(10-007) - Productivity improvement in the food industry companies through Lean methodology and digitalization

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There is a growing interest in increasing the efficiency of companies and the search for greater customer satisfaction. The Lean methodology, which seeks to reduce waste in the industrial sector, can be used in this path. The Lean methodology aims to achieve the highest value delivered to the customer while seeking to minimize the use of resources by identifying and eliminating activities that do not add value. This paper aims to describe the methodology applied by the Lean Best company in the agri-food sector. After describing the fundamentals of the Lean methodology, the process followed is analyzed and exemplified with a study showing its potential.

The paper shows the evolution of the company and the improvement of the most significant indicators.

Keywords: SDG 9; SDG 12; digitalization; continuous improvement; lean; technology transfer

Mejora de la productividad en empresas del sector de la alimentación mediante metodología Lean y digitalización

Existe un creciente interés por aumentar la eficiencia de las empresas y la búsqueda de una mayor satisfacción de sus clientes. En este camino puede ser utilizada la metodología Lean que busca reducir los desperdicios en el sector industrial. La metodología Lean pretende alcanzar el mayor valor entregado para el cliente a la par que busca minimizar la utilización de recursos mediante la identificación y eliminación de actividades que no aportan valor. En este trabajo se pretende describir la metodología aplicada por la empresa Lean Best en el sector agroalimentario. Tras la descripción de los fundamentos de la metodología Lean, se analiza el proceso seguido y se ejemplifica con un estudio mostrando su potencial.

En el trabajo se muestra la evolución de la empresa y la mejora de los indicadores más significativos.

Palabras clave: ODS 9; ODS 12; digitalización; mejora continua; lean; transferencia de tecnología

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1. Introduction

There is a growing interest in increasing the efficiency of production processes. Likewise, there is a growing awareness of the need to limit the use of non-renewable resources, making it essential to study the value of the activities carried out in order to optimize processes (González-Domínguez et al., 2020).

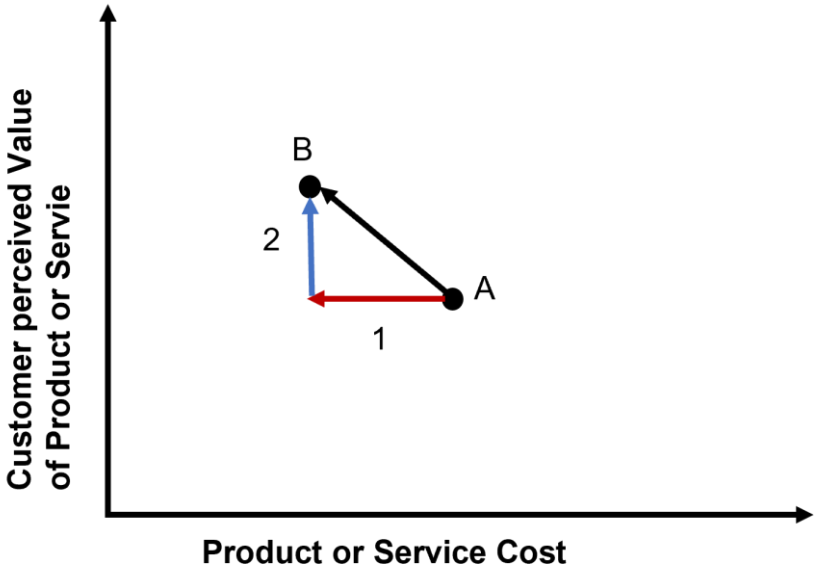
The Sustainable Development Goals (SDGs) were established by the United Nations in 2015 and set out an agenda to achieve a more sustainable, equitable and peaceful social development (General Assembly of United Nations, 2015). One of the characteristics of the SDG agenda is its indivisible nature, i.e., there is a clear interrelation between some goals and others. On the other hand, SDGs are a call for action by developed and developing countries, and for collaboration between all the different agents: public administrations, companies, non-governmental organizations, universities, etc (Dlouhá & Pospíšilová, 2018; Zamora-Polo, Sánchez-Martín, et al., 2019; Zamora-Polo & Sánchez-Martín, 2019). In the industrial field, we can highlight the Sustainable Development Goals: 7, 9 and 12. The first of these, SDG 7, seeks to increase the production and consumption of clean and sustainable energy. SDG 9 seeks the creation of a quality, sustainable industry through non-polluting processes as well as the use of research and innovation. SDG 12 seeks to ensure that sustainable consumption and production patterns are achieved.

