IMPROVING OPERATIONAL EFFICIENCY IN A MEAT PROCESSING PLANT THROUGH LEAN METHODOLOGIES

JOÃO GABRIEL VIDAL FERREIRA DO AMARAL

MASTER IN

INDUSTRIAL ENGINEERING AND MANAGEMENT

ABSTRACT

In a market subject to a growing trend towards globalization, there is in the business world a great competitiveness between companies in the same sector, and the consequent need for improvement of results becomes increasingly evident. This fact and the recent increase in meat consumption in Portugal, originate in Company A, a leading company in the livestock sector, a pressure to achieve excellent results.

The Lean methodology presents itself as a response to this need, having been proven effective in reducing operational costs and increasing productivity. As such, Company A employed the services of Kaizen Institute to develop a Lean project within its meat processing plant in Torres Novas, with the objective of improving its operations.

This dissertation addresses the application of Lean concepts and tools in a production line in the Bovine section of Company A's plant, in order to increase its productivity and reduce the % of breaks in the line's process.

The methodologies applied to the line resulted in a productivity increase of 24%, by removing the waste associated with the number of operators assigned to the line, and a reduction of % breaks of 45%, by using structured problem solving to identify and mitigate the root causes of the problem.

The improvement principles addressed in this paper resulted in an annual benefit of €181k for Company A.

1 INTRODUCTION

Company A is dedicated to the commercialization of meat and meat products. In Portugal, it is a leader in the meat agri-food sector, producing in large quantities and supplying some of the largest retailers in Portugal, such as Jerónimo Martins, Sonae and Macro.

The production of Company A goes from animal breeding to meat packing, it is a process highly subject to product waste, and since companies that operate in the commercialization of meat are under constant pressure from competitors and customers, implementation of methods that reduce this waste is sought and valued.

In this context, Lean thinking, a methodology used to address efficiency problems in companies through cost reduction, emerges as the answer. This cost reduction resulting from the elimination of waste is achieved with the participation of all employees, from top management to the plant operator.

In order to implement a Lean system in its meat processing plant, Company A turned to the Kaizen Institute, a consulting firm with extensive experience in implementing cultures of continuous improvement and in helping leaders achieve their performance improvement objectives, which, through its own methodologies works to achieve results.

2 DESCRIPTION OF THE PROBLEM

2.1 COMPANY A

Company A, present in the livestock sector for over 40 years, is dedicated to the production and marketing of meat and meat products, operating in Portugal and internationally with a number of reputable brands. Through integrated control of the supply chain, Company A raises its animals on farms, which it feeds, selects, slaughters and processes. It is currently one of the largest marketers of meat and meat products in Portugal and is present in over 30 countries on four continents.

The company operates in 3 business areas and they all complement each other. The breeding of the animals, the slaughter of the animals and the transformation of raw material into final product.

This dissertation focuses on improving operations in the processing area of Company A. Currently, Company A has two processing units, one dedicated to fresh and the other to processed products. In the scope of this dissertation, we will focus on the fresh processing unit, located in Torres Novas. The organizational structure of the unit is presented in Figure 1 - Organizational Structure of the Torres Novas UnitFigure 1.

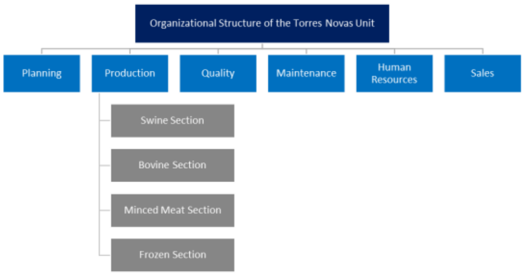

Figure 1 - Organizational Structure of the Torres Novas Unit

The focus of this dissertation will be on one of the lines in the Bovine section, belonging to the production department.

2.2 BOVINE SECTION

The Bovine section is composed of 3 cuvette lines, namely, line 5, line 6 and line 7, as indicated in Figure 2.

