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Analyzing the Lean Waste in Medium-Scale Size Industries by Lean Practice-Waste Impact Matrix

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Abstract
Today, industries faces ongoing challenges related to the cost and quality of products, delivery, and increased global competition. These challenges have forced the industry to change its strategy, improve product quality, and reduce production costs in order to remain competitive in global markets. One of the most effective strategies for dealing with these challenges is Lean Manufacturing. The aim of this article is to establish a methodology for assessing and identifying the level of implementation of Lean Manufacturing practices in medium-sized industrial enterprises in the dairy industry. The proposed methodology integrates Lean Position Map, Percent Point Score method, and Impact Matrix of Lean Practice–Waste. This methodology classifies and categorizes companies based on the level of implementation of ten common Lean Manufacturing practices and examines the impact of implementing these practices on reducing or eliminating eight types of waste, facilitating the development of an action plan for improvement. The Lean Position Map was applied to evaluate twenty dairy companies located in Baghdad in order to examine and understand the level of implementation of Lean Manufacturing practices in the processes and activities of these companies. A matrix of the impact of Lean Manufacturing practices on waste elimination was developed to understand the impact of ten Lean Manufacturing practices on eight types of waste.

Keywords
Lean Manufacturing, Lean Waste, Lean Position Map, , Percent Point Score Method.

Introduction

In today's uncertain and complex business environment, industries face many challenges related to quality improvement, rising customer expectations, costs, competition in global markets, and operational efficiency. These challenges have forced industries to improve their performance in order to remain competitive in global markets and gain a strong competitive advantage by adopting effective production strategies such as Lean Production (LP) (Gobinath et al., 2015), where the word "lean" means less resource consumption (Wei, 2019). The Toyota production system is the source of the Lean Manufacturing philosophy (Dave, 2020). It is considered one of the most influential contemporary practices, which many companies around the world have adopted in order to streamline production processes and use resources efficiently (Alaskari et al., 2016). Lean Manufacturing can be defined as a method, process, concept, system, set of principles, set of tools and techniques, program, approach, philosophy, practice, production paradigm, model, or multidimensional approach aimed at effectively eliminating waste (Bhamu & Sangwan, 2014; Al-Baldawi et al., 2023). Lean Manufacturing, as a philosophy of continuous improvement, aims to increase the competitiveness of companies in the markets by applying lean practices to eliminate or reduce eight types of waste in their processes and activities, namely: overproduction, unnecessary inventory, waiting, excessive transportation, defects, inefficient movements, improper processing, and underutilization, in order to improve productivity, quality, the work environment, and reduce costs (Al-Baldawi et al., 2024). Although small and medium-sized enterprises (SMEs) have adopted the Lean Manufacturing philosophy in their processes and operations to improve performance, the level of its implementation

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has not been studied, and although there are over 100 Lean Manufacturing practices and principles, SMEs are unable to implement them all due to limitations in skills, finances, and expertise (Rose et al., 2013). An alternative for SMEs is to implement feasible practices sequentially, starting with the easiest or cheapest lean practices as a starting point for implementing the lean production philosophy (Rose, 2011). SMEs are considered an important contributor to economic growth, innovation, and job creation. They contribute about 46% of global gross domestic product (GDP) and provide 50% to 60% of all employment opportunities, accounting for about 90% of all businesses worldwide (Al-Baldawi et al., 2024; Weldeslassie et al., 2019).

Literature review

Many publications have been devoted to the process of assessing and analyzing the level of implementation of Lean Manufacturing practices in small and medium-sized enterprises. For example, a questionnaire-based survey was conducted among 30 clothing companies producing cotton shirts, jeans, and T-shirts to assess the level of implementation of lean practices in their processes and activities. The results showed that Lean Manufacturing practices were not widely used in all processes and activities of these companies, but are successfully implemented only in companies with many years of experience, licensed foreign trademarks, or engaged in export (Posada et al., 2010). A waste assessment matrix (WAM) was developed to define the interrelationships between different types of lean waste in the packaging department. Lean Manufacturing practices such as 5S, Kaizen, flow production, and line balancing were used to analyze and improve waste at (Ali et al., 2015). A model for assessing the level of implementation of ten lean practices in 86 micro and small enterprises in the food sector was proposed using a questionnaire-based position map. The results showed that the most commonly implemented lean practices are Kaizen, PokaYoke, and the visual factory (Del Rocio Quesada & Posada, 2019). Sixteen selected aspects of Lean Manufacturing related to the adoption of lean philosophy practices in SMEs were examined, which were identified based on a literature review and verified using a percentage scoring method. The results of the study showed that focusing on waste elimination, customer needs, maintaining a quality policy, continuous improvement, and market research are some of the key perceived aspects of lean that led to the adoption of lean philosophy practices in the studied organization (Saini & Singh, 2020). A lean assessment model based on a questionnaire was proposed to assess the level of implementation of ten commonly used lean philosophy practices in 50 manufacturing companies. The results obtained from the analysis of the questionnaire responses showed that the overall average level of implementation of Lean Manufacturing practices is 56%, and that the level of implementation varies between large enterprises and small and medium-sized enterprises. A discrepancy was also found between the theoretical tools promoted and their use in these companies (Medonos, 2021). Value stream mapping (VSM) and a waste relationship matrix (WRM) were implemented to examine and analyze waste flow in production. A waste assessment questionnaire (WAQ) was developed to determine the percentage of waste. Improvement measures were proposed to reduce lean waste and increase production (Rahmanasari et al., 2021). The waste assessment model (WAM) method was used to analyze lean waste in the textile industry. The final results show that transportation and inventory are the two most critical types of lean waste. Improvement measures were proposed, which include the implementation of production line balancing, layout optimization, efficient means of transportation, and inventory management training (Rahmadianto & Saifuddin, 2025). This article proposes a methodology for analyzing waste in dairy companies in Iraq. The dairy industry is developing dynamically in this country, which is why the diagnosis and evaluation of process efficiency is a very important issue. The proposed methodology is based on a questionnaire containing 35 questions related to 10 Lean Manufacturing practices. The research was conducted in 20 dairy companies, which were assigned to a map in four categories, namely companies with a high level of Lean Manufacturing maturity, Lean Manufacturing companies, companies with a low level of Lean Manufacturing maturity, and companies with Lean Manufacturing potential. A percentage scoring method was used to analyze and identify the level of adoption and implementation of selected Lean Manufacturing practices for each category. The scale of the impact of the practices was proposed based on the level of implementation of Lean Manufacturing practices, and then a Lean Manufacturing practices – waste impact matrix was used to analyze and evaluate waste in the surveyed companies in order to identify the impact of 10 Lean Manufacturing practices on reducing eight types of lean waste. Finally, based on the final waste analysis, an action plan was proposed to improve dairy processes, which is intended to serve as a guide for these companies in their efforts to improve their processes. Table 1 presents a summary of the literature review.