Moreover, the irruption of the Internet and other enabling tools such as the Internet of Things are contributing to the digitization of the economy and industry in particular (Buer et al., 2021). The concept of Industry 4.0 has emerged in the scientific literature in a very powerful way (Ching et al., 2022). On the other hand, Industry 4.0 has a clear relationship with sustainability contributing to cost reduction (economic sustainability), reduction of harmful emissions and resource consumption (environmental sustainability) and is associated with the improvement of the conditions in which workers carry out their activity (social sustainability) (Ching et al., 2022).

Lean methodology can be very useful in addressing these challenges (Braglia et al., 2023; Buer et al., 2021). The origins of the Lean methodology date back to the 1980s in the context of Toyota's automotive manufacturing. Over time, innovations originally linked to automotive manufacturing have spread to other industrial fields (Hines et al., 2004). The first principle of the Lean philosophy is to focus efforts on maximizing added value at each stage of the production process. Figure 1 shows the relationship between the cost of a product and the value perceived by the customer. The path followed by the lean methodology is to reduce the cost of products (1) while increasing the value perceived by customers (2). Lean methodology is very interesting to ensure the competitiveness of companies (Braglia et al., 2023; Husár & Knapčíková, 2024).

There are several tools for the application of the Lean methodology in the company among which we can highlight (Ezzeldin et al., 2022): Value Stream Mapping, a tool to visualize processes and identify possible waste, Kaizen methodology fozalized in continuous improvement through small incremental changes, Just in time and Kanban which are tools to improve the supply chain. The use of the 5S tool allows the organization of workplaces by seeking to improve flow, eliminate waste and reduce processes where possible.

Figure 1: Relationship between product cost and customer perceived value. Source: Own elaboration based in Hines et al. (2004)



As previously mentioned, the Lean methodology was originally born in the automotive sector, its application has been extended to other sectors such as the manufacturing of transformers (Ezzeldin et al., 2022) and healthcare system (Badilla Murillo et al., 2021; Lee et al., 2024; Owens et al., 2024), nevertheless, it used in the food sector is scarce.

2. Case study

This communication analyses the use of the Lean methodology in a company of the food sector (slaughterhouse). This work is a university-industry collaboration that aims to contribute to the mission of knowledge transfer from the university to the company and vice versa. LeanBest is a consulting company whose purpose is to increase the efficiency and quality of its clients through the use of productivity techniques and lean methodology.

The objectives to be achieved with the work are the following:

- Design and implement a system of indicators to detect and monitor problems in each of the areas, being able to quantify the productivity of machines and people.
- Apply the 5S methodology to keep the environment tidy and clean.
- Optimize processes, with the aim of increasing productivity, reducing maintenance and cleaning times and reducing possible failures due to lack of material.
- Optimize the management of human resources, improving the distribution of workloads and production times.

Food industry is of high interest in the regions of Extremadura and Andalusia (Spain). This sector is a priority for the smart specialization strategies of both autonomous communities (Oficina técnica de la RIS3 Extremadura, 2022; Oficina Técnica S4Andalucía, 2023).

3. Results and discussion

Next, the actions proposed for the implementation of the lean methodology in this case study are analysed.

3.1 TOP5 Meetings

To facilitate communication between the company's management team and the workers, TOP5 meetings were proposed. The TOP5 meetings are attended by members of the autonomous group of people (GAP), a group of workers whose objective is to improve production. One of the members of the GAP acts as coordinator. The TOP5 meetings, with an estimated duration of 5 minutes, are usually held at the foot of the production line and in front of the GAP communication panel. At this panel, the desired indicators are established. These meetings, which are operational in nature, are the start of continuous improvement.

In these meetings, planned on a daily basis, diaries and proposals for improvement were raised. The progress of these meetings was reviewed weekly.