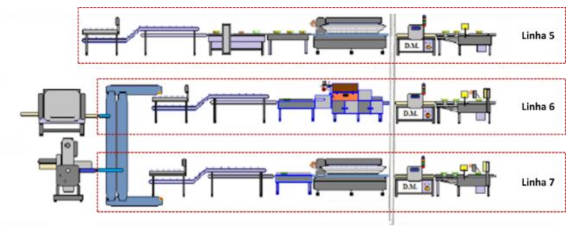

Figure 2 - Bovine Section

The process in this section involves receiving the meat coming from the cutting section. The meat is cut into fillets, cubes, steaks, etc., depending on the product to be produced, then placed on a conveyor belt where it is inserted into a cuvette. Finally, the cuvette enters a packaging machine, where a layer of plastic packs the product. Production on the lines can involve products with a variable or fixed weight type.

Due to the nature of the intended end product, line 6 accounts for 49% of the production of this section. It is therefore on this cuvette line that this dissertation will focus.

2.3 CONTEXTUALIZATION OF THE PROBLEM

Although the KI project in Company A started in 2020 and also falls within the scope of the Planning, Quality and Maintenance departments, this dissertation addresses only issues related to the Production department. Due to the aforementioned need for increased operational efficiency, Company A employed KI services in order to solve three key questions:

- How to increase overall productivity?
- How to reduce downtime?
- How to develop a culture of continuous improvement?

Each quarter, a Value Review meeting would be held to decide in which section the KI project would focus on next.

In the Value Review held in early March 2021, it was defined that the work to be done in the quarter in question would focus on the Bovine section, since this is the section with the second highest volume (the section with the highest volume is the Swine section, which had previously been addressed in a past quarter).

Within the Bovine section, it was decided that Line 6 should be the pilot line, that is, it should be the first line on which to act and test solutions, later unfolding to the other two lines in the section. This decision derives from the fact that line 6 is the line with the highest production volume in the section, being allocated, as previously mentioned, 49% of the section's production.

Two objectives were defined for the quarter, related to Line 6, being aligned with the general objectives of the project in the Torres Novas unit:

1. **Increase in productivity** by guaranteeing the leveling of the number of operators along the line, according to the reference to be produced and the desired production rhythm;
2. **Reduction of production losses** in order to ensure the minimum possible loss of raw material along the line processes.

2.4 LINE 6

The processes of Line 6 are presented in Figure 3 in order to better understand the problem at hand

and the solutions presented later in this dissertation.

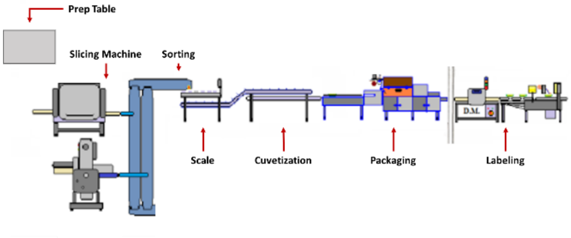

Figure 3 - Processes of Line 6

Slicing Machine/Prep Table: As previously mentioned, these machines have the function of slicing the raw material pieces that are inserted in them, so that they get the final shape in which they will be sent to the customers. There are two slicers: the B36, better suited to cut pieces according to the desired weight, and the Grasselli, better suited to cut pieces according to the desired slice thickness. For the operation of Line 6, only the B36 is used. In case you are producing 'Jardineira', there is the need to add a previous process to the slicers. This process is the preparation (cleaning) of the Jardineira piece by hand on a table. Once the piece is clean, it proceeds to the slicers.

Sorting: In this process, suitable and unsuitable slices are separated, and they are placed in piles in order to facilitate the next process;

Scale: If you are producing cuvettes with a fixed weight, the slices are placed on an eight-pan scale (also called a spider). This scale will automatically match pairs or trios of slices that between them have the right weight to be placed in a cuvette. When the scale makes a match, the plates corresponding to the slices in question project a green light, and consequently the slices are placed on the mat that will take them to the next process. In case you are producing cuvettes with varying weight, the scales are not used, but this is where the slices are placed on the mat for the next process;

Cuvetization: Slice combinations appear one by one on the mat and are placed in cuvettes. These cuvettes appear on a mat located below the first one, and are placed there by an automatic cuvette dispenser;

Packaging: The packaging machine receives the trays with meat and applies a plastic film over each one;

Labeling: The cuvettes are already packed and a label with the product data and reference is automatically placed on them.