Table 1
Summary of the literature review

References	Lean Manufacturing Practices	Method used	Application
Posada et al., 2010	Workplace organization 5S, kaizen, preventive maintenance PM Visual Factory, KANBAN, POKA YOKE, SMED, six	Position map	Textile Sector
Ali et al., 2015	5S workplace organization, kaizen, flow production, and line balancing	Waste Assessment Matrix (WAM)	Packaging department in a safety equipment manufacturing company
Del Rocio Quesada & Posada, 2019	Poka Yoke, SMED, preventive maintenance PM, 5S, kaizen, Just in Time (JIT) system, visual factory, Six Sigma	Lean Position Map	Food industry
Saini and Singh, 2020	Perception of lean Lean practices	Percent Point Score Method	Small and medium-sized enterprises in India
Medonos, 2021	5S workplace organization, visualization, standardization, Kaizen, TQM, pull system, TPM, POKA YOKE, VSM, SMED	Percent Point Score Method	Companies of various sizes from different industries
Current work	Job rotation, 5S – workplace organization, motivation, empowerment and support of employees, preventive maintenance PM, visual management system, POKA YOKE, standardization and simplification of work, Kaizen team, teamwork, multi-tasking workforce	Integration lean position map / Percentage scoring method / Lean practices–waste impact matrix	Dairy companies

Research methodology

The general structure of the proposed waste assessment methodology is explained in diagram IDFE0 (Fig. 1), where the methodology comprises seven stages (Fig. 2).

Step 1: Development of a Lean questionnaire with three appropriate Likert scales:

A Lean questionnaire was developed containing 35 questions related to the ten Lean practices under study (Table 2). Three Likert scales 1, 2, and 3 were selected to capture responses to lean questions related to ten lean practices in dairy companies, where scale (1) indicates the implementation of lean practices in 0–49% of processes or activities, scale (2) refers to the implementation of lean practices in 50–79% of processes or activities, and scale (3) refers to the implementation of lean practices in 80–100% of processes or activities.

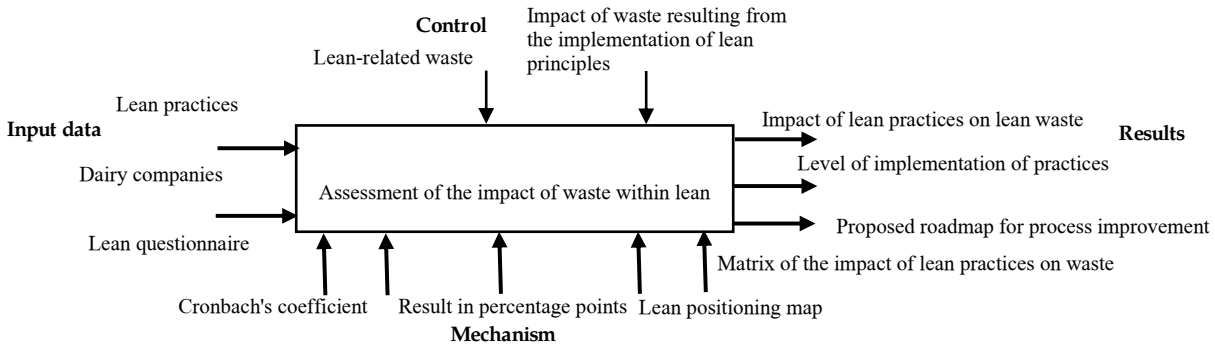

Fig. 1. IDFE0 of the general structure of the proposed methodology

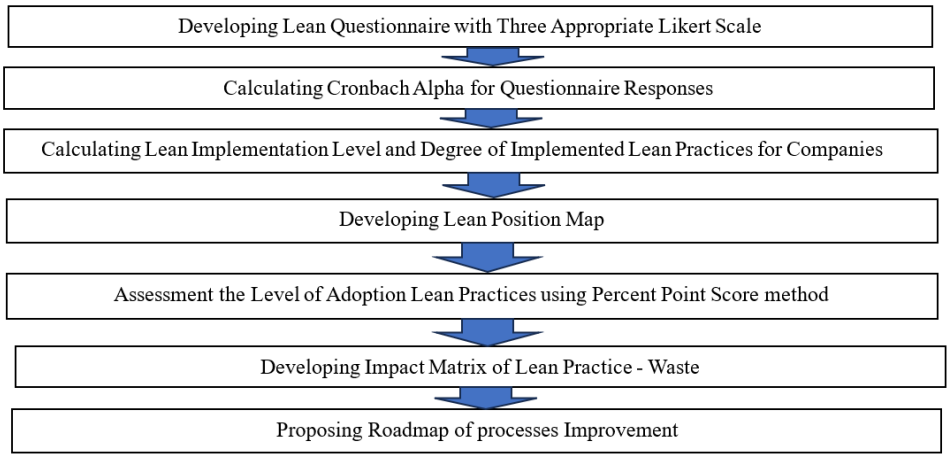

Fig. 2. Methodology for assessing waste in Lean Manufacturing

Step 2: Calculating Cronbach's Alpha (α) for survey responses:

The Cronbach's Alpha test was calculated using SPSS V23 statistical software to check the internal consistency and reliability of the survey responses for each lean practice. The acceptable Cronbach's Alpha (α) coefficient value must be above 0.70 to enable accurate point-based calculations, which indicates high consistency and reliability of responses.

Step 3: Calculation of the lean implementation level and degree of lean practice implementation in companies:

The lean implementation level (LIL) for each company was calculated using Eq. 1 (Del Rocio Quesada & Posada, 2019) as follows:

$$\text{LIL} = \frac{\begin{pmatrix} 1 \times (\text{No.of Questions} = 3) + \\ 0.5 \times (\text{No.of Questions} = 2) - \\ 1 \times (\text{No.of Question} = 1) \end{pmatrix}}{\text{Total Number of lean practices Questions}} \quad (1)$$

The implementation of lean practices (LPI) for each company was determined using Eq. 2 (Del Rocio Quesada & Posada, 2019) as follows:

$$\text{LPI} = \frac{\begin{pmatrix} (\text{No.of Questions} = 3) \cdot 3 + \\ (\text{No.of Questions} = 2) \cdot 2 + \\ (\text{No.of Question} = 1) \cdot 1 \end{pmatrix}}{\text{Total Number of lean practices Questions}} \quad (2)$$

Step 4: Development of a lean positioning map:

The level of adoption of the Lean philosophy was determined using a Lean positioning map, as shown in Fig. 3. The horizontal axis of the map represents the average implementation of Lean practices, and the vertical axis represents the percentage level of Lean implementation (LIL).

The minimum expected and acceptable value is 60%. In fact, a company that is in the early stages of implementing Lean manufacturing must achieve at least a 60% Lean implementation level.