Three GAPs were established in the project:

- Slaughtering GAP.
- Cutting Room GAP.
- Fresh Products Expedition GAP.

In each of the GAPs, a physical panel was set up for the meetings, where production follow-up could be visualized by means of indicators that made it possible to elucidate compliance with the project's objectives.

Among the indicators for the slaughter line, the number of pigs slaughtered in one hour per operator per shift can be found, the downtime in minutes due to breakdowns and specific stoppages of the slaughter line per shift, the number of quality incidents in the shift for the slaughter line and the number of kg of casings prepared in one hour for the slaughter line.

Regarding the cutting room, we can find as indicators: the number of pigs cut in one hour by each operator, the downtime due to breakdowns and specific stoppages per shift, the number of quality incidents in the cutting room shift, the number of customer complaints in the shift due to cutting, the number of prepared for freezing and vacuum and the number of legs shaped in the shift.

The TOP5 meetings are attended daily by employees and managers. The minutes reflect incidents, for example: indicators, correct or incorrect use of the GAP panel, status of improvement ideas, status of compliance with 5S and incidents in the TOP5 meetings.

Weekly project follow-up meetings were held with the participation of the consultant, the promoter and the Lean project coordinator in order to analyze the evolution of the project and the management of problems.

3.2 Workplace improvement (5S)

The 5S methodology is a Japanese methodology consisting of five phases, each of which begins with the letter S in Japanese: Seiri, Seiton, Seiso, Seiketsu and Shitsuje.

The first phase consists of selecting and eliminating what is not absolutely necessary (Seiri). Thus, the first step is to differentiate what is important from what is not important, to keep the former and eliminate the latter.

The second phase seeks to order, systematize (Seiton), it consists of putting things in specific places, so that they can be found when they are needed. In this way, the aim is to eliminate wasted time spent searching.

The third phase consists of cleaning and sanitizing (Seiso). It is the first step towards preventive maintenance, through cleaning anomalies and premature deterioration can be found.

The fourth phase seeks to simplify and standardize (Seiketsu). It describes a series of rules that seek to keep the workstations tidy and clean and without elements that can hinder the manufacturing process.

In the last phase (Shitsuke) maintain, sustain the process over time and discipline. Mechanisms are established to maintain the progress achieved, encouraging team members to respect the agreed rules.

The use of the 5S methodology improves quality, reducing the number of inefficiencies (Sharma et al., 2020).

In order to improve production through the 5S methodology, a workshop was held to find the optimal way of working, the people on the team, the space and distribution of the area, type of machines, manual processes, etc.

An analysis of the existing waste, types of movements that are performed, most common problems that affect the cutting production, etc. was carried out. For this purpose, recordings and data collection were carried out. Based on the analysis of these sources of information and by means of a workshop with the employees, the following problems were detected:

- Existence of repetitive movements, these movements can be reduced or shortened.
- Unnecessary transportation and displacements: time is wasted making movements that can be reduced.
- Waiting time: time lost waiting for information, passing through a site, for colleagues to finish their tasks, etc.
- Rework due to quality defects: due to defective materials or process failures.
- Rework due to changes in planning or changes in customer requirements.
- Quality management malpractice.

The errors detected in the cutting room are listed below:

- Movements to the cold room cause product to accumulate at the exit of the cutting line and the presence of operators was variable.
- The cleaning of boxes accumulates many boxes, and they are not organized to take advantage of the space. Managers did not have ease of movement.
- There were changes in planning due to customer demands.
- The placement of gutted pieces in the cold room is very tight and sometimes it is not possible to place all the flanges on the carcasses.
- The material on pallets and boxes is not sufficient for cutting and shipping, which means that they are constantly moving from one place to another.
- Sometimes the shipping person runs out of boxes and can no longer perform this task.

As a result of the workshop an action plan was elaborated. For each of the actions, a responsible person was defined, as well as a due date to evaluate the actions. Figure 2 shows a detail of the Action Plan.