3 LITERATURE REVIEW

In this chapter, a study of the existing literature regarding concepts relevant to the development of Company A's improvement project is presented. Since the Lean approach is popular in the development of projects similar to the project under study, it is pertinent to relate the reasoning that originates the fundamentals of this thinking with the tools that will be used when solving Company A's problem. Therefore, for the concepts treated to be observed in a comprehensive way, this literature review begins by first considering the framework of Lean thinking. Subsequently, it intends to clarify the main characteristics of the Lean methodologies to be applied and, finally, a description of some tools that could be used in the context of the described problem is presented.

3.1 LEAN THINKING

The principles of the Lean philosophy were first introduced to the scientific community in 1911 by Frederick Taylor. In his book "The Principles of Scientific Management", Taylor introduces Lean as a method of reducing labor through the use of good company practices and task standardization (Taylor, 1911).

However, it is in a post-World War II environment that Lean emerges in a form more similar to what we know today. This transformation takes place at Toyota, as a response to the economic crisis faced by Japan, whose industries needed to reformulate their production processes in order to keep up with the competition from the large American industries. In 1988 the Toyota Production System (TPS), created by Taiichi Ohno and Shoichiro Toyoda, was introduced. TPS emerges as a fully integrated production system, with a foundation in process and product quality, and a focus on quantity control as a method to reduce waste, fostering cultural change within the organization (Wilson, 2010). This production system brought great benefits to Toyota in the form of reduced inventory levels, increased quality control, and reduced cost (Ohno, 1988).

Over the years, TPS started to be adopted by other companies as a system to make their organizations run more efficiently with reduced costs, while maintaining a continuous operational flow. However, it became clear that there were limitations when inserting this methodology in industries with a different context than Toyota. (Bicheno and Holweg, 2009)

This variability of production processes in different companies gave rise to the creation of a new ideology, which is comprehensive to all industries with different sizes and production diversification, called Lean Thinking (Melton, 2005).

This concept was first used by Womack, Jones and Roos, and nowadays is already part of the organizational renewal culture. Based on a study conducted in 1990, Womack, Jones and Roos (1990) number 5 essential steps that a company must go through in adopting a Lean production system. These steps are:

1. Define what the customer considers as value;
2. Identify and eliminate waste;
3. Create a continuous flow in the value chain;
4. Implement a Pull system;
5. Strive for perfection.

3.2 LEAN METHODOLOGIES

In a process of implementing Lean thinking, it is necessary to adopt a rational, data-driven approach. Melton (2005) presents 5 steps necessary for the successful application of Lean. These are:

Collect data, observing the current state of processes, with the aim of finding opportunities for improvement, and involving the people who deal with the processes in question on a daily basis;

Analyze data, using multidisciplinary teams, looking for incidents that currently occur but are not desired;

Proposal of alternative, with the perspective of addressing the waste found previously, using the teams involved in the predecessors, in order to validate the sustainability of the proposed alternatives

Implement the change, on the ground, applying the designed solutions and training people to ensure their correct implementation

Measure the benefits, through indicators capable of evaluating the gains of the new solution, compared to the previous state.

In order to support the application of these five steps in their organizations, Lean methodologies are used, which serve as structured tools to facilitate and implement the organizational change that this system requires.

It is then proposed to analyze some Lean methodologies that can be applied in the KI project in order to solve the problem faced by Company A. These are Pull Planning and Kaizen.

3.2.1 PULL PLANNING

Pull planning, often referred to as Just-In-Time (JIT) is one of the main foundations of the Lean philosophy (Liker, 2004). It was developed by Toyota in the 1950s, and came to serve as the antithesis of the push system paradigm. While push production aims to maintain stock levels to ensure the availability of products when they are needed, the principle behind the pull concept indicates that production should only be triggered by consumption, consumption that does not refer only to the final consumer, but also to any step in the value chain. Therefore, the level of inventory in the value chain should remain constant and controlled, which is allowed by the existence of flow, by transparent processes and with visual control (Masuchun, Davis and Patterson, 2004).

A correct implementation of pull planning presents several benefits and acquired advantages, including: increased production efficiency and material flow, increased product quality, reduction of intermediate product inventories (WIP) and final product, reduced time between customer order and delivery of finished product (lead time), reduced operating costs through the elimination of waste and increased level of service (Alcaraz et al., 2014).