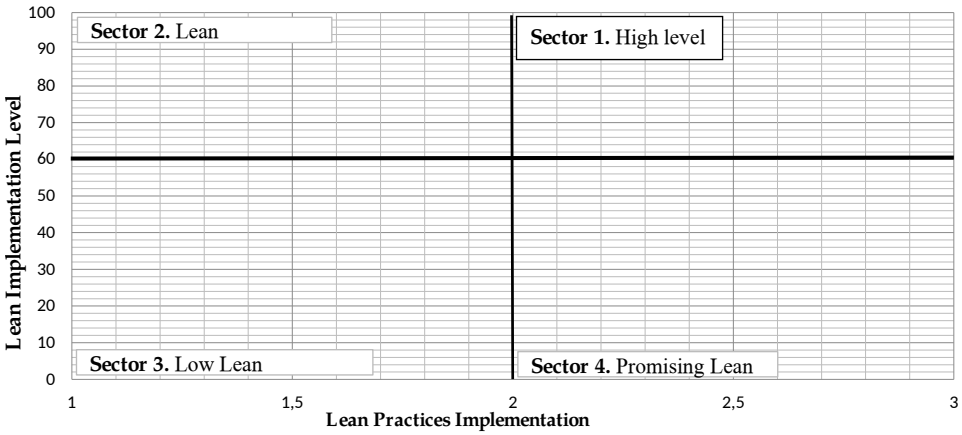

Fig. 3. Map of lean philosophy implementation positions Posada et al., 2010

Table 2
Lean Manufacturing practices and related questions

Lean practice	Definition of lean practice	Question number	Questions
Job rotation	Employees undergo training for positions requiring the skills necessary to replace an absent employee in emergency situations in order to avoid interruptions in work.	1	Employees undergo training in performing various tasks so that in emergency situations, such as absence, illness, death, or other emergencies, they can replace other employees and avoid interruptions in work.
		2	Employees have a high degree of flexibility in terms of rotation between different positions and functional areas.
5S – workplace organization	Employees undergo training in tasks requiring the ability to replace absent employees in emergency situations to avoid interruptions in work.	1	The workplace is safe, has good air quality, low noise levels, and standard lighting.
		2	Continuous cleaning and tidying of workplaces and facilities.
		3	Organizing tools and equipment in their place and removing unnecessary items from the workplace.
		4	Regular cleaning of machines, equipment, tools, racks, cabinets, and shelves.
		5	Create a storage area for broken, useless, or rarely used items.
			Use labels to mark locations, containers, boxes, shelves, and stored items, and use labels to clearly mark storage locations, materials, and products.
		6	Safety equipment and supplies are located in a designated area and are in good condition.
		7	The workplace is safe, has good air quality, low noise levels, and standard lighting.
Motivating, empowering, and supporting employees	Supporting and motivating all employees in a variety of ways: through a fair incentive system, moral support, and frequent meetings with all employees to listen to their problems and resolve them as far as possible, as well as involving them in the decision-making process and analyzing their ideas and suggestions for improving the company's operations and performance and the working environment, and giving them more responsibility for solving the problems they encounter at work.	1	Use an effective reward and incentive system to motivate and encourage employees.
		2	Organizing frequent meetings to listen to employees' problems and complaints and resolve them as far as possible.
		3	Involving employees in the process of continuous improvement of the company's activities and processes, and analyzing their ideas and suggestions in order to improve the company's performance.
		4	Empowering employees and giving them responsibility and opportunities to participate in decision-making to improve working conditions and company performance.
		5	High level of cooperation and commitment from all company employees.

Table 2 continued at the next page

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Lean practice	Definition of lean practice	Question number	Questions
Preventive maintenance (PM)	Periodic preventive maintenance of machines, equipment, and tools in the workplace, as well as planning and performing maintenance activities by the employees themselves to maintain, clean, and lubricate machines, and creating a maintenance log to record machine maintenance dates and breakdowns and continuously update data.	1	The existence of a well-planned preventive maintenance schedule covering the cleaning, lubrication, and maintenance of equipment and tools, machines, devices, and tools.
		2	Assigning employees responsibility for the daily preventive maintenance of their machines.
		3	Ensuring documentation of maintenance and equipment failures in the workplace and quality control checklists for each machine.
Visual management system	Using information displays, visual controls, labels and signs, color coding, directional signage, safety signs, and other markings instead of written instructions.	1	Use of safety signs to prevent accidents at work and clearly mark safety equipment.
		2	Use of labels to identify all processes, machines, and equipment, and marking of electrical switches to turn off each piece of equipment.
		3	Placing warning signs in necessary and dangerous areas, e.g., no entry and no smoking.
		4	Use clear and visible signs indicating the emergency exit.
		5	Placing labels to clearly mark all workstations and offices.
Poka-Yoke Techniques	Devices that detect and signal errors and defects to prevent them from being passed on to the next operation, such as control devices. These can be mechanical, electrical, visual, procedural, human, or other devices that prevent the process from being performed incorrectly.	1	The use of efficient devices and mechanisms to detect errors in the workflow (defects, mistakes), monitor and control factors causing quality problems.
		2	Quality checks at every stage of production by each operator and the use of control systems that provide immediate feedback.
Standardization and simplification of work	Each operator performs the operation in the same way, at a predetermined time and in the best possible way, so that the variation in activities is reduced and they are always performed in the same way to achieve the highest possible degree of consistency and reliability.	1	Develop a master record of all standard operating procedures and update it regularly by introducing improvements and making it available in all workplaces. (In the case of computers, a backup copy is available).
		2	Simplify work procedures and the stages of operations and processes as much as possible.
		3	Standardize and simplify non-production activities.

Table 2 continued at the next page

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Lean practice	Definition of lean practice	Question number	Questions
Kaizen Team	The company has a continuous improvement team – the Kaizen Team, which consists of company management and employees who meet regularly to analyze problems related to the production process and propose solutions and ideas aimed at improving the company's performance by reducing or eliminating various types of waste, such as defects, work in progress, utilization of employee potential, and reduction of waiting times and any activities that do not add value to the product and the customer.	1	The existence of a continuous improvement team, composed of management and employees, to discuss and propose ideas for improvements and make decisions regarding workplace improvements.
		2	The existence of a culture of continuous improvement within the company in order to continuously improve work.
		3	The improvement team often organizes problem-solving meetings, monitors progress in improving work, analyzes employee suggestions, and implements the best ones to improve work.
Teamwork	Teamwork increases work efficiency and improves the work environment, leading to a strong spirit, motivation, and cooperation among all employees.	1	A high percentage of the company's work is performed by teams.
		2	Teams work together, performing their tasks in a spirit of cooperation and with a high level of commitment.
		3	Each employee in the team knows their responsibilities and, if necessary, changes tasks within the team.
Multitasking staff	Employees are able to perform more than one task on the production floor and are willing to adapt to new tasks and responsibilities in order to better cope with changing market needs. This requires a greater emphasis on training and the development of long-term and committed employee relationships in order to align employee skills and competencies with the organization's strategy.	1	Employees have the opportunity to perform multiple tasks throughout the company.
		2	Employees are flexible, allowing them to adapt to new technologies and changing work methods.

The calculated Lean Implementation Level (LIL) allows companies to be placed into four sectors and categories according to their relative position and qualitative Likert scale based on assessment, as shown in Fig. 3. Companies in sector 1 are very well positioned in terms of implementing the ten Lean practices, while companies in sector 2 have poor Lean performance and deficiencies in implementing the ten Lean practices. On the other hand, companies between sectors 3 and 4 and below 60% have room for improvement. The detailed sectors of the position map are as follows:

Sector 1. High level of lean implementation: a company will be considered to have a high level of lean implementation if it implements between 2 and 3 lean practices and achieves lean results between 60% and 100%. This means that the company has successfully implemented the lean philosophy in its processes and activities and has very good opportunities to compete in the markets.