Figure 2: Action plan resulting from the 5s workshop

ACTION PLAN

Open	5		
In progress	0	0%	Status
Overdue	1	20%	80%
Finished	3	60%	
Not applicable	1	20%	

Id	WORKSHOPS	DATE	AREA	PROBLEM	ACTION	STATUS	RESP	SUPPORT
1	Workshop HOSHIN	04/11/2023	slaughterhouse	The processed meat piles up on work tables	Improve the workplace organizacion	Ok	Roque	Lean Best
2	Workshop HOSHIN	04/11/2023	slaughterhouse	A part of the product fall down to the floor. The operator loses a lot of time	Improve the workplace organizacion	Ok	Roque	Antonio
3	Workshop HOSHIN	04/11/2023	slaughterhouse	The cart placed to collect parts at the end of the line is far from the operator's stations.	Analyze a new location for the car.	Ok	Roque	Antonio
4	Workshop HOSHIN	04/11/2023	slaughterhouse	Some long pieces (sirloin type) that are located in the lower part of the cart, touch the ground.	Change the car type. Check parts that may rub on the ground	Overdue	Roque	Antonio
5	Workshop HOSHIN	04/11/2023	slaughterhouse	The space in the cold chamber is very tight and it is not always possible to put all the processed meat.	Improve the Layout and the materials flow	Not applicable	Roque	Antonio

The slaughterhouse manager's office was used as a storage area for items used daily: masks, gloves, etc. The space was rearranged, and the items were removed from this area and placed elsewhere.

The materials storage area was reorganized. New work clothes for the operators were placed in this warehouse. The elements necessary for the production process were classified using stickers to identify the elements that had a larger volume.

The items that were removed from the manager's office were placed on a shelf. In order to optimize the use of space, new shelving was installed.

The implementation of the action plan improved operator comfort, the work environment became safer and some shock and fall hazards were eliminated.

The work procedures of each operator were improved, unnecessary movements and work times have been reduced. Thus, the work is more efficient, and the workload is less.

3.3 SMED

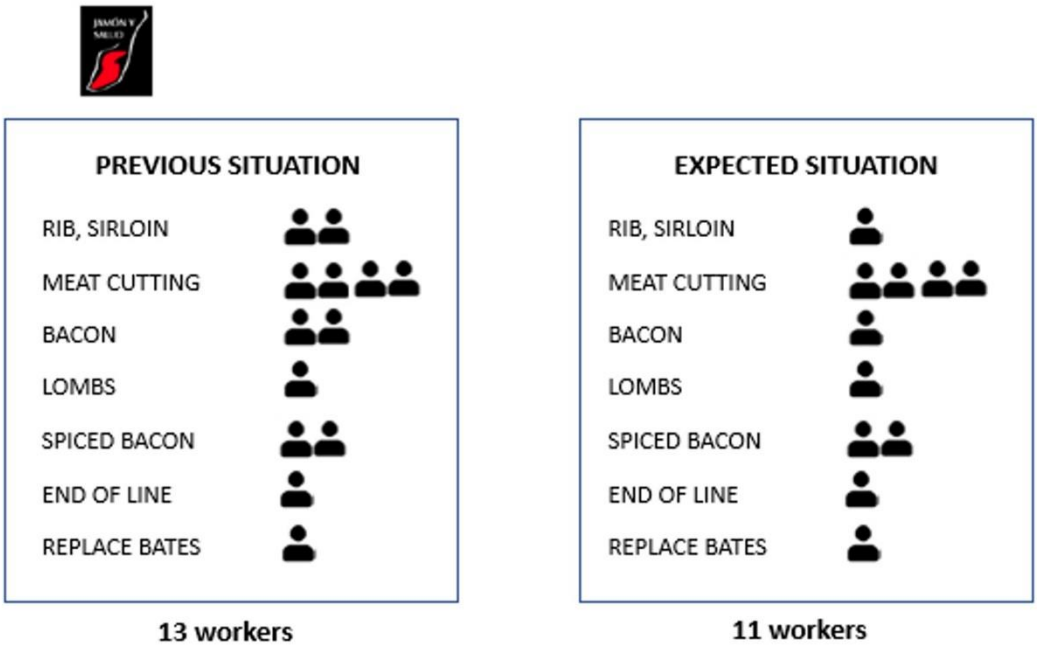
The SMED (Single-Minute Exchange of Die) methodology seeks to reduce equipment setup times and operations when reference changes occur (Shingo, 1985). Although its use was originally proposed for the reduction of time between existing batches in printing presses (Shingo, 1985). Its use has been proven in other sectors such as the garment factories (Mohammad et al., 2024), self-adhesive resin labels production (Braglia et al., 2023) and the production of production of thermal transfer ribbons (Nikolic et al., 2023).