Through these benefits, a pull system ensures flexibility in production, which is an important factor in reducing unwanted variability (by minimizing the bullwhip effect, for example) and a greater ability to meet fluctuations in demand (Melton, 2005).

3.2.2 KAIZEN

As mentioned earlier, in order to correctly implement the Lean philosophy, it is necessary to establish a culture of striving for perfection. This is where the Kaizen methodology comes in, which aims at the continuous improvement of work practices and personal efficiency. (Imai, 1997)

Kaizen is a methodology that relies on process improvement-oriented thinking, rather than the achievement of big results, prioritizing a focus on continuous improvement (Jain, Lad and Tandel, 2015). Chera et al. (2012) dictate that this practice of continuous improvement includes making changes, controlling those changes, and then adjusting practices if they are improved by the changes.

The improvements that arise from applying kaizen are small but incremental, and therefore give rise to very significant results over time. While Western management thinking focuses on major innovations as the source of change, whether in the form of technological breakthroughs, major investments or new production methods, kaizen is based on applying common-sense, low-cost solutions that will have a major impact over the long term. This approach, while requiring a great deal of dedication to cultural change, ensures low risk in its application. (Imai, 1997)

In a kaizen system, change often starts with a Kaizen Event. A Kaizen Event focuses on a point in the company that needs improvement, be it a machine, a production line or even a service desk, and requires participation from employees at all levels of an organization that are included in the process under analysis. An action plan is applied to identify and eliminate the muda in the process in question. The success of a Kaizen Event then depends on three factors: (i) employee involvement; (ii) willingness to change; (iii) good communication (Chera et al., 2012).

Jain, Lad and Tandel (2015) suggest that if the methodology follows the following steps, it can be successfully applied in a wide variety of areas of an organization, be it engineering, production, management or support areas. The steps identified are:

1. Select a target process;
2. Create a team formed by the operators corresponding to the process, defining a responsible person, who will be called the team leader;
3. Define indicators and objectives in order to monitor the progress of the Kaizen Event;
4. Observe the process to understand it;
5. Analyze the current state of the process, focusing on the muda;
6. Create an improvement plan aimed at eliminating the muda;
7. Implement the created plan;
8. Present the results obtained;
9. Standardize and monitor the new process.

Kaizen then presents itself above all as an iterative and continuous process that generates constant improvements in the processes involved, and as a participative system that requires the involvement of multidisciplinary teams.

3.3 LEAN TOOLS

Having explored the fundamentals of Lean thinking, as well as the methodologies that arise from them, next some of the Lean tools that were applied in solving the problem presented by Company A are described. These tools are then the means by which the methodologies discussed above will be applied in the concrete contexts of the processes to be improved.

3.3.1 VALUE STREAM MAPPING (VSM)

Value Stream Mapping is a tool that aims to visually represent the flow of materials or information, encompassing all the processing stages that a product goes through. Once implemented, the VSM assists organizations in finding, identifying and separating VA and Muda, covering the flows in their entirety and not just focusing on individual issues (Liker and Meier, 2005).

In a VSM, not only all processes are identified, but also all people, materials and information along the supply and value chain, with the receipt of materials from suppliers usually represented on the left side of the map, and the delivery of the product or service to the final consumer on the right (Chera et al., 2012).

3.3.2 A3 REPORT

The A3 diagram appears within each Kaizen Event. It is a tool that aims to concisely and visually present the entirety of an implementation plan, regardless of its size (Schawagerman III, Ulmer and William, 2013).

According to Schawagerman III, Ulmer and William (2013), the seven steps that must be contained in an A3 are:

1. Contextualization of a problem;
2. Description of the current situation;
3. Identification of the objective;
4. Root cause analysis of the problem;
5. Identification of countermeasures;
6. Develop a work plan;
7. Follow up the implementation process.

The Kaizen Institute, however, proposes that an A3 should not have only 7 steps, but 9. Therefore, it maintains the use of steps 1 through 5, eliminates steps 6 and 7 shown above, and adds the following (Kaizen Institute, 2021):

6. Testing solutions;
7. Update PDCA;
8. Confirmation of objectives;
9. Analysis of lessons learned.

3.3.3 STANDARD WORK

The Standard Work tool, is a continuous improvement tool that refers to standardizing the most effective and safest way known to date that a worker has to perform a task.

