# The application of lean tools in the food industry: a systematic review of the literature

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## Abstract

This paper seeks to identify the various applications of lean strategies in food companies through a systematic review of the literature between 2017 and 2021, since many authors affirm that the application of these strategies improves the efficiency of the process by eliminating waste and operations that do not generate added value.

According to the findings, a significant proportion of the retrieved articles (62%) are from European countries that address issues pertaining to sustainability, cost reduction, and waste management. This observation highlights the importance and focus of European countries towards adopting sustainable practices and reducing their ecological footprint. The prevalence of articles on this topic suggests that there is a growing interest in the region to develop innovative and practical solutions to environmental challenges. It also underscores the need for greater collaboration and knowledge-sharing among countries to foster sustainable development and reduce global environmental impact. The strategies found with broader applicability were lean six sigma, 5S and VSM.

## Keywords
Lean tools, food industry, systematic review.

## 1. Introduction
The concept of the term Lean encompasses a series of activities or solutions aimed at eliminating waste and non-value-added operations. The Massachusetts Institute of Technology was the first to use the term; however, it was the Japanese who initiated this production system. The latter created this system with the aim of reducing waste and optimizing resources (Manzouri et al. 2014).

The application of lean techniques and tools allows companies to become more profitable and flexible, as these tools satisfy customer demand on the highest possible level by reducing waste, taking into account human resource selections, design, production processes, and inventory or distribution activities, therefore, companies invest in implementing lean practices to remain competitive (Manzouri et al. 2014).

According to the United Nations Sustainable Development Plan for 2030 (2015), ending hunger by providing enough safe, affordable, and nutritious food and reducing food waste from production to consumption are two key objectives for the well-being of humanity and the planet conservation. Sustainable food waste management operations are

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regarded as an essential tool for transforming towards sustainable societies and human well-being (Ingrao et al. 2018). In the food industry, waste is generated, which should be utilized at different stages such as human resource selection within the production and operational process, waste reduction in production and design operations, and even in inventory or distribution activities. (Kazancoglu et al. 2021).

Therefore, different Lean tools can be found for this industry, which optimally cover every stage. Value Stream Mapping (VSM) is a useful tool to process a system that needs to "view the whole" and rethink functions to improve processes. It is also helpful to recognize any gaps between processes and improve performance after careful consideration (Henrique et al. 2016), 5S (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke) to ensure cleanliness and order in workstations (Baena et al. 2008), TPM (Total Productive Maintenance) for the maintenance of equipment used in the process (González Correa 2007), JIT (Just In Time) which focuses on final inventories at each stage of the process, SMED (Single Minute Exchange of Die - waste reduction) is implemented in the changeover times between product types in industries with multiple product lines, and Heijunka (production leveling) based on the method of production scheduling in the company (Cuggia-Jiménez et al. 2020).

The aim of this work is to provide a comprehensive overview of the various Lean tools that are utilized within the food industry. To achieve this objective, it is imperative to undertake a rigorous analysis of existing research and case studies, in order to identify the best practices and techniques for successful implementation of Lean manufacturing principles within the food industry. The application of Lean manufacturing practices has become increasingly relevant in the food industry, given the need for increased efficiency, reduced waste, and improved quality control. By providing a clear understanding of the key Lean tools and practices that are effective in the food industry, this study aims to facilitate the adoption of these strategies by food manufacturers, leading to improved operational efficiency, increased competitiveness, and better customer satisfaction. (Cuggia-Jiménez et al. 2020).

During the review, it was found that authors Cuggia-Jiménez et al. (2020), conducted a systematic review on Lean manufacturing in the food industry, specifically focusing on the bakery industry in Colombia.

## 2. Methodology

A systematic literature review was conducted to study "the improvement of food production through lean strategies." The database has been retrieved from Scopus and Web of Science. The following keywords were included in the search: TITLE-ABS-KEY (lean AND food).