Similar to the 5s methodology, a workshop for the best according to the SMED methodology was held. Among the solutions proposed for the problems detected in the SMED workshop were:

- Improvement of procedures.
- New arrangement of the worktables.
- Installation of a frequency variator to keep the animal lung always full.

The implementation of these actions has led to a decrease in the number of workers required in the activity from 13 to 11. Figure 3 shows the reduction in the number of workers.

Figure 3: Reduction in the number of workers

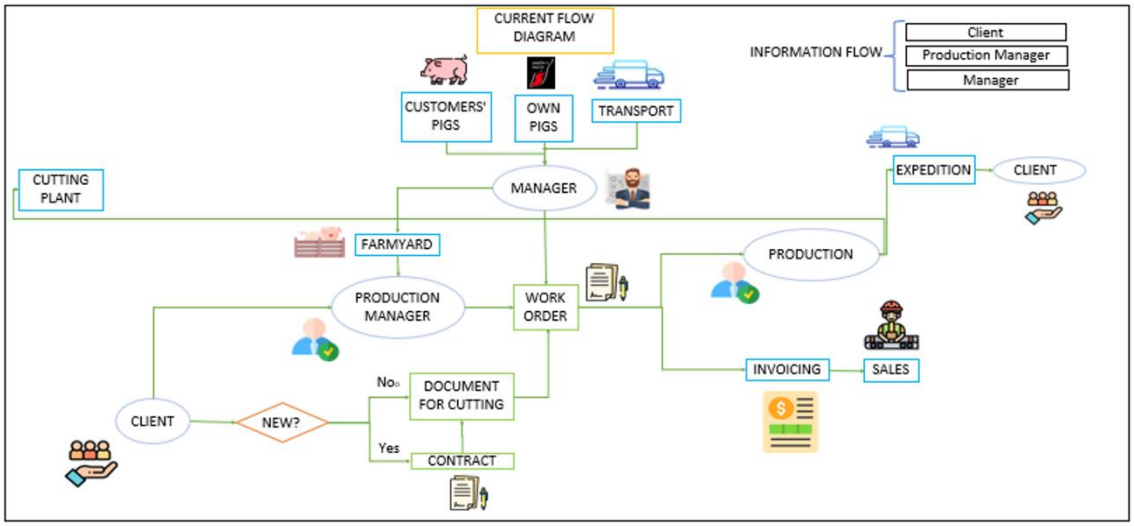


3.4 Material and Information Flow Analysis diagrams

Material and Information Flow Analysis diagrams (MIFA) and Value Stream Mapping are interesting tools of lean methodology (Kolobov & Varfolomeev, 2020).

After data collection, information and material flow diagrams were drawn up (Figure 4). The existing problems were analyzed by conducting a workshop with the presence of the employees. The processes of planning, ordering, customer management, administration and production were included.

Figure 4: Material and Information Flow Analysis diagrams (MIFA)



The main problems detected were:

- The planning suffers variations according to the client's needs that arise during the day.
- The communication of the planning reaches two people (slaughterhouse manager and dispatch administration), the rest of the workers are not informed.
- When modifications are made, communication is by telephone and sometimes the information does not arrive correctly.
- Customers telephone to know the status of their order and there is no defined person for this (they talk to different people).