These standards are based on the principle that, within several methods for performing an activity, there is always a most correct way to do it based on the indicators that you want to maximize, often indicators related to quality and time.

The definition of Standard Work for a given task is often accompanied by a visual standard, which is accessible to the workers who will be involved in the activity in question. According to MÍkva, Prajová and Yakimovich (2016), this standard should have the following 5 characteristics:

1. Contain only the information necessary to perform the task at hand;
2. Be simple and visual, to facilitate interpretation;
3. Allow changes in process parameters;
4. Ensure that process-relevant activities are assigned to all operators involved;
5. Allow monitoring of the implementation of the standard.

3.3.4 LAYOUT DESIGN

The ideal layout of production lines in a factory is not universal, since it depends on factors that vary with what one intends to produce. Generally, the adoption of a certain layout in a production line involves the preference of reducing a certain muda in relation to another (Silva, 2010). Therefore, each of the layouts analyzed below presents certain benefits that will be more or less important depending on the context in which it is inserted:

Straight Line Layout: This distribution promotes simplicity, guiding the production flow so that a great level of complexity is not required in its interpretation.

Functional Layout: Focuses on reducing unnecessary movement, organizing the position of each sector in order to generate proximity between them.

U-shaped layout: Often used in manufacturing industries, this arrangement of the production line allows great flexibility in the number of operators working on it, allowing it to be handled by only one operator (Salleh and Zain, 2012).

3.3.5 METHODOLOGY

For each of the two problems in question, the A3 Diagram will be applied as a problem-solving framework. As indicated, A3 is a tool often used as the standard for organizing a workshop (another name for Kaizen Event). As such, and in order to better reflect the thinking behind each of the problem-oriented workshops, I find it appropriate to use it in structuring this dissertation. The following chapters of this dissertation will reflect the conclusions drawn from each of the steps for each of the problems.

4 CURRENT SITUATION ANALYSIS

In this chapter, we proceed to analyze the situation of Line 6 prior to implementing solutions. The chapter will then go through, for each workshop, the 3 steps that take place before considering solutions to the problems in question. It is then intended that, for each workshop, the problem to be addressed is contextualized, the initial situation is studied and the objectives are defined.

4.1 INCREASE IN PRODUCTIVITY

The first step in the analysis was to calculate the current value of the workshop indicator, namely productivity. These values were already monitored, so defining a baseline value for the indicator was made easier, as indicated in Table 1.

Table 1 - Productivity Baseline

	Procura (kgs)	Tempo Trabalho (h)	Tempo Pausa (h)	Nº operadores	Produtividade
Por turno	1765	8	0,25	10,9	20,9
Por dia	3530	16	0,5	10,9	20,9

The figure of 10,9 operators per shift is derived from a weighted average between the two possible operator arrangements on the line, resulting from the two categories of articles produced. Thus, when the line was producing the article category called 'Jardineira', the line would have 13 operators. When the line was producing 'Steaks', it would have 10 operators.

An analysis of the articles in each category immediately identified an opportunity for improvement. Certain items require fixed weight cuvettes and others require variable weight. Fixed-weight items require an additional process over variable-weight items, that of ensuring the right weight. However, fixed-weight and variable-weight items were encompassed in the same categories, indicating that they would be subject to the same processes and that the allocation of operators to the line did not change by weight type. Therefore, four families of products were defined:

Family A: 'Jardineira' with fixed weight; Family B: 'Jardineira' with variable weight; Family C: 'Steak' with fixed weight; and Family D: 'Steak' with variable weight.

4.2 REDUCTION OF PRODUCTION LOSSES

As in the productivity workshop, the description of the current situation began with an analysis of the key indicator, the % of production losses. The values of production losses took into account the amount of raw material that enters the process of Line 6 per week, and the amount of raw material that leaves the process, the value of the difference would be the amount, in kgs, of losses in this line.

The baseline values were of 5,13% production losses, distributed among the 4 families of end-product as indicated in the Table 2.