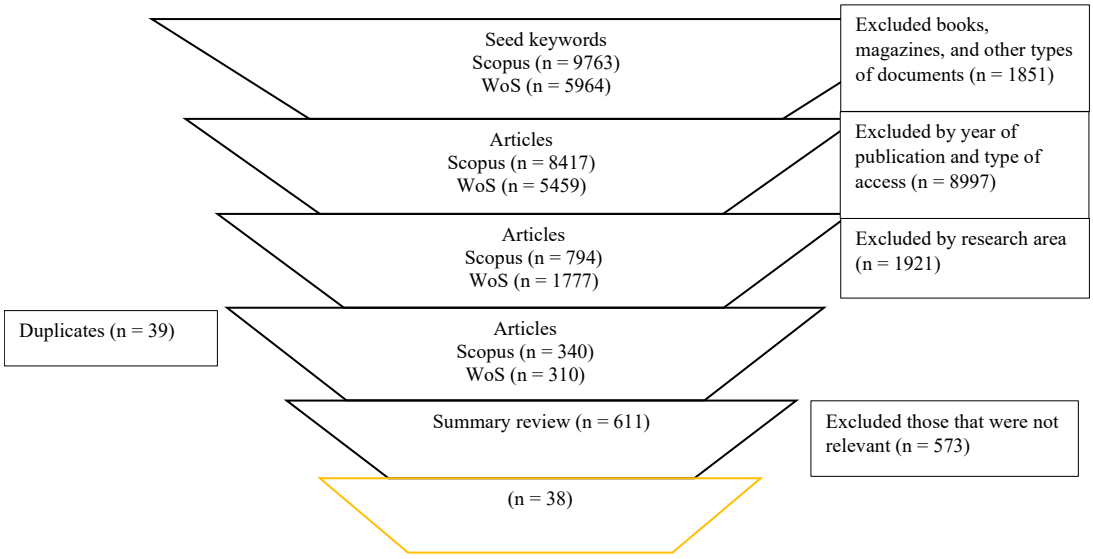


Figure 1. Prisma flow diagram

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As shown in Figure 1, we obtained a total of 15,727 publications from the databases, of which books, journals and other sources were excluded, resulting in a total of 1,851 studies being discarded.

We examined articles published between 2017 and 2021 that are publicly available, resulting in a total of 2,571 articles. Next, we filtered out 1,921 articles that are not related to our research area, using the filter of areas and topics of interest present in each database while maintaining a set criterion.

Table 1. Research areas

| Research areas |
|---|
| Economics. |
| Engineering. |
| Energy. |
| Business administration and accounting. |
| Business. |
| Scientific decision making. |

Then, using the Excel digital tool, duplicates per title were excluded, resulting in a total of 611 articles.

Finally, we determined the relevance of each article as we went through the headings. We excluded 480 articles based on this review, followed by an exclusion of 60 articles based on keywords. We detail below the keywords used.

Table 2. Keywords

| Keywords | Justification |
|---|---|
| “Food waste”, “Efficiency”, “Optimization”, “Innovation”, “Standardization” | Areas for improvement |
| “Lean manufacturing”, “Lean management”, “Lean six sigma”, “Lean green”, “Food supply chain”, “5S”, “VSM” | Applicable tools in the food industry |
| “Food production”, “Food products”, “Food companies”, “Food industry” | Targeting industry |

The "Areas for Improvement" section includes keywords which express a situation or context for improvement, standardization, and innovation in order to achieve beneficial changes in each case study. The following section, "Applicable tools in the food industry," refers to the implementation or application of procurement and lean tools used in the food sector. The third section, "Targeting industry", refers to interest in research in the food sector.

This review was completed by reading the abstracts, resulting in 38 articles. All these articles are in English language.

Through this exclusive analysis, we are seeking data to conduct qualitative and quantitative analyses such as place of publication, number of publications per year, author participation, Lean strategies present in various industries, and their relationship with the food industry. The goal is to establish decision criteria for selecting a Lean strategy in the food industry at every stage of the production process.