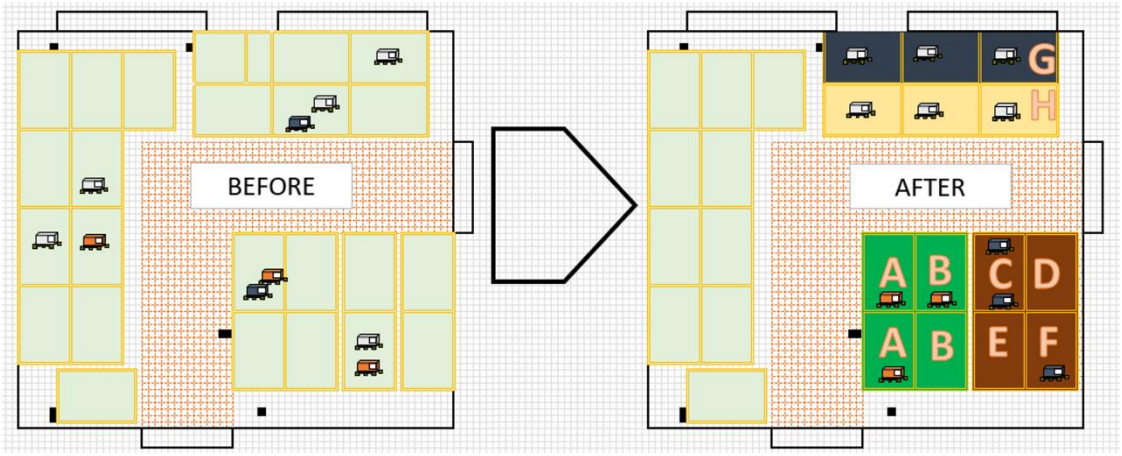
In the workshop, a search for waste was carried out, defining waste as those activities that generate added value or cause undesired elements, as well as process variability and overload.

The following improvements were proposed:

- Improved information flow between all departments involved.
- Reduction of call time and internal information requests by standardizing the information in a common document.
- Reduction of meeting times and calls with managers for daily problems that are solved in weekly meetings.
- Improved workload distribution by knowing who is available.
- Improved organization of the production department, planning of the slaughterhouse manager

Likewise, in this phase, a new layout of the rapid cooling tunnel was carried out. The new plant layout is shown in Figure 5.

Figure 5: New rapid cooling tunnel lay-out



3.5 Digitalization

One of the key elements to ensure the success of the implementation of the tools proposed by Lean is to include digitization in their implementation (Braglia et al., 2023). In a context of increasing digitization, data collection and the digitization of activities can make a decisive contribution to reducing operating costs and increasing the value delivered to consumers (Braglia et al., 2023).

The use of Lean methodology and digitalization can contribute to the sustainability of companies in all dimensions of the triple helix of sustainability: economic, social and environmental.

3.6 Staff involvement

One of the keys to the implementation of the Lean methodology is the involvement of the staff. Workers were encouraged to propose an improvement idea on a weekly basis. In these improvement ideas, the current situation and the proposed situation were to be described. The lean promoter collected the improvement ideas and will respond to them by identifying the accepted ideas, with an indication of the date to carry them out, the rejected ideas and the ideas that have been carried out, indicating the group that proposed them and their outcome.

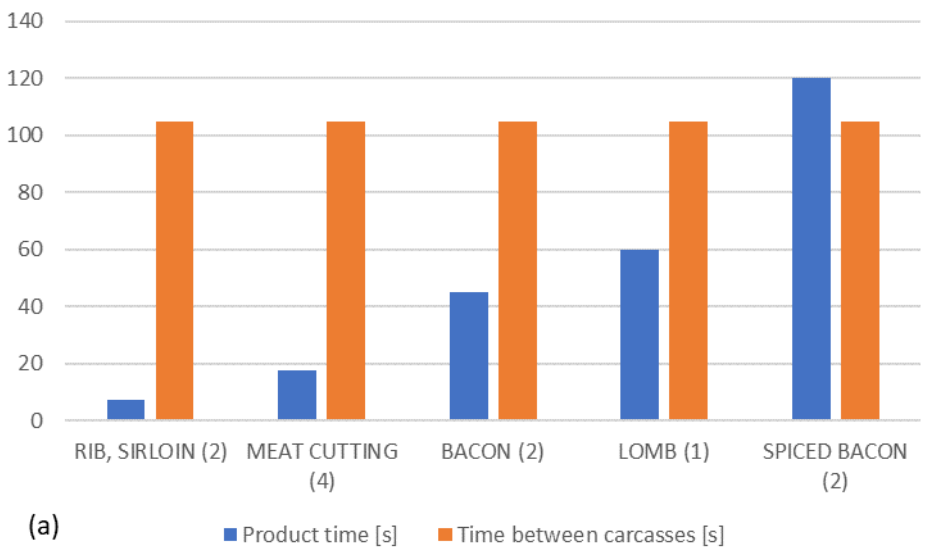
A criticism that can be made of the Lean methodology may be that it leads to increased pressure on workers (Hines et al., 2004). Previous work has explored the relationship between Lean and digitization, showing that although the Lean methodology was developed before the popularization of computers, both methodologies are very complementary, with digitization contributing to the achievement of Lean objectives (reduction of waste and increase in the value perceived by customers (Buer et al., 2021).