Table 2 - Production Losses Baseline

	% Relative Losses	% Total Losses
A	6,38%	1,20%
B	7,79%	1,02%
C	6,41%	1,96%
D	2,53%	0,95%
Total	5,13%	5,13%

5 SOLUTION IMPLEMENTATION

5.1 INCREASE IN PRODUCTIVITY

In a production line where there are several processes, distributed among several operators, it is common that the distribution is not well leveled, resulting in certain operators being responsible for tasks or processes that have a shorter duration than others. This unevenness will necessarily result in muda, be it excess material or, in the case of line 6, waiting operators.

In order to quantify the time of each process of the line and the waiting time of operators, we proceeded to the analysis of each of the following defined families, seeking to define:

- Takt time: how soon a cuvette must be produced on the line, in seconds. This value is calculated by dividing the number of hours available for production in a shift by the demand per shift;
- Cycle time: considering that the line doesn't work efficiently 100% of the time, the takt time value is multiplied by the OEE of the line, for a better approximation of how much time a cuvette should be produced, considering that there are stoppages and delays;
- Time of each process: how long it takes to perform each process on the line;
- Yamazumi Chart: represents the occupation time of each operator of the line against the cycle time.

In a Line Design workshop, step 5 is about identifying opportunities to reduce the lead time of each operator, ensuring that they are adding value as much of the time as possible. This is achieved by grouping tasks that were previously distributed across multiple operators into as few operators as possible, ensuring that they meet the cycle time without quality losses occurring.

The biggest sources of waste on the lines were:

- For families A, B, C & D: The waiting time of the machine operators;
- For families A, B, C & D: The waiting time of the cuvetization operators;
- For families A & B: The overhead of the table operators;
- For families B & D: The waiting time and rework in the scale process.

Countermeasures to address each of these sources of waste were then discussed. The countermeasures included the redistribution of tasks among operators and the implementation of low-cost automation solutions.

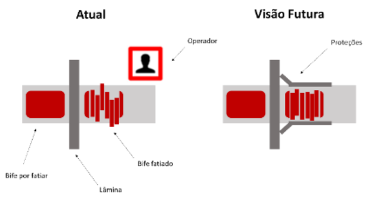

Figure 4 - Low-cost automation solution

Having successfully tested de solutions discussed, a visual standard was designed regarding the allocation of operators to the processes of line 6 for each family, making it clear which items would be included in each family and what the hourly objective was.

The following figure represents one of the standards implemented on a wall next to line 6. For confidentiality reasons, the name of Company A is covered in the pictures, as are the names of the planter articles.

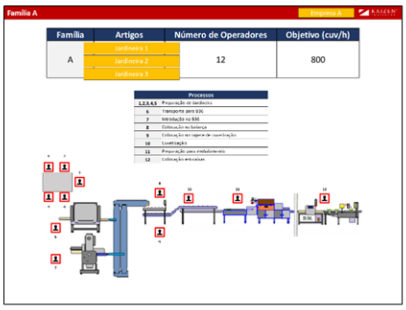

Figure 5 - New standard for allocation of operators

5.2 REDUCTION OF PRODUCTION LOSSES

The root cause analysis of breaks in line 6 began with an Ishikawa diagram. In this way, the workshop team was brought together and the reasons that would lead to breaks in line 6 were discussed. Since the workshop team was attended by the head of the Bovine section, the root causes were immediately identified, represented in the figure below:

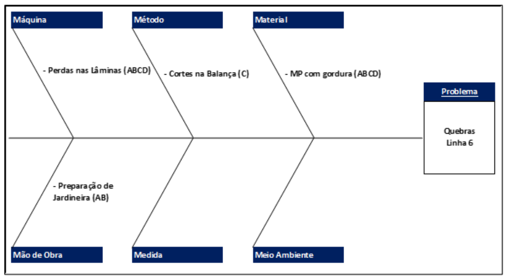

Figure 6 - Ishikawa Diagram for root causes

The root causes found for production losses were:

- Losses on slicer blades;
- Extra cuts in the scale process;
- Extra cuts while preparing 'Jardineira' meat.

For each of these causes, a solution was found:

- A new routine for substitution of the slicer blades;
- Calibrating the slicer machine so there was no need for extra cuts on the scale process;
- The implementation of a visual standard for the preparation of 'Jardineira' meat, as seen in Figure 7.