Sector 2. Lean implementation: a company will be considered a Lean company if it implements Lean practices at a level of 1 to 2 and achieves Lean performance between 60% and 100%. The concern with this company, then, is that it has not fully implemented the process improvements required by Lean Manufacturing procedures.

Sector 3. Low Lean Implementation: A company will be considered a low Lean company if its Lean implementation is between 1 and 2 and its Lean performance is below 60% of the desired minimum. This company has adopted some Lean practices but needs to do a lot of work to change and improve its processes and activities to improve Lean performance.

Sector 4. Promising lean implementation: A company will be considered a promising lean company if its lean implementation is between 2 and 3 and its lean performance is below the minimum desired lean level (60%). This means that the company is implementing lean practices in its processes and activities, but lean performance is not yet fully satisfactory, or the company has not yet begun an in-depth assessment of its lean performance. However, this company has a promising future if it continues its improvement programs.

Step 5: Assess the level of lean practice implementation using the percentage scoring method:

Percent Point Score method (Saini & Singh, 2020) is used to calculate the level of implementation of lean practices in each section of the map based on data from a Likert scale questionnaire.

$$\text{Total number of points } (\text{TPS}_i) = \sum N_i \times S_i = A \times 1 + B \times 2 + C \times 3 \quad (3)$$

$$\text{Percentage result } (\text{PPS}_i) = \text{TPS}/(n \times 3). \quad (4)$$

where: N_i is the number of responses, S_i is the Likert scale, N = number of SMEs, i = number of lean practices, j = types of lean waste, 3 indicates the Likert scale used.

Step 6: Development of a matrix of the impact of lean practices on waste:

First, lean practices related to each type of lean waste were identified to create the basis for the impact matrix (Table 3).

Table 3
General description of the eight types of waste, adopted by the author based on the following sources (Rajpurohit, 2017; Nwanya & Oko, 2019, Enaghani et al., 2009; Caldera et al., 2019; Amin, 2013; Soni & Narkhede, 2017)

Lean-related waste	Description	Causes of waste	Related lean practices
Overproduction	Producing more products than necessary, without taking into account demand, or producing faster than necessary.	Unstable schedule, batch production, bottlenecks, large batch sizes, unbalanced cells, poor information flow, and inaccurate demand information.	Kaizen team.
Unnecessary inventory	Delays in product or information delivery and excessive warehousing lead to excessive inventory, such as work in progress (WIP) and finished goods inventory, resulting in high product storage costs and poor customer service.	Long changeover times, large batch sizes, high raw material inventories, high work in process (WIP) inventories, high finished goods inventories, warehouse inventories, and excessive management decisions.	Kaizen team, workplace organization, standardization, and simplification of work.

Table 3 continued at the next page

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Lean-related waste	Description	Causes of waste	Related lean practices
Waiting	Long periods of inactivity for machines, people, and products.	Part shortages, downtime, rework time, long lead times, long downtime, and unreliable processes.	Preventive maintenance (PM), workplace organization, Kaizen team, standardization, and simplification of work.
Excessive transport	Excessive flow of materials, people, and products, resulting in high costs and wasted time.	Inappropriate use of space, inadequate layout, distances traveled by operators, reverse material flow, large batches, damage during transport, and multiple storage locations.	Workplace organization, Kaizen team, job rotation, visual management system,
Disadvantages	Frequent errors in documentation, materials, and problems with the quality of end products, resulting in the need for rework and/or scrapping, and poor delivery performance.	Low employee engagement, inadequate training, low process efficiency, limited knowledge of processing, poor communication, lack of skills, excessive work in progress, and operator errors.	Pokayoke, standardization and simplification of work, workplace organization, teamwork, preventive maintenance, multi-skilled employees, Kaizen team, employee engagement and empowerment.
Inefficient movements	Imperfections in process design that cause operators to waste a lot of time on unnecessary movements related to process handling.	Multiple handling, low productivity, operator downtime, large batches, inadequate layout, inadequate method design, and inadequate workplace organization.	Workplace organization, standardization and simplification of work, visual management system, job rotation, Kazien team.
Inappropriate processing	Spending more time or effort than necessary on processing a product or responding to customer communications, mainly due to the use of inappropriate procedures, tools, or systems.	Misunderstanding of quality requirements, unnecessary systems, inadequate process design, and unclear standards or specifications for quality acceptance.	Workplace organization, standardization and simplification of teamwork, Kaizen team, multi-skilled employees.
Underutilization	Failure to utilize the potential of employees' skills due to lack of training, motivation, or inspiration.	Inappropriate working conditions, inadequate training, and inappropriate task assignment.	Kaizen team, multi-skilled workers, job rotation, motivation, empowerment and support for employees, teamwork.

The matrix of relationships between lean practices and waste was developed based on Table 4, which explains the impact of each lean practice on reducing or eliminating lean waste for each category of companies by marking ($\surd$).

This matrix was then used as the basis for developing a matrix of the impact of lean practices on lean waste. The level of implementation of lean practices, presented in the results of the percentage analysis (PPS%), was included in the matrix as an impact scale (Table 5), and the total impact of the implementation of each lean practice on the eight types of Lean Manufacturing waste was determined.

Step 7: Proposal for an action plan " " for process improvement

An action plan for process improvement in the dairy industry has been proposed to help companies continuously improve their processes and operations in order to remain competitive in the market.

Application

The proposed methodology was implemented in the dairy industry, and dairy companies in Baghdad were selected as a practical example. Information on these

Table 4
Matrix of relationships between lean practices and lean waste

Waste in lean Lean practices	Defects	Inventory	Overproduction	Movement	Underutilization	Excessive processing	Transport	Waiting
Job rotation				√	√		√	
Workplace organization	√	√		√	√	√	√	√
Motivation	√				√			
Preventive maintenance	√							√
Visual management system				√			√	
Poka Yoka techniques	√							
Standardization work	√	√		√	√	√		√
Kaizen team	√	√	√	√	√	√	√	√
Teamwork	√				√	√		
Multi-skilled employees	√				√	√		
Frequency	8	3	1	5	7	5	4	4

Table 5
Impact scale

Level of implementation Lean practices	Impact on waste	Definition
1–20	1	Very little impact of practices on waste volume
21	3	Practice has a slight impact on the amount of waste
41	5	Medium impact of the practice on the amount of waste
61	7	High impact of the practice on the amount of waste
81	10	Very high impact of practices on waste generation

companies was obtained from the Industrial Development Office and the Iraqi Industrial Union. After rejecting companies that had ceased operations, 45 medium-sized dairy companies registered with both offices were included. A lean questionnaire was developed and completed by these companies in two ways: in person during interviews with the managers of these companies, and via social media, using the WHATSAPP application and the official email addresses of these companies, where the questionnaire was sent in Microsoft Word format to make it easier for managers to complete, and then returned in the same way. Unfortunately, 15 companies refused to cooperate, 5 companies did not return the questionnaire after two months of waiting and constant reminders to complete it, and 5 companies returned incomplete answers to the questions in the questionnaire, so they were omitted. Twenty questionnaires with completed answers were returned, representing 45% of the company population, and the response rate is acceptable for research in the case of a homogeneous sample (same industry).