## 3. Results and Discussion

Figure 2 shows the total number of articles per year, with no growth observed between 2017 and 2018. Furthermore, it is evident that during 2019 there was the lowest number of articles. However, despite the decrease, there was a notable growth in the following two years, with the number of articles increasing from 2 in 2019 to 11 and 15 articles

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in 2020 and 2021, respectively. The table also highlights the significant contribution of articles generated in 2017 and 2018 and the steady growth starting from 2020.

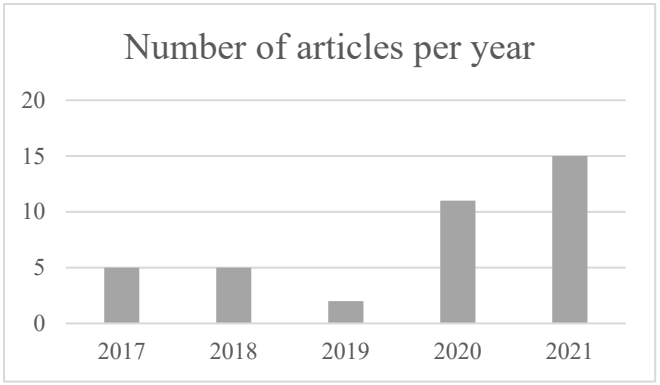


Figure 2. Number of articles per year

Table 3. Contribution per year

| Year | Number | Contribution |
|---|---|---|
| 2017 | 5 | 13.2% |
| 2018 | 5 | 13.2% |
| 2019 | 2 | 5.3% |
| 2020 | 11 | 28.9% |
| 2021 | 15 | 39.5% |

Likewise, Table 3 shows the notable contribution of articles generated in 2017 and 2018, as well as the steady growth since 2020.

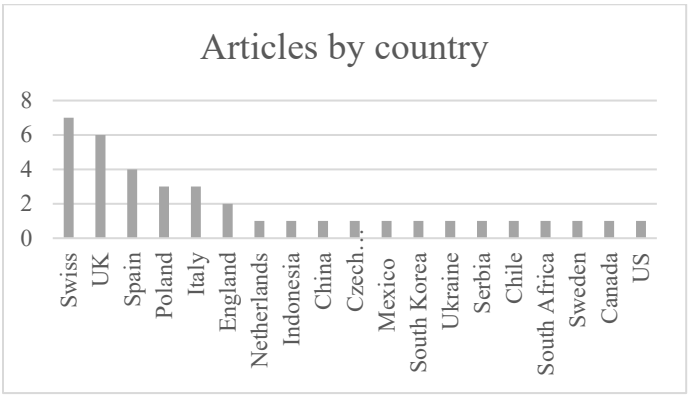


Figure 3. Number of articles by country

Figure 3 shows that Switzerland and the United Kingdom have the highest number of scientific studies published on our topic, followed by Spain, Italy, Poland, and England. The trends found indicate a substantial interest in addressing issues related to implementing Lean in the food industry. According to the World Intellectual Property Organization list of results (2022), the report indicates that investment in research and development (R&D) and other initiatives that promote innovation worldwide experienced a significant increase in 2021, despite the impact of the COVID-19 pandemic. However, these efforts are in an uncertain position in the short term due to the new challenges that have emerged in the world, making their future uncertain. Switzerland, the United States, Sweden, and the United Kingdom

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lead the list as the countries where research and development were most developed.(World Intellectual Property Organization 2022)

Within the quantitative analysis of the consulted journals, the presence of four publications by Sustainability (Switzerland) is because it is an international academic open-access journal that covers areas of environmental, cultural, and economic sustainability. Likewise, it publishes online on a semi-annual basis through MDPI.

Similarly, every article in this study relates economic and environmental sustainability with the application of lean techniques in the food industry. These areas focus on reducing production costs or increasing profits by implementing tools to optimize the system or eliminate non-value-adding operations and minimize waste to prevent environmental damage.