Figure 7 - Standard for the preparation of 'Jardineira'

6 DISCUSSION OF RESULTS

6.1 INCREASE IN PRODUCTIVITY

The productivity increase target set at the beginning of the workshop was 15%. This value would correspond to a reduction in the average number of operators per shift on line 6 from 10,9 to 9,5. Namely, the reduction of one operator in families A and C, and two operators in families B and D. However, having successfully implemented the changes discussed in the previous chapter, it was found that the impact on the line's productivity would be much higher.

Due to the average production time of each family per shift, the number of operators assigned to the line would be on average 8,7, presenting a difference of 2,2 operators per shift. This change in the number of operators implies a 24% improvement in the line's productivity, confirming the success of the Line Design workshop.

Since for the management of Company A, the interest in productivity improvement is related to the monetary benefits associated with it, an estimate was made of the gains that this increase could bring.

The estimated costs associated with an operator at the Torres Novas plant, taking into account the base salary, the amount of social security supported by the company, work insurance inherent to the food processing sector and food subsidies, is around 15 000€/year. Taking into account the average reduction of 2,2 operators per shift, equivalent to 4,4 operators in total, the benefit associated with the increase in productivity resulting from the reduction of operators is 66 000€/year.

6.2 REDUCTION OF PRODUCTION LOSSES

After the implementation of the standards set for line 6 regarding the decrease in the % of breaks, we proceeded to implement them during a period of two weeks, in order to ascertain their impact.

The result was a 45% improvement in the % of breaks in the line. Comparing this value with the projected goal of 28%, corresponding to a final break value of 4%, we can see that the improvement from the implemented solutions was almost double the original proposal.

Similar to what was done for the Line Design workshop, the results obtained in this Kobetsu Kaizen workshop were presented to the management of Company A regarding the monetary benefits resulting from the implemented initiatives.

In order to calculate this figure, an estimate was made of how many kilograms of meat could be used per week compared to the baseline figures. Since this raw material is now available, there is no need to buy more to meet the demand. Therefore, the impact of using the meat that does not go to slaughter is reflected in savings on the purchase of raw material. Thus, the estimated monetary benefits for this workshop were based on the average value of the raw material cost and the amount of raw material saved per week. The estimated monetary impact for the workshop was a benefit of $115,118 per year.

6.3 COMMENTARY ON THE RESULTS

The Value Review of June 2021 analyzed, among others, the results and respective impact of the workshops held on line 6. The estimated annual monetary benefit is as shown in the table below.

Table 3 - Line 6 benefits

Benefício *Line Design*	Benefício *Kobetsu Kaizen*	Benefício Total
66 000 €	115 118 €	181 118 €

As can be seen, the gains obtained in line 6 were substantial. Compared to what was defined as an objective in the Diagnostic Phase carried out in 2020, the improvement regarding the increase in productivity and reduction of breaks exceeded expectations, at least in the line in question. The deployment for the remaining lines of the section would be done in the following quarter.

It is important to emphasize that the implementation of the proposed improvement initiatives was carried out with relative ease. In both workshops, the root causes of the problem were quickly and clearly identified, and the solutions implemented proved to be effective at the first attempt. However, it is common to find more difficulties and constraints in solving problems and implementing improvement solutions. Contrary to what was observed in the two workshops presented here, often the process of defining the root causes of a given problem is more iterative, and not as straightforward as reported here. Similarly, it is common that in the testing of solutions, solutions need to be revised or simply do not work.

Fortunately, this did not happen in both situations analyzed in this dissertation. Thus, the two workshops presented here are case studies that prove the effectiveness of Lean thinking, and demonstrate that with little investment, based on the right fundamentals, large gains can be achieved with common sense solutions.

7 CONCLUSION

The solutions implemented in the two workshops held in the Novilho section in the quarter in question resulted in a combined monetary benefit of about 181 k€ per year, a significant gain for Company A.

The conclusion to be drawn from this case study is in line with the statement by Masaaki Imai, founder of the Kaizen Institute, "the solutions with the greatest impact are usually the result of common sense applications", a statement founded on Lean thinking. Thus, the solutions discussed in this document may seem simple, and indeed they are, but this does not mean, as we can see, that they do not have a great impact, as long as they are clearly structured and based on logical principles, such as the fundamentals presented.

In its application to the case of Company A, Lean thinking proves itself, as it has done several times in the past, as a solution to the problems faced by many companies from the most varied sectors, and as the key to survival in a global market

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