Results and discussion

Finally, the 20 completed questionnaires were analyzed using Cronbach's Alpha test to check the reliability and consistency of the responses, where the value (α) for all lean practices exceeds the acceptable value (Table 6).

Table 6
Cronbach's Alpha coefficient for lean practices

Lean practice	Cronbach's Alpha coefficient
Job rotation	0.74
Workplace organization	0.75
Motivating and empowering employees	0.77
Preventive maintenance (PM)	0.74
Visual management system	0.7
Poka Yoke techniques	0.7
Work on standardization and simplification	0.7
Kaizen team	0.72
Teamwork	0.78
Flexible/multitasking staff	0.77

The Lean Implementation Level (LIL) was calculated using equation 1, and the Lean Practice Implementation (LPI) was determined using equation 2 (Table 7), taking into account the answers provided in the questionnaire, where these calculations were used to place dairy companies on a map of Lean Manufacturing philosophy implementation. Companies 2, 14, and 19 were classified as companies with a high level of lean implementation according to the calculations, while the remaining companies were classified in sector 4 as promising companies in terms of implementing Lean Manufacturing practices (Fig. 4).

The level of implementation of Lean practices in companies with a high degree of Lean implementation located in sector 1 and in companies with high Lean implementation potential located in sector 4 on the positioning map was calculated using the percentage scoring method (Table 8 and Table 9). The Lean practice of preventive maintenance was classified as the practice with the highest level of implementation in companies with a high level of Lean implementation, where the level of implementation is 92% (Table 8), and at the same time is the second most frequently used practice in promising companies (Table 9) with an implementation level of 83.63%. This means that the dairy companies surveyed periodically perform preventive maintenance of machines, equipment, and tools in the workplace and involve the employees themselves in the maintenance, cleaning, and lubrication of machines, recording the dates of maintenance and machine failures and constantly updating the data. Motivating, empowering, and supporting employees was identified as the least frequently used lean practice, with an implementation level of 70.4%, as shown in Tab. 8, and at the same time, it is the least frequently used practice in promising companies, with a level of 68.58% (Tab. 9), indicating that dairy companies have neglected the role of employees in decision-making related to work improvement, have not listened to their complaints about working conditions, and have not introduced a fair incentive system.

The level of implementation of lean practices in sectors with high and promising potential was compared, as shown in Figure 5, where ten lean practices in companies located in the sector with high lean potential were implemented more effectively than in companies from the sector with promising lean potential.

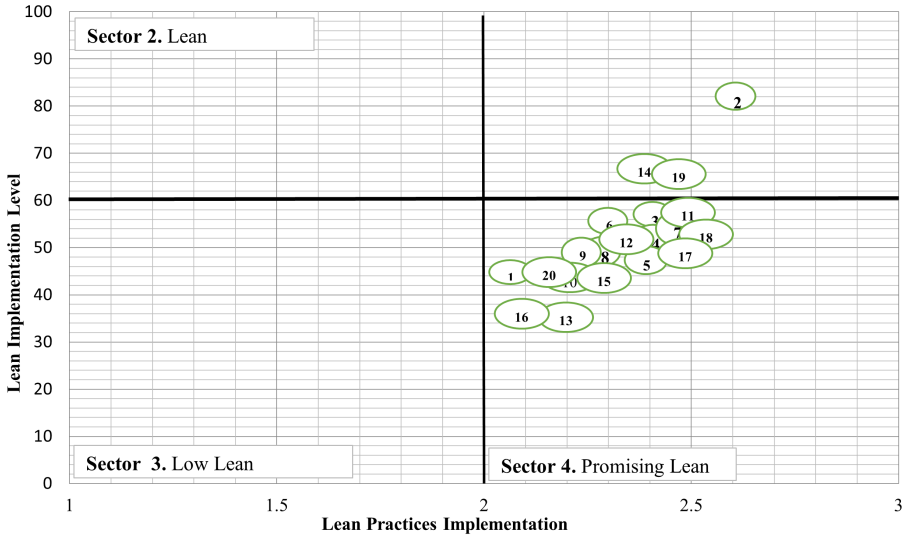

Fig. 4. Positioning of dairy companies in relation to the implementation of the Lean philosophy

Table 7
Calculations of lean implementation level Implementation practice

Company	Likert scale			Lean implementation level (LIL)	Lean practice implementation (LPI)
	C	B	A		
	3	2	1		
1	8	24	4	44	2.1
2	24	11	1	79	2.6
3	21	10	5	58	2.4
4	18	14	4	58	2.4
5	16	14	6	47	2.3
6	14	19	3	57	2.3
7	20	11	5	57	2.3
8	15	16	5	50	2.3
9	18	12	6	50	2.3
10	12	18	6	42	2.2
11	21	10	5	58	2.4
12	15	18	3	58	2.3
13	17	10	9	36	2.2
14	16	18	2	64	2.4
15	15	15	6	46	2.3
16	12	17	7	38	2.1
17	12	22	2	58	2.3
18	18	14	4	58	2.4
19	15	19	2	63	2.4
20	14	16	6	44	2.2

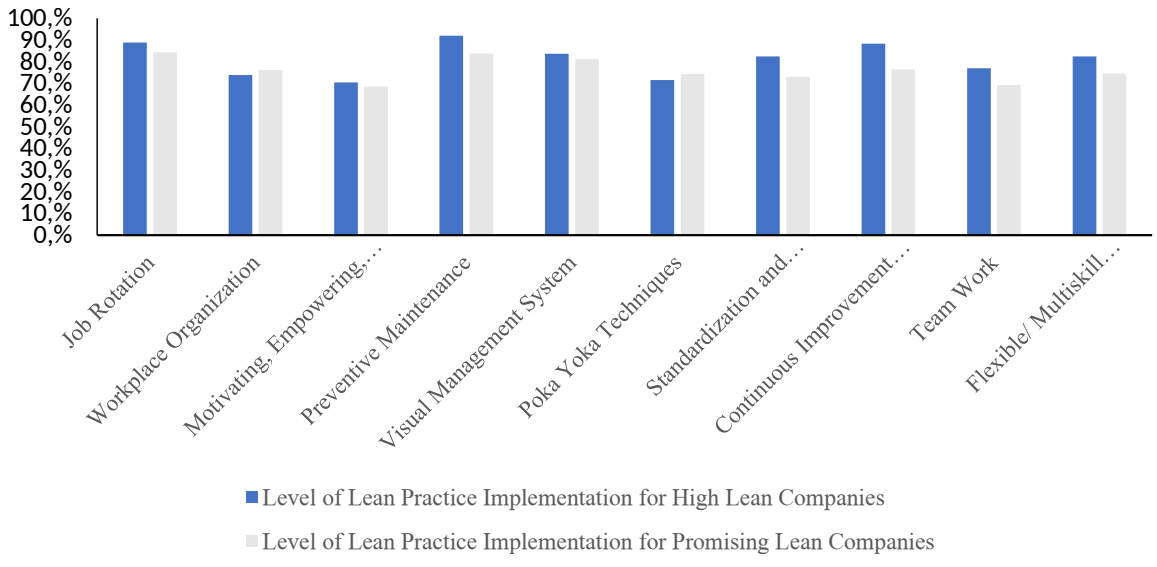

Fig. 5. Comparison of the level of implementation of lean practices

The matrix of the impact of lean practices on waste in companies with a high level of lean and companies with a promising level of lean was developed taking into account both the matrix of lean practices – lean waste and the results from Tab. 8 and Tab. 9 by transforming the results into an impact scale. Ten lean practices have the greatest impact on reducing waste caused by defects and the least impact on waste caused by overproduction (Table 10 and Table 11).