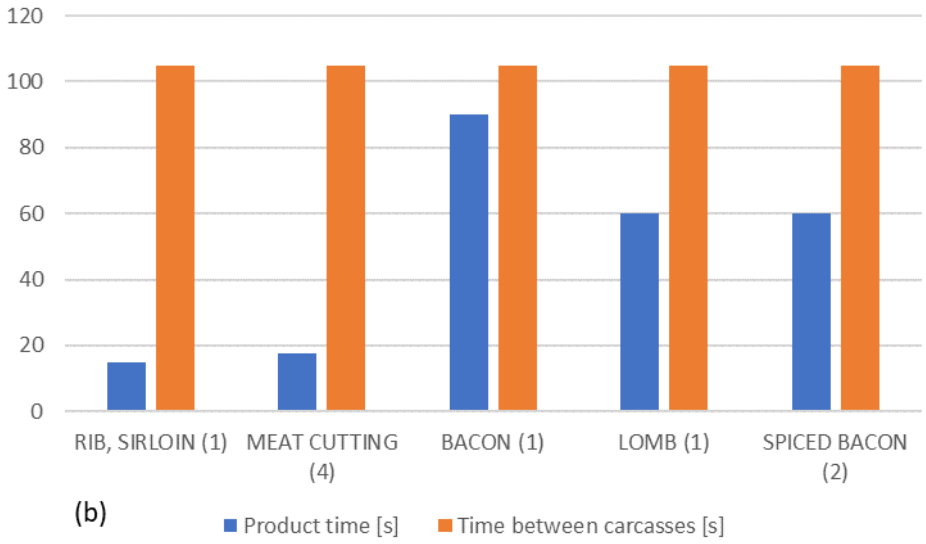
In previous work the importance of training has been emphasized (Husár & Knapčíková, 2024). Among other tools for lean training are games (Husár & Knapčíková, 2024). Gamification consists of the use of games in environments that are not initially playful (Deterding, 2012). Its use has been previously tested by the authors in the university environment (Sánchez-Martín et al., 2020; Zamora-Polo, Corrales-Serrano, et al., 2019).

3.7 Main advances achieved

Figure 6 shows the production times achieved with the implemented improvements. In the blue bars the times required to obtain the products are represented and in the orange lines the time between carcasses. In the proposal, there has been a reduction in the number of workers needed in the rib and sirloin and bacon workstations. Thus, taking into account that daily production reaches 200 pigs, productivity has gone from 15 pigs per worker to 18 pigs per worker.

Figure 6: Production times before intervention before (a) and after (b)





4. Conclusions

This paper analyses an experience of applying the lean methodology to a slaughterhouse and meat expedition. The work has described the different actions carried out such as TOP5 meetings, the improvement of the workplace through the 5S methodology, the development to apply the SMED methodology and MIFA workshops. Likewise, the importance of digitalization and the involvement of workers has been shown. Our analysis shows the transformative potential of lean methodology and justifies its interest for other industries in the agri-food sector.

All these actions have contributed to a saving of 70000 euros by the company and have positioned it in a more advantageous position that will allow it to ensure its survival in a very competitive market. These savings for the company are mainly related to a reduction in the number of operators required. A 20% reduction in downtime and breakdowns and an improvement in product quality were improved. In addition, the improved material flow contributed to a reduction in costs.

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Communication aligned with the Sustainable Development Goals