean Process Efficiency Tools

Lean tools 2: Value Stream Mapping
Lean tools 8: Just in Time
Lean tools 15: One piece flow
Lean tools 5: Statistical Process Control (SPC)
Lean tools 12: Work standardization

The third principal component was named as "Operational Efficiency and Quality Management Tools" since the tools focus on improving quality (Poka-yoke/error proofing system), reducing set-up times (SMED), optimizing production flows and inventory management with kanban cards and Level scheduling. Table 9 show the group of lean tools in third principal component extracted.

Table 11
Operational Efficiency and Quality Management Tools

Lean tools 9: Poka yoke / Error proofing system
Lean tools 4: Single Minute Exchange of Dies (SMED)
Lean tools 14: Level scheduling / Heinjuka
Lean tools 7: Kanban cards

4.3 Factor Analysis: Lean Output Indicators

The proportion of variance of which variables were accounted for were measured and the extraction values of all 8 components (lean output) were high (above 0.5) close to initial solution implying that they are fit for factor solution. To ascertain the number of components to be extracted, the minimum variance collected by the factors (at least 60%) when combined with the latent root criterion (eigenvalue more than 1.00) was applied (Mano et al., 2022). From Table 12, two (2) factors were extracted whose eigenvalue is greater than 1 and the total variance explained from the extraction for 2 components extracted was 72.341% which is above acceptable variance (60%) effective for factor analysis.

Table 12
Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.640	58.003	58.003	4.640	58.003	58.003	3.398	42.474	42.474
2	1.147	14.338	72.341	1.147	14.338	72.341	2.389	29.867	72.341
3	.662	8.280	80.621						
4	.550	6.870	87.491						
5	.380	4.755	92.246						
6	.276	3.444	95.690						
7	.224	2.803	98.493						
8	.121	1.507	100.000						

Extraction Method: Principal Component Analysis.

With the Scree plot in Figure 4, the two components whose Eigenvalue were above 1 while the remaining 6 components were below Eigenvalue 1, implying that only two principal components will be retained.

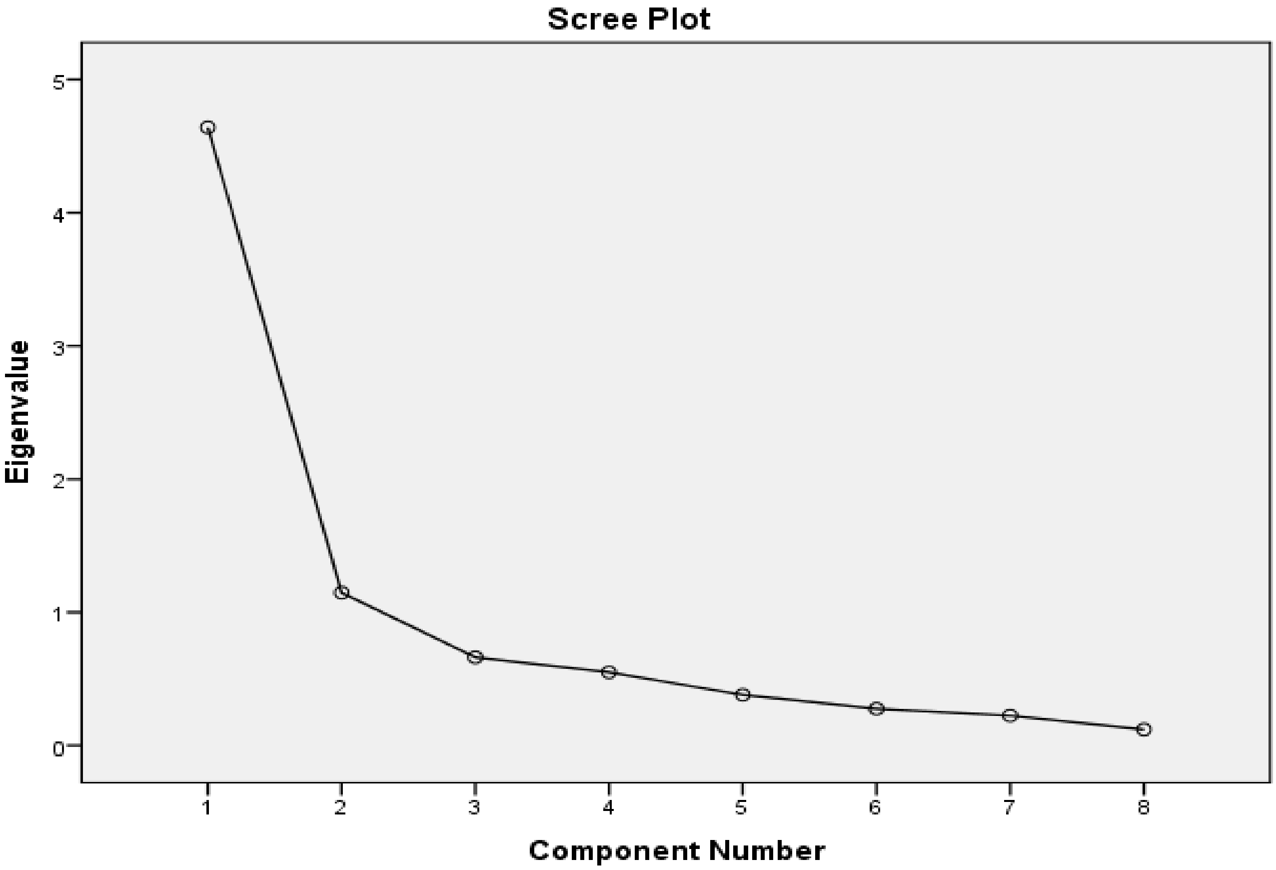

Figure 4
The Scree Plot

4.3.1 Components/ Variables from Factor Analysis

Varimax rotation with Kaiser Normalization rule was done. Factor loading/Rotated component matrix shows Pearson correlation between variables and the principal components from which trait can be identified. Table 13 show the lean output grouping into the principal components which were further interpreted.