The impact of implementing lean practices on eight types of waste was compared (Fig. 6). Ten lean practices have a greater impact on reducing waste in companies with a high level of lean than in companies with a promising level of lean.

An action plan was proposed to improve dairy production processes (Table 12), which is intended to help companies continuously improve their processes in accordance with lean principles. The action plan suggests improvement measures through the implementation of lean practices related to each type of lean waste (Table 4), a matrix of the relationship between lean practices and waste.

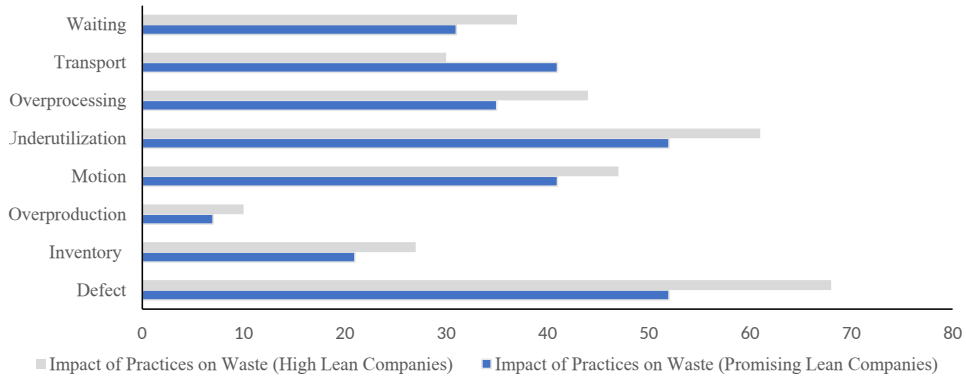

Fig. 6. Impact of lean practices on waste

Table 8
Assessment of the level of implementation of lean practices (sector 1: high level of lean)

2.14.19	Questions	Number of N_i responses for each Likert scale S_i			TPS $(N_i * S_i)$	Level of implementation $(N_i * S_i)/(n * 3)$	Level of adoption of Lean practices	Average level of adoption of Lean practices Average level of PPS%	Ranking
Lean practice		1	2	3					
		A	B	C					
Job rotation	1	0	1	2	8	$8/9 = 0.88$	88	88.8	2
	2	0	1	2	8	$8/9 = 0.88$	88		
Workplace organization	1	0	3	0	6	$6/9 = 0.66$	66	73.8	8
	2	0	1	2	8	$8/9 = 0.88$	88		
	3	0	1	2	8	$8/9 = 0.88$	88		
	4	0	1	2	8	$8/9 = 0.88$	88		
	5	1	2	0	5	$5/9 = 0.55$	55		
	6	1	2	0	5	$5/9 = 0.55$	55		
	7	0	2	1	7	$7/9 = 0.77$	77		
Motivating, empowering, and supporting employees	1	1	2	0	5	$5/9 = 0.55$	55	70.4	10
	2	0	2	1	7	$7/9 = 0.77$	77		
	3	1	2	0	5	$5/9 = 0.55$	55		
	4	0	2	1	7	$7/9 = 0.77$	77		
	5	0	1	2	8	$8/9 = 0.88$	88		

Table 8 continued at the next page

Table 8 continued from the next page

2.14.19 / Lean practice	Questions	Number of N_i responses for each Likert scale S_i			TPS $(N_i * S_i)$	Level of implementation $(N_i * S_i)/(n * 3)$	Level of adoption of Lean practices	Average level of adoption of Lean practices Average level of PPS%	Ranking
		1	2	3					
		A	B	C					
Preventive maintenance	1	0	1	2	8	$8/9 = 0.88$	88	92.0	1
	2	0	1	2	8	$8/9 = 0.88$	88		
	3	0	0	3	9	$9/9 = 1.00$	100		
Visual management system	1	0	1	2	8	$8/9 = 0.88$	88	83.6	4
	2	0	2	1	7	$7/9 = 0.77$	77		
	3	0	1	2	8	$8/9 = 0.88$	88		
	4	0	1	2	8	$8/9 = 0.88$	88		
	5	0	2	1	7	$7/9 = 0.77$	77		
Poka Yoka techniques	1	0	1	2	8	$8/9 = 0.88$	88	71.5	9
	2	1	2	0	5	$5/9 = 0.55$	55		
Work related to standardization and simplification	1	0	1	2	8	$8/9 = 0.88$	88	82.5	5
	2	0	2	1	7	$7/9 = 0.77$	77		
	3	0	2	1	7	$7/9 = 0.77$	77		
	4	0	1	2	8	$8/9 = 0.88$	88		
Continuous improvement – Kaizen	1	0	0	3	9	$9/9 = 1.0$	100	88.3	3
	2	0	1	2	8	$8/9 = 0.88$	88		
	3	0	2	1	7	$7/9 = 0.77$	77		
Teamwork	1	0	3	0	6	$6/9 = 0.66$	66	77	7
	2	0	1	2	8	$8/9 = 0.88$	88		
	3	0	2	1	7	$7/9 = 0.77$	77		
Flexible/multi-tasking workforce	1	0	2	1	7	$7/9 = 0.77$	77	82.5	6
	2	0	1	2	8	$8/9 = 0.88$	88		

Table 9
Assessment of the level of implementation of lean practices (sector 4: promising lean)

1,3,4,5,6,7,8,9,10, 11,12,13 15,16,17,18,20 / Lean practice	Questions	Number of N_i responses for each Likert scale S_i			TPS $(N_i * S_i)$	Level of implementation $(N_i * S_i)/(n * 3)$	Level of adoption of Lean practices	Average level of adoption of Lean practices Average level of PPS%	Ranking
		1	2	3					
Job rotation	1	0	8	9	43	$43/51 = 0.843$	84.3	84.3	1
	2	0	8	9	43	$43/51 = 0.843$	84.3		
Workplace organization	1	0	5	12	46	$46/51 = 0.901$	90.1	76.12	5
	2	1	10	6	39	$39/51 = 0.764$	76.4		
	3	3	6	8	39	$39/51 = 0.764$	76.4		
	4	1	5	11	44	$44/51 = 0.862$	86.2		
	5	5	11	1	30	$30/51 = 0.588$	58.8		
	6	2	9	6	38	$38/51 = 0.745$	74.5		
	7	4	7	6	36	$36/51 = 0.705$	70.5		