Table 4. Contribution of the journal Sustainability

| Journal | Title | Area |
|---|---|---|
| Sustainability (Switzerland) | Business process re-engineering to digitalize quality control checks for reducing physical waste and resource use in a food company. | Food Company |
| | Lean 6s in food production: Haccp as a benchmark for the sixth s “safety” | Food production |
| | Lean–green improvement opportunities for sustainable manufacturing using water telemetry in agri-food industry. | Agri-Food industry |
| | Uncovering Readiness Factors Influencing the Lean Six Sigma Pre-Implementation Phase in the Food Industry | Food Industry |

It is worth noting that there are two open-access academic articles from the International Journal of Lean Six Sigma due to the high presence of the Lean Six Sigma tool in the food industry. Similarly, the fact of the two articles published by the Journal of Industrial Engineering and Management is due to the growing application of various Lean techniques in each stage of the food production process.

Table 5. Issues addressed.

| Issues | Authors | Description |
|---|---|---|
| Lean Strategies | Abd Rahman et al. 2020<br>Almasarweh 2020<br>Al-Refaie et al. 2020<br>Alvarado-chávez 2018<br>Benyahya & Macurová 2021<br>Daryl Powell et al. 2017<br>Garcia-Garcia et al. 2021<br>Das 2018<br>Melin and Barth 2018<br>Rodríguez-Medina et al. 2021<br>Vaněček et al. 2018 | The authors define lean strategies as tools that seek to eliminate waste and non-value-added operations. They also establish their application in food industries considering the multiple existing tools for each stage of the process, such as JIT, LEAN GREEN, 5S, SIX SIGMA, VSM, and LEAN MANUFACTURING. |
| Lean and Food | Azalanzazllay et al. 2022<br>Azucena Domínguez et al. 2021<br>Barge et al. 2020<br>Cabrera et al. 2020<br>Cuggia-Jiménez et al. 2020<br>Dolgopolova et al. 2021<br>Farissi et al. 2021<br>González-Boubeta et al. 2021 | According to the authors, the application of Lean strategies in the food industry is crucial nowadays because each stage of the production process must be efficient. This implies the elimination of waste and emissions, achieving sustainability in the production line. On the other hand, reducing activities that do not generate value to achieve higher profits and lower costs is also important.<br>The studies by these authors express the following: |

| | | |
|---|---|---|
| | Kazancoglu et al. 2021<br>Poole et al. 2019<br>Viles et al. 2021 | According to these authors' studies, Lean Manufacturing establishes that proper streamlining in the supply stage generates a 50% utilization of defective materials. Lean Six Sigma contributes to greater environmental sustainability and quality improvement due to the restructuring it offers, efficient use of resources, and identification of critical points. Lean-green is established as a good approach to achieve sustainability in manufacturing industries. Likewise, Lean tools such as Just in Time (JIT), Value Stream Mapping (VSM), and 5S methods allow for practical increase in work efficiency, reduction of production cycle times, and decrease in energy consumption. VSM is used to identify waste in the value chain. |
| Improvement of the production process | Barabanova et al. 2018<br>Castro and Jaimes 2017<br>Goemaere et al. 2021<br>Kalsaas et al. 2020<br>Lagarda-leyva 2021<br>Marttonen-Arola and Baglee 2020<br>Mor et al. 2021<br>Orynycz et al. 2020<br>Parmar et al. 2017<br>Perboli et al. 2018<br>Satolo et al. 2017<br>Setene and du P.S. Jordaan 2021<br>Shah and Naghi Ganji, 2017<br>Sujová and Simanová 2021<br>Talukder et al. 2021<br>Tran et al. 2020 | The authors conclude that by implementing lean strategies, the management of resources and the production process in the food industry can be improved. The techniques and tools used are designed to make the organization efficient and effective in terms of quality, reliability, flexibility, innovation, and cost. This generates greater competitiveness and creates a value-oriented approach that is offered to stakeholders. |

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Finally, the strategies found in the investigated articles and their respective applicability were as follows:

Table 6. Applicable Tools

| Lean Tool | Authors | Objective/applicability |
|---|---|---|
| TQM | Lyons et al. 2013 | TQM (Total Quality Management) ensures the effectiveness of each process in a company while focusing on customer satisfaction. |
| Just in time | He and Hayya 2002 | Its objective is to ensure that materials arrive at their destination just when they are needed, neither too early nor too late.<br>It is not recommended to use JIT in food processing, especially for small companies, due to the uncertainty of demand. |
| Cell production total productive maintenance (TPM) | Dora and Gellynck 2015 | This consists of a series of maintenance operations in all phases of the cycle. |
| Value stream mapping (VSM) | Jiménez et al. 2012 | This refers to Value Stream Mapping (VSM), which consists of a flowchart with a series of symbols representing different work activities and information flows. |
| Single-minute exchange of dies (SMED) | Jiménez et al. 2012 | This consists of ensuring that any machine changeover does not exceed 10 minutes. |
| 5S | Saja et al. 2013 | It is based on five principles to achieve better organized, cleaner, more orderly, and ultimately, more productive workplaces. |
| Six Sigma | Jiménez et al. 2012 | Its goal is to reduce product failures or defects to a practically zero level. |

Compared to Cuggia-Jiménez et al.(2020), the most commonly found tools in their research were JIT, TPM, SMED, and 5S due to their focus on lean manufacturing. On the other hand, our research focuses on lean tools not only in lean manufacturing but in a more general aspect, where the most commonly used strategies are lean six sigma, 5S, and VSM. Another difference found was the countries where more articles were found. They detail that there is a more significant number of publications in Asia, with Indonesia and Malaysia being the countries with the most publications. At the same time, for our findings, there was an outstanding contribution of publications in the European continent, specifically Switzerland and England. Despite the increasing popularity of lean strategies, there has been a noted inadequacy in their implementation in companies, as they seem to focus mainly on ensuring good quality and compliance with legal requirements, which leads them to overlook the opportunity to improve by eliminating waste. If companies adopt this tool, they benefit not only in terms of quality and regulatory compliance, but also in productivity and profitability.

This article explored the most used tools and techniques in the case studies included in this research, highlighting the use of VSM, 5S, and Six Sigma tools, each for a different industry.

The findings in our researched articles indicate that VSM and 5S are more applicable to the food industry. The study conducted by Cabrera et al. (2020), indicates that the implementation of VSM, 5S, SPC, and the HACCP system reduces returns of products in a food company. Furthermore, the study recommends that the results of the pilot project should motivate SMEs in the food industry to apply these tools.

While we consider that Lean Six Sigma is more applicable to the manufacturing industry with more complex processes and specific problems. According to Saja et al. (2013), in recent years, Lean Six Sigma (LSS) has become the most popular business strategy for implementing continuous improvement (CI) in the manufacturing and service sectors.

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This is because continuous improvement is the primary objective of any organization in the world to help them achieve operational and quality excellence and improve their performance.

## 4. Conclusions

Based on the presented results and discussions, it can be concluded that there is an increase in publications regarding the application of lean tools in different industries between 2020 and 2021. Analogously, with a continuity criterion, it is established that this behavior will continue to follow a growing trend in publications on the subject due to its impact.

Furthermore, it is confirmed that there is a more significant number of publications in Europe due to the application or proposed application of these tools in various companies in the country where the article is published, to obtain monetary benefits and resource efficiency.

According to the quantitative analysis of results, it is established that there are more publications in Sustainability (Switzerland), a European journal. This fact confirms the greater interest in the application of Lean tools and the impact it generates in environmental, cultural, and economic sustainability for the food industries.

According to the applicable tools found, it is evident that the implementation of quality management practices in the food industry is essential to ensure the safety and quality of food products. In addition, the application of techniques such as Just in Time (JIT) and Lean Manufacturing, including tools such as Total Productive Maintenance (TPM), Value Stream Mapping (VSM), Single Minute Exchange of Die (SMED), 5S, and Six Sigma, has been highly effective in improving efficiency and reducing costs in food production.

The lack of Latin American articles as research references posed a limitation for comparison with the national reality regarding the application in industries.

Based on the findings that Lean Six Sigma was the most frequently mentioned tool in the reviewed articles, its practical application for improving food production processes is recommended since it aims to reduce production defects to almost zero, bringing more excellent benefits to the company.

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