Table 13
Rotated Component Matrix

	1	2
Lean output 1: Reduced Number of defective products	.931	
Lean output 4: Reduced Inappropriate processing of products	.911	
Lean output 2: Less Waiting and queuing	.750	
Lean output 7: Reduced Overproduction	.738	
Lean output 3: Fewer Unnecessary stocked inventory	.540	
Lean output 6: Reduced Unnecessary movements		.908
Lean output 8: Minimized Excessive transportations		.859
Lean output 5: Fewer Non-utilized talents		.557
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		

The first principal component was named based on the commonality of lean outputs after lean manufacturing tools implementations which are; reduced number of defective products reduced inappropriate processing of products, less waiting and queuing, reduced overproduction and finally, fewer unnecessary stocked inventory. The five outputs aim to eliminate inefficiencies by minimizing resource use, time, and excess production, thereby improving overall process flow and product quality while reducing costs and waste. with. The first principal component was named as “Product and process efficiency”. This supported in the survey study done by Bashar et al. (2024) on mediation analysis of Lean manufacturing and operation performance identified that waste elimination in garment industries for developing countries improves operational efficiency (Bashar et al., 2024).

Table 14
Principal Component 1 – Operational Efficiency Improvement

Lean output 1: Reduced Number of defective products	.931
Lean output 4: Reduced Inappropriate processing of products	.911
Lean output 2: Less Waiting and queuing	.750
Lean output 7: Reduced Overproduction	.738
Lean output 3: Fewer Unnecessary stocked inventory	.540

The lean outputs after lean implementation in the principal component 2 were; reduced unnecessary movements, Minimized Excessive transportations and fewer non-utilized talents which focus on streamlining workflows, reducing wasteful activities, and ensuring that skills are effectively used. The second principal component was named as “operational efficiency and resource utilization” based on the targets of group presented in Table 15.

Table 15
Principal Component 2 - Operational Efficiency and Resource Utilization

Lean output 6: Reduced Unnecessary movements	0.908
Lean output 8: Minimized Excessive transportations	0.859
Lean output 5: Fewer Non-utilized talents	0.557

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

This paper was set to identify the status of lean manufacturing implementation in food and beverage SMEs found in Dar es Salaam and Coast region in Tanzania through lean tools integrated and lean wastes minimized as lean outputs. Results shows that majority of the food and beverage SMEs have adopted and mostly implement Work standardization through presences of operation procedures to avoid variations; this is followed by SPC which is widely used by these industries in controlling the process by identifying the deviations. Further revealed that out of the seventeen (17) lean tools indicators, the first five indicators ranked higher by average are Work Standardization, SPC tools, VSM, JIT and one-piece flow. This implies that these lean tools are highly implemented in most of the selected industries for increasing process utilization, efficiency and quality improvement. On the other hand, five lean tools indicators which are predominantly level scheduling, Kanban cards, group technology, Poka yoke/error proofing system and SMED ranked low and implied they are not highly implemented in most of the SMEs in Tanzania due to resources constraints, lack of expertise and awareness and their complexity in implementation. Similar results were revealed through mere descriptive statistics and could be strengthened more by factor analysis. With regard to defective products, the findings have shown that, defective products are highly reduced in most of the studied SMEs after the implementation of lean tools which is followed by reduction of inappropriate processing of products. In general, the lean output indicators provide an insight on their dependence to lean inputs where as lean output is achieved through wastes minimization and the lean inputs are considered by the lean tools implemented. Therefore, the extent different kinds of lean wastes are minimized depend with the application of identified lean tools.

5.2 Recommendations

Following the results above, it is recommended that, the policy implication should enlighten on several areas. Firstly, there should be a kind of support for training to the SMEs to assist them understand and subsequently implement the lean manufacturing techniques in an effective manner. The government should thus engage industries in accomplishing this. Implementing lean manufacturing requires upfront investment in technology and processes. There should be arrangement to ensure available policies support SMEs through financial incentives by creating enabling business environment that would easier access to financial services. Policies in place should thus focus on ensuring SMEs are getting access to technical services and consultancies as need required. The findings suggest that policies should focus on promoting the adoption of lean tools in SMEs to reduce defects and minimize waste, thereby improving production efficiency. This can be supported by providing training and resources to SMEs, along with incentives for effective waste minimization. Additionally, implementing monitoring and evaluation mechanisms can ensure the continuous improvement of lean practices. Tailoring lean strategies to specific sectors within SMEs is also important, as the effectiveness of these tools may vary depending on the industry and the types of waste being targeted. Since lean manufacturing attracts innovations, lean techniques are therefore required through enabling policy environment in industrial operations. Finally, infrastructural development is key to allow for the lean manufacturing through digital tools as well as technology upgrading.

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