Table 9 continued at the next page

Table 9 continued from the previous page

1,3,4,5,6,7,8,9,10, 11,12,13 15,16,17,18,20	Questions	Number of N_i responses for each Likert scale S_i			TPS $(N_i * S_i)$	Level of implementation $(N_i * S_i)/(n * 3)$	Level of adoption of Lean practices	Average level of adoption of Lean practices Average level of PPS%	Ranking
Lean practice		1	2	3					
Motivating, empowering, and supporting employees	1	1	9	7	40	$40/51 = 0.784$	78.4	68.58	10
	2	5	9	3	32	$32/51 = 0.627$	62.7		
	3	3	12	2	33	$33/51 = 0.647$	64.7		
	4	3	9	5	36	$36/51 = 0.705$	70.5		
	5	6	5	6	34	$34/51 = 0.666$	66.6		
Preventive maintenance	1	0	6	11	45	$45/51 = 0.882$	88.2	83.63	2
	2	2	4	11	43	$43/51 = 0.843$	84.3		
	3	2	7	8	40	$40/51 = 0.784$	78.4		
Visual management system	1	3	7	7	38	$38/51 = 0.745$	74.5	81.14	3
	2	1	3	13	46	$46/51 = 0.901$	90.1		
	3	1	6	10	43	$43/51 = 0.843$	84.3		
	4	5	4	8	37	$37/51 = 0.725$	72.5		
	5	1	6	10	43	$43/51 = 0.843$	84.3		
Poka Yoka techniques	1	3	4	10	41	$41/51 = 0.803$	80.3	74.45	6
	2	3	10	4	35	$35/51 = 0.686$	68.6		
Work related to standardization and simplification	1	2	10	5	37	$37/51 = 0.725$	72.5	72.97	8
	2	3	5	9	40	$40/51 = 0.784$	78.4		
	3	2	6	9	41	$41/51 = 0.803$	80.3		
	4	7	6	4	31	$31/51 = 0.607$	60.7		
Continuous improvement – Kaizen	1	3	6	8	39	$39/51 = 0.764$	76.4	76.40	4
	2	0	12	5	39	$39/51 = 0.764$	76.4		
	3	3	6	8	39	$39/51 = 0.764$	76.4		
Teamwork	1	5	8	4	33	$33/51 = 0.647$	64.7	69.23	9
	2	3	8	6	37	$37/51 = 0.725$	72.5		
	3	3	9	5	36	$36/51 = 0.705$	70.5		
Flexible/multi-tasking workforce	1	0	7	8	38	$38/51 = 0.745$	74.5	74.50	7
	2	3	7	7	38	$38/51 = 0.745$	74.5		

Table 9 continued at the next page

Table 10
Matrix of the impact of lean practices on waste (high level of Lean Manufacturing)

Waste Lean practices	Defects	Inventory	Overproduction	Movement	Underutilization	Excessive processing	Transport	Waiting
Job rotation				10	10		10	
Workplace organization	7	7		7	7	7	7	7
Motivating, empowering, and supporting employees	7				7			
Preventive maintenance	10							10

Table 10 continued at the next page

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Waste Lean practices	Defects	Inventory	Overproduction	Movement	Underutilization	Excessive processing	Transport	Waiting
Visual management system				10			10	
Poka Yoka techniques	7							
Work on standardization and simplification	10	10		10	10	10		10
Kaizen Team	10	10	10	10	10	10	10	10
Teamwork	7				7	7		
Multi-skilled employees	10				10	10		
Frequency of implementation	8	3	1	5	7	5	4	4
Impact of practices on waste	68	27	10	47	61	44	30	37
Ranking	1	7	8	3	2	4	6	5

Scale of the impact of Lean practices on waste; Strong = 10, Moderate = 5, Weak = 1

Table 11
Matrix of the impact of Lean practices on waste (promising Lean)

Waste Lean practices	Defects	Inventory	Overproduction	Movement	Underutilization	Excessive processing	Transport	Waiting
Job rotation				10	10		10	
Workplace organization	7	7		7	7	7	7	7
Motivating, empowering, and supporting employees	7				7			
Preventive maintenance	10							10
Visual management system				10			10	
Poka Yoka techniques	7							
Work on standardization and simplification	7	7		7	7	7		7
Kaizen Team	7	7	7	7	7	7	7	7
Teamwork	7				7	7		
Multi-skilled employees	7				7	7		
Frequency of implementation	8	3	1	5	7	5	4	4
Impact of practices on waste	52	21	7	41	52	35	41	31
Ranking	1	7	8	3	2	5	4	6

Scale of the impact of Lean practices on waste; Strong = 10, Moderate = 5, Weak = 1

Table 12
Action plan for improving dairy processes through Lean Manufacturing practices

Lean-related waste	Lean practice	Improvement measures
Defect	Workplace organization	Removal of residues, contaminated materials, and unnecessary tools to avoid errors during processes, e.g., regular cleaning of residues from pasteurization equipment to prevent contamination and conducting weekly routine inspections for early detection of signs of equipment or tool failure.
	Employee motivation and empowerment	Establish a reward system for employees for early detection of defects or potential sources of defects, especially in key processes, by encouraging and motivating quality control teams.
	Preventive maintenance	Introduce daily or weekly routine maintenance activities to ensure the proper and trouble-free operation of machinery and equipment, giving priority to equipment that is critical to product quality, such as pumps, valves, and sensors in homogenizers and pasteurizers, in order to maintain accuracy.
	Poka-Yoke techniques	Installation of an automatic quality control station at multiple stages of the production process.
	Standardization and simplification work	Develop clear step-by-step instructions for each production process to ensure accuracy and consistency, and regularly update standard operating procedures (SOPs) based on feedback or in the event of changes to equipment or processes, using visual aids.
	Kaizen team	Develop training on the latest techniques for detecting, identifying, and preventing defects, as well as training on Kaizen principles and tools such as PDCA cycles and root cause analysis.
	Teamwork	Motivate teamwork as a way to prevent defects.
	Multi-skilled employees	Training employees to perform multiple tasks, routine maintenance of key equipment, and assigning highly skilled employees to key processes.
Inventory	Workplace organization	Removing excess and currently unnecessary items and inventory from the workplace, regularly removing spoiled or contaminated products, and keeping the warehouse clean. Establishing standard inventory management procedures to prevent shortages or excess inventory, and labeling dairy product batches with the date of manufacture to ensure proper delivery from oldest to newest.
	Standardization and simplification work	Implementation of a "first in, first out" (FIFO) system to reduce spoilage of milk and various dairy products.
	Kaizen team	Identifying potential causes of inventory waste by regularly reviewing data such as expiration rates, inventory levels, and storage conditions.
Overproduction	Kaizen Team	Providing accurate demand forecasts tailored to customer needs in order to achieve sales success and avoid unnecessary processing costs.
Movement	Job rotation	Studying employee time and movement by observing and recording movements, especially in key production processes such as milk processing, homogenization, quality control stations, and packaging, as well as reducing employee fatigue by implementing daily or weekly employee rotation plans to change tasks requiring different levels of physical activity or intense movement, and involving employees in analyzing the inefficiencies of their movements to improve workflow.
	Workplace organization	Organize the workplace to optimize workflow and reduce unnecessary or inefficient movements by removing unused or rarely needed items to simplify the workspace, and ergonomically arrange materials and tools to minimize unnecessary walking, reaching, or bending, e.g., placing milk hoses, filters, and nozzles near pasteurization equipment to reduce unnecessary searching and walking. In addition, daily cleaning of filling stations to remove spilled materials that may hinder employee movement.

Table 12 continued at the next page

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Lean-related waste	Lean practice	Improvement measures
	Visual management system	Quickly direct employees to the right equipment or tools without having to search, and assign different colors to tools and equipment used in specific processes, e.g., blue for pasteurization, green for homogenization, use wall colors or floor markings to distinguish between operational areas, such as finished product storage and raw material handling, marking equipment with clear, color-coded labels to indicate maintenance status, e.g., color-coding milk transport hoses, which reduces movement-related losses by enabling employees to quickly find the right hose for specific tanks. Additionally, displaying the progress of pasteurization batches on visual screens to minimize movement to the control room for up-to-date information.
	Poka-Yoke Techniques	Installing sensors or cameras to detect defective products, such as milk cartons with incorrect printing, installing audible or visual alarms to alert employees to problems without the need for manual inspection, using rejection mechanisms such as rejection chutes to automatically reject defective items into a reject bin to reduce manual handling, using automatic sensors to monitor levels, such as level sensors in milk storage tanks, to notify workers when refilling is necessary, eliminating unnecessary monitoring movements.
	Standardization and simplification work	Develop and document standard operating procedures (SOPs) for key tasks such as milk filling, milk pasteurization, packaging, and cleaning processes to ensure that all employees follow the same procedure. Use of visual step-by-step guides posted at workstations to ensure consistency in task performance. In addition, training employees in standard methods to eliminate variability in movements and improve efficiency.
	Kaizen Team	Observe and analyze employee movements on the production floor to identify inefficient and unnecessary movements and create detailed process maps to visualize workflow and identify areas of excessive movement. Analyze movements and time using video recordings to analyze and evaluate repetitive tasks to find ways to minimize movements.
Underutilization	Job rotation	Use a map of current employee skills to identify underutilized employees, rotate employee roles to develop new skills and maintain employee engagement.
	Workplace organization	Simplifying processes to allow employees to focus on skill-intensive tasks, optimizing workplace layout, creating a work environment that improves productivity and pride in skill utilization, developing standard procedures that allow employees to effectively utilize their skills in different areas of the business.
	Motivation and empowerment of employees	Empowering employees and involving them in decision-making, process improvement, suggestion reporting, problem-solving initiatives, and other improvement activities. Building a motivating work environment that inspires employees to make the most of their skills and establishing a skills-based incentive system.
	Standardization and simplification of work	Creating detailed standard operating procedures (SOPs) for key tasks to reduce complexity and allow employees to focus on using their skills effectively, such as on-site cleaning, milk pasteurization, homogenization, and packaging. Eliminating unnecessary steps in the process to free up employees and allow them to focus on higher-value tasks. Assign tasks to employees based on their skills. Involve employees in improving and reviewing standard operating procedures (SOPs) and workflows.
	Kaizen Team	Creating skill-based kaizen teams to leverage the diverse knowledge and skills of employees. Encouraging employees to share ideas and solutions based on their expertise and implementing a continuous improvement system based on collecting and evaluating employee ideas. Focusing on developing multi-skilled employees

Table 12 continued at the next page

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Lean-related waste	Lean practice	Improvement measures
	Teamwork	Create a collaborative environment that encourages employees to freely share ideas and solutions and participate in decision-making.
	Multi-skilled employees	Training employees in multiple tasks to enhance their skills and developing a skills matrix to categorize and analyze employee and process skills and identify gaps in areas requiring additional training. Rewarding and encouraging employees who develop and apply diverse skills.
Excessive processability	Workplace organization	Eliminating unnecessary elements to streamline processes. Organizing equipment and tools to reduce labor and time. Creating consistent processes to avoid errors and process repetition.
	Working on standardization and simplification	Establishing consistent specifications, procedures, and workflows to reduce rework and variability, and simplifying workflows by eliminating unnecessary processes to reduce effort, time, and redundancy.
	Kaizen Team	Identifying root causes to analyze why unnecessary processes or rework occur by developing feedback loops and engaging a variety of experts to uncover ideas and solutions for improvement.
	Teamwork	Assign specific areas for improvement to each team and hold regular meetings to share insights and opinions, review and implement suggestions, and identify and eliminate causes of waste resulting from overprocessing in different departments.
	Multi-skilled employees	Ensure a consistent skill level among employees and implement job rotation to improve productivity and skills. Encourage employees to submit process improvement suggestions during Kaizen events or team meetings.
Transport	Job rotation	Train employees to work in multiple areas, reduce unnecessary movement between departments, involve them in suggesting layout changes or enable them to combine multiple processes near their workstation, and use digital transportation systems such as AGVs to automate transportation or RFID to track material flow.
	Workplace organization	Optimizing the layout to ensure that raw materials and tools are stored close to where they are used
	Visual management system	Use arrows or labels, directional signs to provide clear visual cues that optimize material flow and minimize unnecessary transport, and standardize and optimize transport routes.
	Kaizen team	Promoting a culture of continuous improvement by solving problems as a team, mapping and analyzing current transport processes, changing the layout of the workplace to optimize material flow, and standardizing transport routes.
Expectation	Workplace Organization	
	Preventive maintenance	Implementing predictive maintenance to minimize machine downtime and waiting for repairs.
	Standardization and simplification work	Creating standard working times and standardizing workflows to develop consistent processes
	Kaizen team	Encouraging continuous improvement and teamwork in problem solving to identify, analyze, and eliminate bottlenecks, especially in critical processes, and to continuously review and simplify work procedures.

Conclusions

Lean Manufacturing philosophy practices can be considered an effective tool for reducing or eliminating the eight types of lean waste. Lean philosophy practices have been successfully implemented in large companies, but their implementation in small and medium-sized enterprises remains unclear. This article develops a lean assessment model to examine the level of adoption of lean philosophy practices in medium-sized enterprises, selecting the dairy industry as the most dynamic and developed sector. The lean position map was implemented as a benchmarking tool to examine and understand the level of implementation of ten lean practices in the processes and activities of twenty dairy companies located in Baghdad. The lean position map provided a clear picture of the level of adoption of these practices in these companies, which were divided into two sectors of the map, namely high and promising lean implementation, with a level of implementation of practices between 70 and 90% for companies with a high level of lean implementation and between 68 and 84% for companies with a promising level of lean implementation. Preventive maintenance is the practice most widely implemented in companies with a high level of lean implementation, while job rotation is the practice most widely implemented in companies with a promising level of lean implementation. A matrix of the impact of lean practices on waste was developed to assess the impact of implementing ten lean practices on reducing lean waste, with the results showing that these practices have the greatest impact on waste related to defects and the least impact on waste related to overproduction, both in companies with a high level of lean implementation and in promising companies. An action plan has been proposed to improve processes in the dairy industry to help such industries in their pursuit of lean. A limitation of this article is the difficulty in obtaining data from dairy companies. In the future, a model for analyzing and evaluating waste that integrates the Waste Assessment Matrix (WAM), QFD, lean position map, and scoring method could be proposed, with research on a larger number of lean practices in different industries.

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